The Australian Wine Research Institute

Fact Sheet
WINEMAKING

Reducing ethanol levels in wine

Background

There is a growing public and consumer interest in wines with lower ethanol concentration that do not compromise the aroma and flavour profile. Producers are also faced with financial penalties for high ethanol wines in some markets where taxes are levied based on alcohol concentration. Although several engineering approaches have the potential to deliver lower ethanol wines, their impact on wine appearance, aroma profile and flavour profile has not been fully established.

The aim of this fact sheet is to provide practical information on a range of approaches that may be used to adjust ethanol concentration. The information has been gathered from the collective expertise of practical grapegrowers, viticulturists, winemakers and scientists, and is based on experience and review of current scientific data.

Sensory impacts and consumer preferences

Elevated ethanol levels clearly increase the perceived warmth or hotness of wine. Ethanol increases the perception of bitterness in both white and red wines. High levels of ethanol are sometimes associated with increased apparent sweetness, which may or may not be appropriate for the intended style of the wine. Higher ethanol levels might mask some wine aroma and flavour attributes. In a study on the effects of ethanol on sensory properties, ethanol did not cause any noticeable changes in the intensity of white wine aroma when the concentration was varied within the range of 11.6 % v/v to 13.6 % v/v. In the same study, however, elevated ethanol levels increased the hotness, bitterness, drying, roughing and metallic sensations on the palate, while it did not consistently alter fullness or viscosity (Gawel et al. 2007).

The link between ethanol and consumer preference varies across consumer groups. In one study, winemaker preference did not relate to ethanol concentration, while almost 40% of wine consumers in Australia and more than 50% of wine consumers in China reported lower levels of liking for higher ethanol wines, with reference to hotness and bitterness. Similar trends were found for Riesling and Chardonnay, where the preferences of a sizable proportion of consumers tested were correlated negatively with ethanol levels (Lattey et al. 2010). Hence, it is important for wineries to consider market demands and their market segment when adjusting ethanol levels in wine.

Viticultural practices

Reducing leaf area

The rate of sugar accumulation in berries is largely determined by the ratio of leaf area to fruit weight (LA/FW). However, flavour and phenolic ripeness may be independent of LA/FW. A relatively high LA/FW may cause sugar concentration to reach unacceptably high levels by the time that flavour or phenolic ripeness is judged to be optimal for a particular wine style. Therefore, reduction of leaf area after fruit set may lead to better synchronisation of sugar and flavour/phenolic ripening, and thus lower ethanol concentration in wine without any detrimental effect on flavour/phenolic profile. This can be achieved by shoot topping to reduce leaf number per shoot or by leaf removal above the bunch zone. However, these practices should be trialled with caution because they may cause excessively delayed ripening at high crop loads or excessive bunch exposure.

Pre-harvest irrigation

Contrary to the views of some in the industry, a substantial increase in irrigation volume during the pre-harvest period does not appear to have any significant effect on sugar accumulation in grapes or ethanol concentration in the resulting wine. Adverse risks associated with this practice include a significant delay in the ripening of high crop loads and, in some regions, a prolonged maturation period that might extend beyond the onset of autumn-winter rains.

Maturity and flavour profile

Delaying harvest produces grapes with fuller flavour and reduced green characters, especially for Cabernet Sauvignon grapes. It is commonly assumed, therefore, that wines made from such grapes will be preferred by consumers. However, recent studies have shown that this is not necessarily the case. A series of wines made from sequentially harvested Cabernet Sauvignon grapes showed a range of ethanol contents between 11.8 % v/v to 15.5 % v/v (Bindon et al. 2014). These wines were subjected to extensive chemical and sensory analyses and consumer preference tasting. Although fruit flavours, viscosity and hotness increased with maturity and fresh green characters decreased with grape ripeness, consumer preferences did not increase with maturity. In fact, consumer liking was similar for wines containing 13.6 % v/v to 15.5 % v/v, indicating that harvesting earlier could deliver a wine that consumers prefer and that contains less ethanol (Bindon et al. 2014).

Opportunities

Consider whether there is a relationship in your particular vineyard between leaf area and yields in lowering sugar concentration in berries and, if so, evaluate methods to decrease the leaf area/yield ratio in order to lower grape sugar concentration.

Understand the relationship between grape flavour and final wine flavour, and consider if your berry sensory assessment is providing an accurate guide to the final flavour profile in wine.

Consider whether harvesting earlier can deliver wines containing lower ethanol without a negative impact on wine style.

Fermentation and winemaking practices

Blending

Technologies exist which now make it possible to fractionate grape musts and wines. Those fractions can later be recombined in various proportions or combinations to achieve optimal wine quality.

Standard winemaking practices, which ensure the efficacy of any wine additions, necessitate the use of water, for example to dissolve tartaric acid or to convert bentonite into a usable slurry. These practices are regulated in most countries with the total amount of water not to exceed certain limits. In Australia, water added as part of permitted wine additions, such as fining agents, is limited to 7% v/v (70 mL of water per litre of wine). Winemakers normally limit any dilution factor due to the resultant effect of diluting wine flavour. However, if the total permissible addition of 7% were made, it could potentially lower the final ethanol concentration by almost 1% v/v. Again, it is of key importance that the effects of dilution on other must parameters (e.g. titratable acidity) and wine flavour be considered (see Water addition section below).

Enzyme additions

The enzyme glucose oxidase (GOX) from the fungus *Aspergillus niger* catalyses the conversion of glucose into gluconic acid and hydrogen peroxide. Addition of commercial preparations of the enzyme to grape juice prior to fermentation has been shown to decrease ethanol concentration in the resulting wine by 0.7% v/v compared to untreated wines. Since GOX works more efficiently when oxygen is supplied, this figure could be improved by aeration. GOX activity also causes an increase in total acidity, a slight decrease in pH and generates hydrogen peroxide. The effect of hydrogen peroxide production on wine colour or phenolic compounds has not been investigated.

Fermenter design

There is some evidence that aeration and higher fermentation temperatures can decrease ethanol levels. Tank type and design have also been indicated as important factors, with open top fermenters reported to give lower ethanol concentrations after fermentation. However, scientific studies have yet to establish the degree to which these factors modify ethanol levels and wine flavour.

Choice of wine yeast

Generally, commercial wine yeasts do not show much variation in the amount of ethanol yielded in wine following fermentation. However, the yeast strain AWRI 796 has been shown, in some laboratory-scale trials, to give lower ethanol concentrations than several other commercial wine strains. For example, compared to EC1118, AWRI 796 delivered a reduction of ethanol of up to 0.4% v/v. In addition, AWRI 796 is able to complete fermentation of musts prepared from high Baumé fruit, although attention to YAN (yeast assimilable nitrogen) and aeration are important in clarified musts. This yeast also produces higher titratable acidity (TA) than others. Recently, $\text{IONYS}_{\text{WF}}^{\text{TM}}$ a strain obtained by adaptive evolution, has been reported to decrease ethanol concentration between 0.4-0.8 % v/v. This strain increases glycerol concentration and total acidity.

Non-*Saccharomyces* yeasts are part of the natural microflora present on grapes, harvest equipment and in wineries. Non-*Saccharomyces* yeasts are present at least during the early stages of wine fermentation but are generally not capable of completing alcoholic fermentation. When used as inocula in winemaking, these yeasts have to be accompanied by a wine strain of *S. cerevisiae* to complete fermentation. A strain of *Metschnikowia pulcherrima* has been identified that can produce wine with reduced ethanol concentration when sequentially inoculated with a wine strain of *S. cerevisiae*. Chardonnay and Shiraz wines produced by this combination had 0.9% v/v and 1.6% v/v less ethanol, respectively, than control wines produced by *S. cerevisiae* alone. This strain is available as AWRI Obsession. Research has shown that AWRI Obsession increases colour, aroma complexity and mouth-feel and has the potential to reduce ethanol concentration.

Water addition

Until recently, the addition of water to must in Australia was not permitted. Regulations were revised by FSANZ in 2017, allowing for the dilution of high sugar musts with water prior to fermentation and to not less than 13.5°Be. This legislation was intended to enable wineries to lower the risk of stuck fermentations but also to help resolve logistical problems caused by compression of the vintage period (i.e. acceleration of grape ripening caused by shorter and warmer growing seasons). A number of studies have been conducted using water addition to lower ethanol in Australian Cabernet Sauvignon and Shiraz and showed variety-dependent results (Schelezki et al., 2018). For Cabernet Sauvignon, wine tannin, colour, aroma and flavour could be enhanced or maintained when juice was substituted for water. For Shiraz, on the other hand, replacing juice with water consistently led to losses in tannin, colour, aroma and flavour. Interestingly, the work on Shiraz wines showed that despite losses in colour and tannin, the way that water was added – either through juice substitution or direct addition made little difference to wine composition or sensory properties. Based on the results of the dilution studies to date, careful consideration should be given to the use of water addition to remedy high sugar musts in favour of harvesting to a targeted ripeness.

Opportunities

Assess winemaking practices for fermentation of early-harvested low Brix grapes.

Understand how alcohol might be lost during fermentation due to factors such as open versus closed fermenters, and active pump-overs versus plunging or heading down.

Assess the use of yeast strain AWRI 796 or $\text{IONYS}_{\text{WF}}^{\text{TM}}$ for your particular grape must and wine style and confirm the quantum of reduction in wine ethanol.

Evaluate if water addition has an impact on wine chemical composition, colour (particularly in red wines), aroma and flavour for your particular grape must and wine style.

Post-fermentation practices and processing technologies

The following methods should only be used if they comply with wine regulations of the destination market.

Physical removal of grape sugar or wine ethanol

Engineering options for reducing sugar content of juice and ethanol concentration in wine include membrane-based systems (such as reverse osmosis and evaporative perstraction), vacuum distillation and spinning cone distillation. These techniques allow for effective and precise control of ethanol reduction, and have seen widespread evaluation across the industry. However, in some circumstances, other sensory compounds might also be removed which could impact on wine quality; scientific evidence for establishing and minimising the impact of these approaches on wine flavour is currently limited.

Loss of ethanol by evaporation

During barrel maturation, both water and ethanol evaporate. Ethanol concentration slowly increases in dry cellars as water evaporates faster than ethanol in this environment. Conversely, in cellars with a relative humidity over 70%, ethanol concentration slowly decreases over time. Ethanol was reported to drop by 0.2% v/v when barrels were stored for 12 months at 15°C with relative humidity over 90%. Mould development is a risk when barrels are exposed to high humidity for prolonged periods without appropriate monitoring.

Opportunities

Where appropriate, use blending of high and low alcohol wine to achieve the desired final alcohol concentration, balance and quality.

Consider whether engineering techniques to decrease alcohol in wine are appropriate for your production scale and wine style.

If wine is to be kept in barrels for long periods of time, pay attention to relative humidity and mould development in the cellar.

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