The Memstar AA process for alcohol adjustment

(A discussion paper by David Wollan, Memstar Pty Ltd, July 2007, www.memstar.com.au, dwollan@memstar.com.au)

Introducing Memstar AA

Specialist wine technology company, Memstar, has developed a revolutionary new process for reducing excess wine alcohol without affecting any other wine components. This is in response to a worldwide trend to higher wine alcohol. This process is now offered to winemakers who are concerned about the increasing levels of alcohol in their wines.

Memstar Alcohol Adjustment plant – Model RA8-08/10-02

The problem of excess alcohol

One of the major defects in many modern wines is excessive ethanol; even if it is not always recognised as such – either by winemakers or consumers.

For many winemakers high levels of alcohol are deemed to be inextricably associated with fully ripe, high quality fruit. This is a consequence of striving for more mature fruit flavours and tannins and softer acidity rather than a desire for higher alcohol per se. Nevertheless this pursuit of greater ripeness by winemakers in many parts of the world has resulted in wines with alcohol levels well in excess of 14% by volume. A number of respected international critics reacted to these ripe, extravagant wine styles with generous praise so winemakers responded with even riper, more extractive and alcoholic styles. Consumers followed along and validated this approach with their purchasing power.

So what's the problem? If winemakers are producing wines that critics endorse and their consumers are prepared to pay a premium for, then there is no problem. However many winemakers are beginning to have their doubts. Besides increasing the intoxicating effect of the wine, this manifests itself in a reduced perception of wine aroma as well as an unpleasant hotness on the palate. Many high alcohol wines seem heavy and lack fruit flavour and freshness. At the extreme they are dull and jammy and seem to age prematurely. There are other damaging effects of high alcohol on wine quality such as prolonged or arrested primary and secondary fermentations, leading to higher levels of residual sugar, with consequent microbiological spoilage, elevated volatile acidity, Brettanomyces taint, loss of SO_2 and oxidation. (AWRI 2003)

On a commercial level, in some export markets high alcohol concentrations are punished with extra taxes and, in others, with outright prohibition from sale.

A measure of the extent of this problem shows it is growing. Wine samples analysed by the Australian Wine Research Institute over the past 20 years have shown a steady increase in alcohol level over this period so that the mean for all samples analysed in 2002 was 14.2% compared with 12.4% in 1984.

Why remove alcohol?

The simplest method for achieving lower alcohol is to pick the grapes earlier. The result is less sugar but also less flavour, colour and body as well as more acid and more of that hard to define group of characteristics called 'greenness'. And if

consumers are coming to reject over-ripe, excessively alcoholic wines, they like thin, green under-ripe wines even less.

Purists will declare that sound grapes of the appropriate cultivars from balanced vines grown on favourable sites do not have these problems. They display full fruit flavour at low sugar ripeness. This is undeniable but hardly helpful. If winemakers only made wine from perfect grapes they would make very little wine at all. And what they did produce would be unacceptably expensive.

In the absence of a widespread supply of perfectly balanced and matured grapes, winemakers require a method for removing some of the excess alcohol in wines from fully ripe grapes. This would allow them to pick their grapes at optimum ripeness from the point of view of flavour maturity without suffering the negative effects of excessive alcohol.

Options for alcohol reduction

One approach is to add water to the grape must or wine. While this has been practised for centuries, it diminishes wine quality by reducing the overall concentration of the wine. It is also illegal in many jurisdictions.

Other more acceptable processes for reducing alcohol have been offered previously but all are deficient in some way:

Vacuum distillation

One approach is to remove alcohol using a vacuum distillation technique such as the spinning cone or AlcoTECH processes.

With the spinning cone, a portion of the wine is shipped to the plant for complete dealcoholisation then it is returned and blended with the untreated wine. In these systems, the wine is warmed to the vicinity of 40^{o}C and a vacuum applied. All the volatile components of the wine, including alcohol are removed in the distillate and the volatile flavours are separated from this and returned to the wine being treated. This system is complex, capital intensive and immobile. There is also some possibility of flavour loss, but most importantly, with the Spinning Cone, the alcohol is removed at relatively low strength (approximately 50% v/v) so overall volume loss from the wine is significant.

The AlcoTECH process differs in that the alcohol is evaporated off under vacuum and the distillate is further distilled to remove all of the alcohol before returning the low alcohol (water) portion back to the wine.

Reverse osmosis and permeate distillation

Another technique is described by the Smith patent (Smith 1996). In this, wine is processed through a reverse osmosis plant to generate a permeate stream which is then distilled in a high energy distillation column and the distillate which consists very substantially of high strength alcohol, is removed and sold. The residual material, being dealcoholised permeate, is returned to the wine, thus reducing its alcohol content. This is effective but costly in energy terms as well as infrastructure costs. Like the Spinning Cone, this method suffers from being relatively immobile, meaning the wine or permeate must travel to the still and back.

Reverse osmosis cannot remove alcohol

A popular misconception, promoted by less scrupulous vendors, is that reverse osmosis can reduce alcohol. This is not true. By itself, reverse osmosis will separate wine into permeate and concentrate streams. If the permeate is discarded, the result is a reduction of overall volume in the concentrate but an increase in the concentration of most wine components, including alcohol. To reduce the wine alcohol the permeate must be further treated before reblending.

Reverse osmosis and water addition

One option practised (where allowed, and sometimes when not) is to remove a certain amount of permeate by reverse osmosis and to replace it with the same amount of water. This water could be from grape or non-grape sources according to the local regulations but in most wine producing countries the practice is illegal or of

dubious status. Irrespective of the legal or regulatory concerns, there is another limitation of this technique: Permeate does not contain just water and alcohol. Depending on the membranes and operating conditions, it does contain other minor components such as some acids and a few flavour volatiles. These are lost if the permeate is discarded and replaced with water. Wine quality and integrity is generally compromised by this approach.

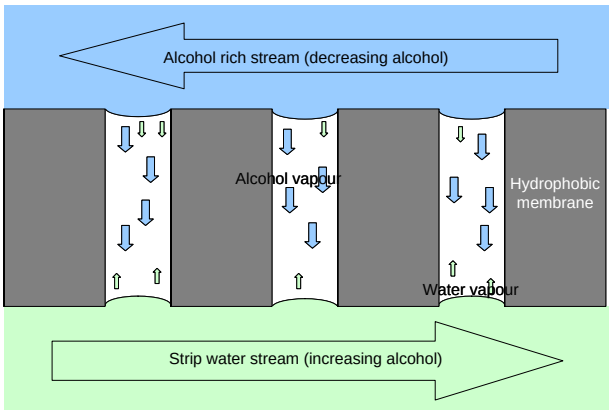
Wait for new yeast strains

On the more distant time horizon, microbiological researchers at our institutes are promising new yeasts which produce less alcohol from a given amount of sugar. Presumably these would have metabolic pathways modified to divert the carbon from sugar into other, more benign by-products than ethanol. Past attempts to do this have resulted in the production of large amounts of acetic acid, which have not been helpful. Glycerol is suggested as a possible endpoint and, if this can be achieved, it will probably be appealing to winemakers and consumers alike. However this work is some way off and the problem of high alcohol is immediate. Finally, this technique will very likely suffer from the consumer's suspicion of genetically modified organisms as these new yeast strains are almost certainly going to be the product of genetic recombination.

Evaporative perstraction

Evaporative perstraction is the technical name for the membrane technique used in the Memstar AA process. (It is also sometimes referred to as 'osmotic distillation'.)

Perstraction - "Separation process in which membrane permeation and extraction phenomena occur by contacting the downstream with an extracting solvent" (IUPAC 1996)



Evaporative perstraction

An approach described by Hogan et al. (1998) uses the process of evaporative perstraction to remove alcohol directly from wine. In this process, a stream of alcohol rich liquid (wine) passes through a membrane contactor. Separated from this stream by a hydrophobic membrane, a counter-flow of water is passed through the same contactor and alcohol passes through the membrane from the wine side to the water. This process is based on the principle that ethanol, as a volatile wine component, has a significant vapour pressure. This leads to its movement into the porous matrix of the hydrophobic membrane and by virtue of the concentration difference across the membrane, its subsequent movement into the water on the other side. In the process, the wine becomes weaker in ethanol content and the strip water becomes richer.

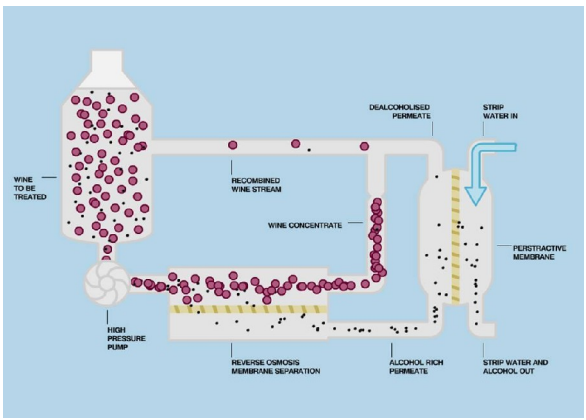
Water also has some vapour pressure so its vapour passes into the porous matrix until the space is saturated. Because the water activity on both sides of the membrane is high and similar, there is no significant water vapour pressure gradient driving force and so virtually no movement of water from one side to the other.

In practice this process leads to high levels of extraction of other desirable volatile components from the wine, such as flavours, esters and sulphur dioxide. One approach suggested by the developers of this technique was to 'spike' the strip solution with these compounds so that no concentration gradient for the compound exists. This is complex and expensive and renders the by-product less useful. Other efforts to limit the

extraction of desirable volatiles by recycling some of the strip stream reduce the efficiency of the process. Efficiency is also compromised by the relatively low temperatures at which it is performed, by the tendency of wine to foul the membranes and by the presence of relatively large concentrations of CO_2 and other gases in wine. These cannot easily be removed without also removing desirable volatiles.

Memstar AA – Alcohol reduction by reverse osmosis and evaporative perstraction

Memstar AA is a new technique based on a combination of two physical processes - reverse osmosis and evaporative perstraction. It applies the previously described principle of evaporative perstraction to the permeate stream of reverse osmosis processed wine. It is the subject of Australian and international patent applications. (Wollan 2004)



Alcohol reduction by reverse osmosis and evaporative perstraction

Wine to be treated is separated by reverse osmosis into retentate and permeate streams. The alcohol rich permeate is degassed, heated and passed through a proprietary perstractive membrane array on the other side of which is a counter-flow of filtered, deoxygenated strip water. Alcohol passes through the membrane from the permeate into the water. The rate at which it does this depends on the alcohol concentration gradient across the membrane and the temperature. The dealcoholised permeate is then recombined with the wine from which it was extracted, thus lowering the alcohol of the blend.

By treating RO permeate and not wine in the perstractive membrane array, the extraction of volatiles is reduced because of their limited passage from the wine into the permeate stream. This is controlled by the selection of appropriate membranes and operating parameters to maximise the passage of ethanol while limiting the passage of other compounds. Typically, with one 'pass' the alcohol is reduced by 0.9 to 1.5% v/v. In practice, the wine being treated generally does not pass from tank to tank - it is circulated in one tank. Processing continues until the alcohol of the whole batch is reduced to the desired level.

The improvement in treated wines is clear and compelling.

The concept of 'sweet spot'

Reducing alcohol in wines from high levels has exposed the unexpected phenomenon of the alcohol 'sweet spot'. In this, it is a common experience for tasters to notice that when the alcohol level in a given wine is varied by as little as + or – 0.1%, significant changes in the flavour intensity and balance occur. In bench trials of the same wine at different alcohol concentrations, it is not unusual for a group of tasters to agree on certain levels where the wine is significantly superior to the wines bracketing them. These are 'sweet spots' and the process of finding them is sometimes compared to tuning a radio.

It is also common to find that there may be more than one sweet spot for a given wine and each of these could exhibit quite different style characteristics. For example, a Chardonnay at 14.2% may display rich, 'New World' qualities, but at 13.6% the flavours may be more subtle and 'Burgundian' and at 12.8% possibly 'Chablis-like'.

When the alcohol adjustment is done wholly on site and in one process the winemaker then has the opportunity to tune the desired wine style, set specifications and monitor progress. As part of their service, Memstar personnel are available to explain the concept and to assist winemakers with the appropriate tasting procedures to optimise the process.

Memstar AA – summary features

In summary, Memstar AA is different to all other approaches to alcohol reduction:

- **Reverse osmosis, membrane based process preserves flavours, colour and tannin**

The Memstar AA process is a 'closed loop' with two membrane separation steps between the wine being treated and the strip water which removes the alcohol.

The actual alcohol stripping step is performed on the reverse osmosis permeate which contains very little of the vinous characters that would otherwise be lost.

- **No dilution or degradation of wine quality**

The process is carried out in a closed, oxygen free environment and does not involve the addition of any extraneous material which would dilute wine flavours or otherwise degrade quality.

- **No high temperature distillation**

The wine itself is not heated or evaporated so there is minimal loss or change to desirable wine components. The process does not involve high temperature distillation with its substantial infrastructure and energy costs. It avoids the taxation, OH&S and other regulatory issues associated with the production and handling of high strength alcoholic spirit.

- **No legal issues as a result of water addition to wine**

This process does not involve the addition of water to wine – a practice which is not permitted in most wine producing countries. It also avoids the addition of water derived from grape sources – a practice that is of dubious legal status.

The process is a closed loop with no extraneous additions or blending so complies with most countries' regulatory requirements.

- **Minimal volume losses**

Only alcohol is removed so compared to other processes, volume losses are the lowest possible. In fact for every litre of pure ethanol removed, only about 900 ml of total volume is lost (a consequence of the different specific gravities of ethanol and ethanol/water solutions).

- **Wine processed entirely on-site**

Wine doesn't leave your winery. The alcohol reduction processing is done by Memstar skilled personnel using Memstar's unique mobile equipment. This is brought to the winery and the whole process is done on site.

No need for any portion of the wine to be shipped away for further processing and return. So there are no extra freight costs - less risk of contamination or loss.

- **Finding the 'sweet spot'**

The winemaker determines the preferred alcohol level or "Sweet Spot" at the commencement of the process. The preferred amount of alcohol to remove is entered and the plant automatically monitors and controls the job. The process can be stopped at any time or may go further as the winemaker wishes.

- **Rapid, cost effective and flexible**

The Memstar AA alcohol adjustment process is available as a cost effective, on site service provided by our skilled personnel; on a short to long term hire basis; or to purchase (including a license for the use of the technology). Systems are available to process 2,500 to 500,000 litres per day, reduced by 1% or more.

A number of models and capacities are available.

International

Memstar AA Alcohol Adjustment technology is available from Memstar and its licensees in Australia, New Zealand, USA, Canada, Chile and South Africa. Recent trials in France and Argentina are expected to lead to regulatory

approval with service and sales following shortly through licensees in those countries.

Contacts and affiliates

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