Advances in tannin management using ultrafiltration and micro-oxygenation

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Introduction
Phenolic compounds in general and tannins more specifically are essential components of wine – providing colour and mouth-feel. Historically, part of the winemaker’s skill has been to work with these compounds and to optimise their impact on the final wine. This impact has been characterised by the ripeness of the tannins in the grapes, and the selection of harvest date is the major tool used by winemakers to ensure minimisation of unripe tannin flavour and characters.

Historical tannin management
A vast array of methods has been used to manipulate tannins in wine.

Pre-fermentation maceration has often been claimed to improve colour and tannin and is widely practised, however a recent article (Sacchi et al.) suggests that this process has no effect on colour or tannin extraction.

Tannin extraction has been historically achieved during fermentation using pump overs, plunging, heading down, automatic fermenters and a variety of other techniques aimed at maximising colour and tannin extraction.

Post-fermentation maceration for up to four weeks in some cases has also been popular as a technique to increase tannin, but not anthocyanins.

Addition of exogenous tannins before and during and after fermentation is currently a very popular technique to increase tannin levels.

The process of pressing is the method used to extract as much as possible from the fermented must by separating the liquid fraction from the mixture of skins, seeds and juice.

Once the wine is made, winemakers continue to manage or manipulate tannin levels in wine by maturation in oak barrels, which adds oak tannin to the wine. This has been the historical method while more recently the addition of chips, planks or other oak pieces has increased in popularity. The addition of further exogenous tannin is often used to achieve desired levels of tannin in the final wine. These processes are enhanced by aeration or racking, which is said to provide the oxygen necessary for polymerisation and other reactions that produce soft finished wines. Tannin is often added at this stage or even earlier with a view to stabilising colour and further improving the mouth-feel or structure.

Following all these activities and prior to bottling, wines are often fined with proteinaceous materials to reduce the tannin or modify its characters to produce an acceptable final product.

Finally there is the bottling process and in some cases a maturation period in bottle which further modifies the tannins as they soften with age. The actual mechanism of this process is the subject of some conjecture at present.

It is the combination of these well-known processes that eventually produces the red wines we regularly enjoy.

Future tannin management techniques
Having summarised the historical techniques, how will we manage tannins in the future? Without a doubt the best solution is to manage...
tannin in the vineyard. Balanced and uniform vines in the perfect site should provide the opportunity to produce the perfect fruit. Other than efficient extraction of the tannin from the grapes, very little management or manipulation will be required to produce great wine. However, not all of us are in this fortunate position and may continue to need assistance from tannin manipulation techniques, and there are now some new options:

**Micro-oxygenation** – this technique is now well established and will be discussed a little later; and

**Ultrafiltration** – the next generation of tannin manipulation methods – and that is what we will now discuss.

Ultrafiltration is a ‘pressure-driven membrane-based separation process in which particles and dissolved macromolecules smaller than 0.1 micron and larger than 2 nm are rejected’. This is the International Union of Pure and Applied Chemists (IUPAC) definition of the process.

Figure 1 shows where ultrafiltration (UF) fits into the big picture of pore sizes and molecular sizes – the diagram is complex but the main point is that ultrafiltration fits between nanofiltration and microfiltration. Note the position of metal ions, sugar, gelatine and yeast cells. Ultrafiltration will stop the passage of molecules from approximately: MW >1000 to MW <150,000.

UF is a membrane-based separation technique using cross flow filtration in much the same manner as the well recognised RO and nanofiltration processes. In UF the pore sizes are much larger allowing most of the wine components through the membrane, except tannin and similar sized macromolecules, and in fact the flow of tannin through the membrane depends on not only the size of the tannins, but also their concentration.

As the concentration increases towards the end of a filtration run, the passage characteristics change and more of the tannins pass through the membrane which produces some interesting results. This allows us to concentrate the tannin and sometimes to separate the fractions by size, the smaller tannins passing through the membrane under certain conditions.

An overview of the process can be explained best by observing what happens to phenolic material in a UF system in Figure 2.

The wine is circulated through a UF filter and almost everything but the tannin and colour passes through the membrane, as permeate, into the second tank. This effectively leaves an almost phenolic free wine and a tannin concentrate in the original tank.

There is great potential for UF in the wine industry despite its somewhat ignominious beginning. In the early 1980s UF was promoted as an alternative to bentonite as a means of filtering out heat unstable protein in white wine. While it was able to remove some of the protein, winemakers found it removed many other valuable components as well.

Less well known at the time was the ability of UF to fractionate tannins allowing their selective removal or even concentration. It is this function that will be of most use to the modern winemaker. It is early days but it appears to have great potential.

So what would be the main benefits of this process in a commercial winery?

**Replacement of proteinaceous fining** – by removing some or all of the tannins from a red wine it may be possible to eliminate the need for final treatment with Gelatine (ground up horses’ hooves), Isinglass (ground up internal organs of Russian fish) and egg whites – incidentally that should also eliminate the need for some of those unnecessary back labels warning of the presence of fish products. Furthermore using a UF for these duties would significantly reduce fining losses.

The by-product in most cases is a tannin concentrate that you may wish to add to other wines instead of using the commercial exogenous tannin preparations, some of which are made from grapes.

Let’s look at some practical applications that have already successfully been used in the U.S. First consider harsh red pressings, probably obtained from a continuous press. If these pressings are passed through a UF at the start of the run, the filtrate will contain very little colour and tannin – it will produce a light red coloured wine with very little or no tannin. Eventually the concentration of the tannin in the original tank is such that some smaller molecular weight tannins start flowing through the membrane and the colour starts to reappear. This may require increases in pressure. The experience in the US has been that this is when the body and structure of the wine returns but without any harsh or astringent tannin. The last 5% through the UF is darker and richer in colour and tannin (Figure 3). Clark Smith refers to this as black gold, which is probably quite appropriate as at this stage it does appear that this is somewhat of a black art!

And if the process continues down to about 5% of the original volume, which appears to be as low as you can go, then 95% of the original has passed through the filter. This produces a rich soft wine with good colour but no hard astringent tannin. What remains in the original tank is a concentrate which is useful as a tannin adjunct that the Americans sell as XPress! A colour and tannin concentrate which is very useful.

When this tannin concentrate is produced our colleagues at Vinovation in the USA have noted that within hours they see changes in the material. The significantly increased concentration of the tannins means that reaction rates for condensation and polymerisation are increased dramatically – you can then add this back to the same wine or another wine to provide softer, smoother mouth-feel.

The by-product, or X-press, can be used to boost red wines in much same way as expensive exogenous tannins – the system provides the opportunity for you to make tannin additive from your own grapes. No added chestnut gall or other tannin of dubious origin!

But what about white pressings? Using a similar process a tannin reduced filtrate is produced which will be a pale white wine, usable...
as such. Towards the end of the run as the concentration of tannins increases there is some flow across the membrane and this contains large amounts of low molecular weight tannins. This fraction can be used as a co-factor concentrate. This can be side-streamed and used for adding to red wine fermentations, instead of using valuable or unprociable Viognier. There is also more tannin adjacent in concentrated form (another useful tannin addition concentrate) for addition to weak or poorly coloured and flavoured red wines.

The process is also extremely effective at removing discolouration for whatever reason it is present. It might be a Rosé style wine, Pinot Gris, Pinot noir sparkling wine pressings or even a wine in which some red has been accidentally pumped in to the wrong tank. (Of course it never happens in your winery, but it has happened to others!)

The process allows one to recover useful wine from hard pressings – the hard pressings are circulated through the UF and the tannins end up as a concentrate and the filtrate is useful wine. The by-product of this process, the concentrate, as noted above would also be very useful.

But as with most good things, there are problems and there are some drawbacks. Unlike RO and NF, the wine flow rate is relatively slow as most of the wine is going through the membrane. A large surface area of membrane is required, therefore the UF tubes are long and somewhat bulky. The membranes are relatively intolerant of solids so the wine must be very clean, which basically precludes its use on juice or fermenting wine. Finally a UF machine is very costly; otherwise we would already have one in Australia.

It is still relatively early days in the development of UF for wine and at this stage the systems in use are relatively unselective for tannins, although that is likely to improve with time.

Memstar, Wine Network’s technology division, is keen to bring one of these units into Australia and is attempting to secure pioneer wineries willing to participate in the process.

Micro-oxygenation

Micro-oxygenation, often referred to as MOX, was first developed by Patrick Ducorneau and his team on the Tannat wines from the south of France.

Basically it simulates the conditions in a barrel by allowing very small amounts of oxygen into the wine which is utilised in tannin condensation. The levels of oxygen uptake are well below the measured dissolved oxygen in wine. The technique appears to be reasonably well understood by some, but we still find wineries that have the equipment but for whatever reason fail to use it, or fail to use it properly. On a recent trip to Chile, co-author, David Wollan, observed a number of MOX units lying around in Chilean wineries while they moaned about their green or hard tannins – they had obviously tried the technique or been convinced to buy it, but had no success.

We have observed that MOX is often used on poor wines as a remedial technique rather than for improving good wines, which is its best application. This probably occurs because in the initial phase of the process a wine being treated seems to harden and become more tannic, and users are spooked into stopping. To succeed you have to press on through that phase and get to what Patrick Ducorneau calls the ‘structuring phase’. We have seen excellent results in a number of situations, provided it is monitored and provided the winemaker is prepared to ride through the storm of tannin building to achieve the desired results.

Wines with under-ripe or green tannins in particular can be significantly improved with MOX. It appears to improve stability of colour and flavour. But perhaps the most useful summary of MOX is that it ‘TURNS TANKS INTO BARRELS’. All you need is a MOX system and some form of high quality oak insert (staves, beads, chips) at the right rate, and you can achieve results that are basically difficult to differentiate from oak aged wines. Such a system will provide a number of advantages: it will improve the structure and flavours, reducing green or unripe tannin flavours. It will soften tannins – it is an artificial barrel maturation system.

MOX can also be used in older barrels; as the older barrels do not have the same high oxygen flow through the staves you can replicate the new oak flow rates and in fact you can even speed up the oxygen flow in new oak if you believe the wine needs more oxygen.

The procedure works best with good wine – would you put your overcropped Riverland Merlot into good wood? Probably not! MOX is really a tannin management technique and offers the chance to turn tanks into barrels providing greater control. There is the chance to work with good wine in tanks with planks (or chips) and turn good wine into great wine without using expensive barrels.

Memstar, and its predecessor Wine Network Technology Pty Ltd, developed its own form of introducing micro-oxygenation to wine known as O2Mate. In this system oxygen is introduced into the wine via a permeable membrane so there are no bubbles of gas and no possibility of any problems should there be any system failure, including power. It simply means nothing happens. Our systems will work in barrels or moderate sized tanks, while other systems are more economical for larger tanks such as 50,000L and above.

But as a general principle we would encourage those winemakers with green hard wine to consider giving it a go, especially if you have a system sitting in the back of the winery.

Summary

The modern winemaker has a couple of excellent new tools for manipulating tannin in red and even white wines:

Ultrafiltration

• Removes red colour and phenolic material from white wines – solving the sparkling pressings dilemma,
• Produces tannin concentrate from your own material,
• Replaces proteinaceous fining – no more horses’ hooves, no more fish guts and health warnings,
• Softens some reds and builds up others

Micro-oxygenation

• For softening red wines
• For reducing green characters in red wines (the bane of the gatekeepers at present)
• For reducing investment in expensive oak for mid-market wines

Notes

The Wine Network Group recently changed the name of its Technology Company, from Wine Network Technology to ‘Memstar’, an acronym for Membrane – Separation, Treatment and Recombination, a broad-brush description of the processes Memstar uses for VA removal, taint removal and other activities.

This presentation has been prepared by David Wollan, Robert Paul and Gary Baldwin and we would like to acknowledge the assistance of Clark Smith of Vinovation Inc. USA in the preparation of much of the ultrafiltration work in the presentation.

References