Quality in a cool climate – maceration techniques in Pinot Noir production

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Australia's cool climate wines are gaining favour. At the 2011 Melbourne Wine Show, a Tasmanian cool climate Shiraz won the Jimmy Watson Trophy, while in the past the Australian wine sector has built its reputation on ripe, robust, fruit-driven red wine styles. With higher production costs, cool climate viticulture can be challenging; consistent, high quality is essential for wines to be able to target higher price points in the market. This article explains how maceration techniques can influence the tannin and colour profiles of Pinot Noir, an important cool climate red wine varietal.

THE BACKBONE OF PRIZED PINOT NOIR

If red wines have a 'backbone', in sensory terms that backbone is made up of phenolic compounds. The taste and appearance of red wine is determined by anthocyanins, tannin monomers and tannin-anthocyanin polymers – examples of the 'phenolics' found in wine. These phenolic compounds also have strong antioxidant properties, ensuring the preservation of wine quality during red wine production and maturation. Since they occur in gram-per-litre quantities, phenolics play a significant role in the management of wine quality (Smith *et al.* 2007).

Accounting for most of the pigment in grapes is a class of phenolic compounds known as anthocyanins. Pinot Noir grapes generally feature lower anthocyanin concentrations when compared with other red varieties. Pinot Noir also contains no acylated anthocyanins, which are a more stable form of the compound (Agati *et al.* 2007). Since Pinot's low-concentration anthocyanins are also less stable, it is all the more important that the pigment is efficiently extracted and stabilised during the maceration/fermentation process.

The process of red wine colour stabilisation has been a focus of research at the AWRI for some time: it dates back to Chris Somers' work in the 1960s (Somers 1966). The process involves a chemical reaction, namely, polymerisation – involving anthocyanins and tannin (Herderich and Smith 2005). Although Pinot Noir grapes have high tannin concentrations, information held on the AWRI Tannin Portal (http://tannin.awri.com.au/) demonstrates that Pinot Noir wines tend to be low in tannin (Figure 1). This anomaly is most likely due to Pinot's low ratio of skin-to-seed tannin, when compared with other varieties (Kennedy 2008). Seed tannin is more difficult to extract than skin tannin and tends to come out later during fermentation.

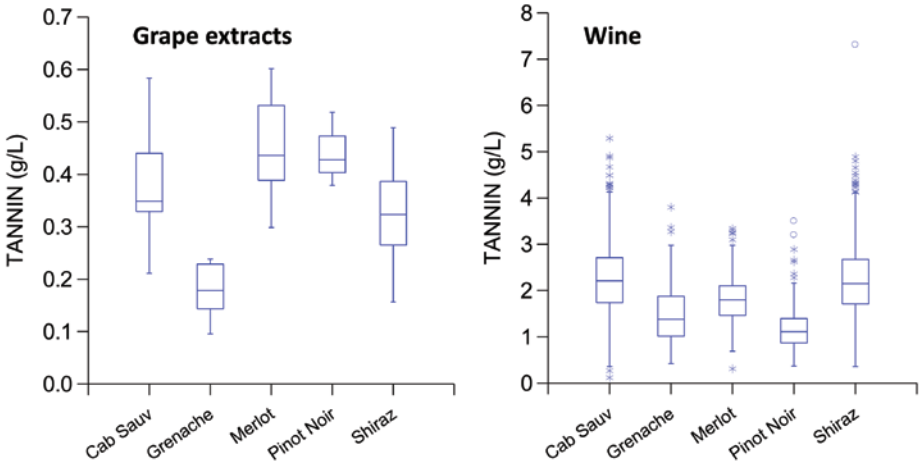

Figure 1. Tannin concentrations in grape extracts and wine. Box plots indicate the spread of values: median is indicated by the horizontal line; 50% of samples are within the box; whiskers indicate upper and lower quartiles; symbols indicate extreme outliers.

Anthocyanins are easily extracted and, as a result, can be found in juice early during fermentation. Since they are highly reactive, it is important that stable pigment formation is encouraged, and tannin plays a role in this.

Due to low concentrations of tannin in the skins of Pinot Noir, other parts of the grape are also used during the winemaking process. Seeds and stalks are also used and both contain high concentrations of tannin, as shown by the spectral fingerprints in Figure 2 (see page 20). Typically, Pinot Noir grape must is made up of 39% juice, 28% pulp, 24% skin, 5% stalk and 4% seeds (on a wet weight basis). Although stalks and seeds are a relatively minor component by weight, their high tannin concentrations make them an important tannin source. The downside is they can introduce green flavours, and astringent and bitter characters – encouraging their extraction into wine must be approached with caution.

There is no doubt that tannin and pigment determine quality in Pinot Noir. Analysis at the AWRI of wines in the two-year-old Pinot Noir category (Class 18) at the 2010 Tasmanian Wine Show found that gold and silver medal-winning wines had high tannin and high pigment concentrations. Samples from the wines were analysed for tannin, total phenolics and total pigment using the AWRI Tannin Portal (http://tannin.awri.com.au/). The results are shown in Figure 3 (see page 21) ▸

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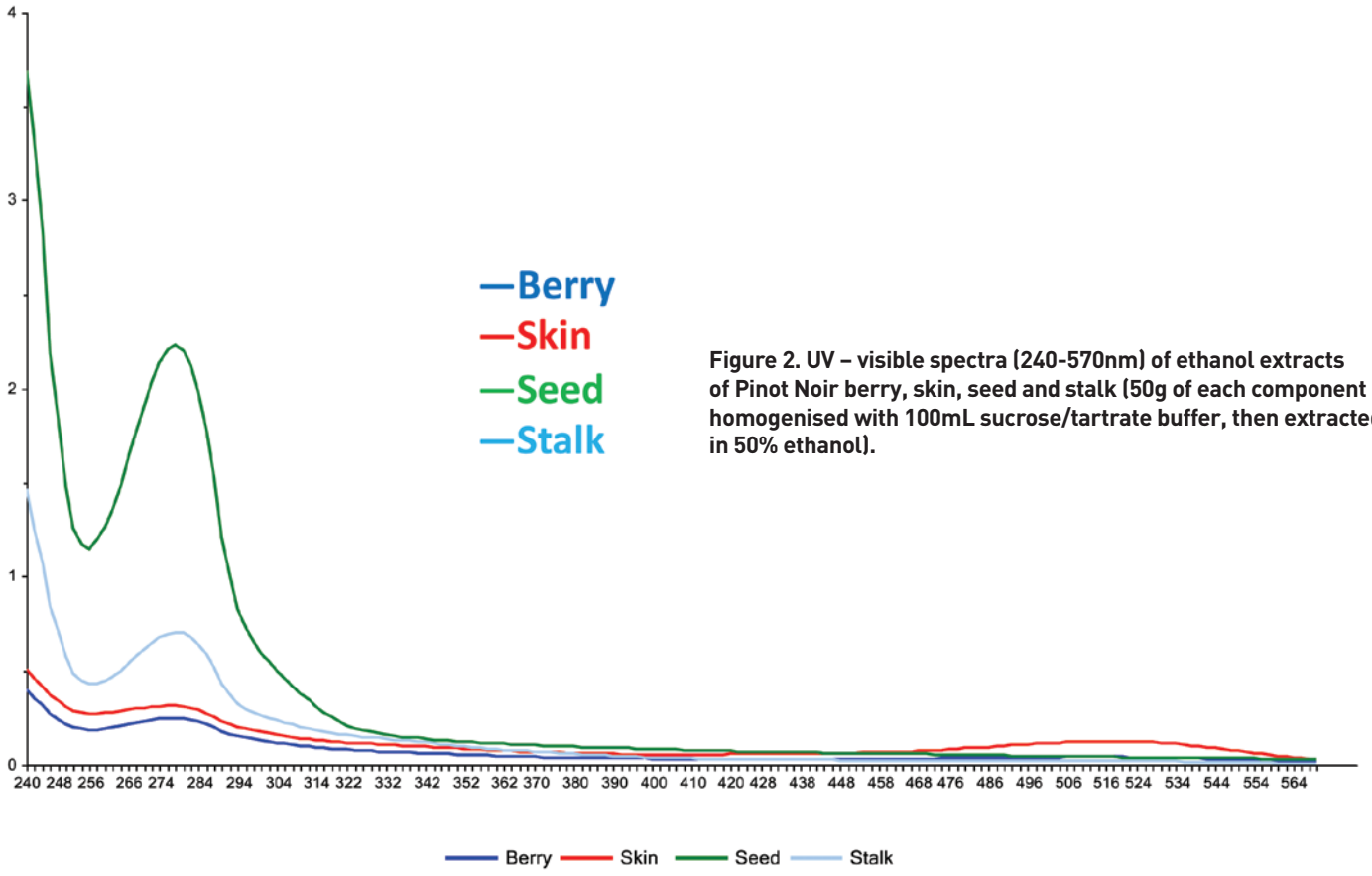

Figure 2. UV – visible spectra (240-570nm) of ethanol extracts of Pinot Noir berry, skin, seed and stalk (50g of each component homogenised with 100mL sucrose/tartrate buffer, then extracted in 50% ethanol).

These recent findings at the AWRI are supported by previous research: Chris Somers examined the relationship between wine show score and colour in Shiraz wines in the 1970s (Somers and Evans 1977). In the past decade, a visible/near-infrared spectral study of Pinot Noir from the Adelaide Wine Show also revealed the importance of colour wavelengths, including those related to tannin (Dambergs *et al.* 2002).

There is evidence, therefore, that phenolic compounds drive quality; there is also evidence that their management requires intervention. Given the behaviour of Pinot Noir's phenolics, climatic sensitivity and the high degree of clonal variability with the Pinot variety (Smart *et al.* 2010), it might not be viable for many producers to rely solely on 'terroir'. Consistency in style and quality requires intervention by winemakers, regardless of vintage conditions.

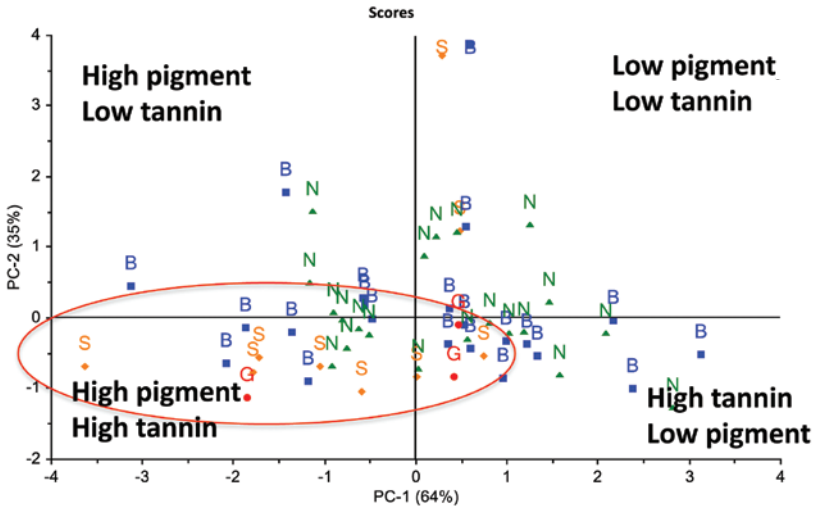

Figure 3. Principal component analysis (PCA) scores plot for samples from class 18 of the Tasmanian Wine Show. PCA was performed using tannin, total pigment and total phenolics data for each wine. G= gold medal; S= silver medal; B= bronze medal; N= no medal. The cluster containing the majority of gold and silver medal wines is contained within the red ellipse.

MANIPULATING PHENOLIC PROFILES

Maceration gives red wine its colour: it is the process whereby phenolics – the tannin, pigment and flavour compounds described in this article – are leached from grape skins, seeds and stems into the must. In the case of Pinot Noir, maceration methods have traditionally focussed on optimising colour and tannin extraction.

Cold maceration is a common method. Pinot must is held at low temperatures, in the presence of sulfur dioxide, before the onset of fermentation. During this process, the easily-extracted anthocyanins enter the must. The general breakdown of cellular tissue, at this stage, may also help tannin extraction during fermentation.

For best results, skin tissue components can be concentrated by removing juice immediately after crushing (the process is

also known as 'saignée' or 'bleeding'). Stalk tannin can also be incorporated by using whole bunches or by adding rachii separately to the must. Oak is another possible source of tannin, although oak tannins are readily hydrolysed, or broken down, modifying their impact. The extraction of tannin from skins and seeds can also be enhanced by maceration at the post-fermentation stage.

Choosing the right yeast strain can also have an effect on aroma and phenolic performance, according to recent findings. Yeast metabolites are thought to be involved with wine and pigment stabilisation (Herderich and Smith 2005), so the key to efficient colour stabilisation may be to synchronise anthocyanin and tannin extraction with the availability of yeast metabolites. Pinot ferments start slowly when using cold maceration or wild yeast ferments and tend to proceed very quickly once fermentation has begun. This is because they are usually allowed to heat up to enhance extraction. As a result, the period of yeast activity is short; one way to increase this active fermentation window may be to remove juice at crushing, then return it near the end of fermentation.

RETHINKING THE COFFEE PLUNGER...

To provide winemakers with statistically valid data, trials assessing different winemaking methods must be carefully designed: they must be well-replicated and completed under controlled conditions. Experimental winemaking can be difficult on an industrial-scale, since logistical constraints, risk and cost make it hard to achieve adequate replication and control over the process.

One difficulty is cap management. With red varieties, poor cap management can mask other treatment effects in a trial. Researchers at the AWRI have developed and demonstrated a simple red wine fermentation method that can be carried out on a scale ranging from approximately 100 grams to one kilogram of grapes. The method involves the use of commercial coffee plungers to perform submerged cap ferments. Cap management is simple and results in good extraction with reproducible fermentation conditions.

The method can be used to rapidly assess differences between parcels of fruit and the effects of winemaking additives and methodology, before scaling-up to a production level (Dambergs and Sparrow 2011). Submerged caps are also the most efficient way to manage small-scale ferments, according to AWRI research. Small-scale ferments can be performed in the aptly named Bodum® 'French Press' coffee plunger, made of Pyrex and stainless steel. This has led to 'Bodum tank farms', which are easy to use, on a small-scale, for replicated ferments (Figure 4).

Using these 'farms', the progress of ferments can be monitored for carbon dioxide loss efficiently and non-invasively by weighing the fermenters with a top-pan balance. This monitoring can also be automated if the balance has a computer interface. During fermentation, the cap disperses throughout the whole space below the plunger, allowing the efficient extraction of must components. Wine is forced up through the plunger screen by gas pressure, which sets up a gentle percolating action.

Complete mixing can be ensured by lifting the plunger daily to allow the wine and skins to mix. When fermentation is complete, the plunger is pushed down and the wine on top is decanted. Replicate control ferments in the 'farm' show little variation (a coefficient of variation in the order of 2% for tannin). This repeatability allows small treatment differences to be observed.

Figure 4. Small-lot, submerged cap ferments using 'French press' coffee plungers.

MODIFYING 'TERROIR'

Researchers at the AWRI trialled various maceration treatments to assess the effect on phenolic compounds, as drivers of Pinot Noir quality and colour.

The AWRI analysed 1kg replicated, submerged cap ferments using the same batch of fruit. To examine the effects of maceration methods on wine outcomes, the following treatments were applied to different ferments in the trial:

- control ferment using crushed fruit with stems removed; no other treatment
- cold maceration for four days at 4°C
- extended post-ferment maceration for 45 days
- 20% of juice run-off before fermentation
- 20% of juice run-off, then returned in two stages near the end of fermentation
- stems added back (in a quantity of 30g/kg)
- oak powder added (in a quantity of 2.5g/kg).

All musts had 50mg/kg of SO_2 added. They were also inoculated with the wine yeast RC212, and 200mg/kg of diammonium phosphate (DAP) was added after fermentation had started. They were then incubated at 28°C. Fermenters were 'plunged' when dry, racked to bottles and incubated at 28°C for a further 24 hours before cold settling (4°C). Wines were racked twice and 60mg/L of SO_2 was added at the final racking.

The resulting wines were analysed using a spectral tannin method (Dambergs *et al.* 2012) and a modified 'Somers' method (Mercurio *et al.* 2007).

INTERPRETING THE RESULTS

Tannin concentrations (both total and pigmented) were dramatically higher in the extended maceration wines (Figure 5).

Wines with stems added were also high in tannin, but not pigmented tannin. The combined analyses for each sample can be better understood by referring to the principal component analysis (PCA) plot in Figure 6. PCA is a data reduction method that highlights relationships among samples. In this case, analyses for tannin, total phenolics, total pigment, total anthocyanin, colour density and hue were used to calculate two principal component scores that best describe the differences among the samples, and when plotted against each other, show clustering related to wine treatment.

The extended maceration wines form a distinct cluster in Figure 6, driven by the first principal component (PC1). These wines were high in tannin, pigmented tannin and hue, but lower in colour density, anthocyanins, total pigment and total phenolics. This reflects reactivity (namely, polymerisation) between anthocyanin and tannin to produce the more 'garnet' hue of an aged wine.

The cluster is also a good example of a disconnection between total phenolics and tannin. Phenolics and tannin sometimes correlate strongly, but in this situation where

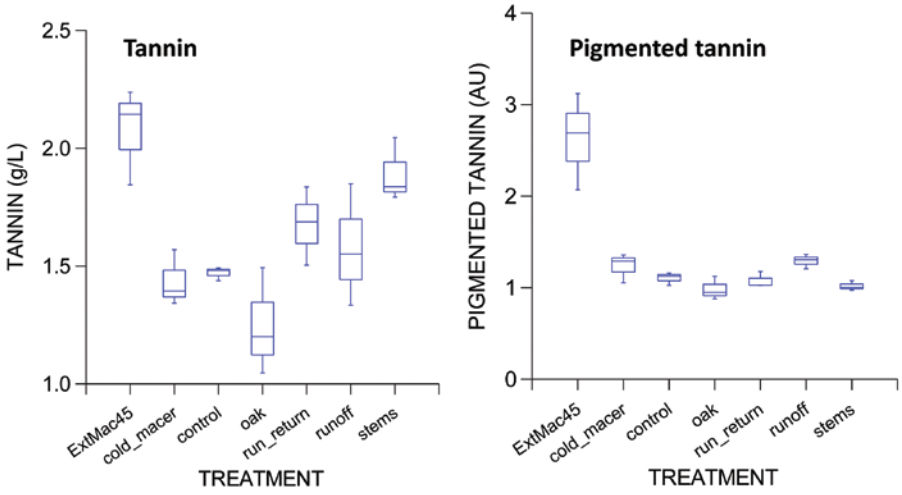

Figure 5. Total tannin and pigmented tannin for extended maceration (ExtMac45), cold maceration, control, oak addition, juice run-off and return, juice run-off (without return) and stem additions to Pinot Noir ferments.

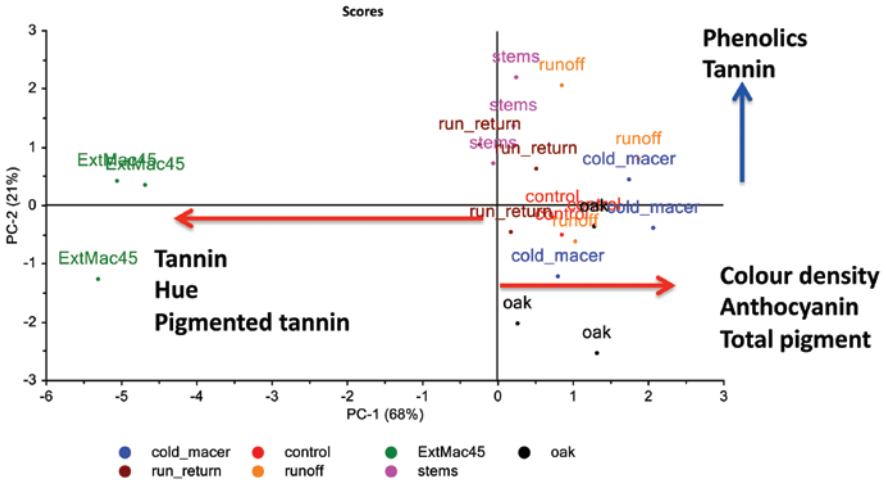

Figure 6. Scores plot for principal component analysis (PCA) performed using data for tannin, pigmented tannin, total phenolics, total pigment, anthocyanin, colour density and hue analysed on Pinot Noir wines made with the following treatments: extended maceration (ExtMac45), cold maceration, control, oak addition, juice run off and return, juice run off (without return) and stem additions. Red arrows indicate strong loadings for PC1, blue arrow indicates strong loadings for PC2.

anthocyanin levels (which also contribute to total phenolics) are distinctly different, phenolics do not correlate with tannin. Note, also, that part of the reason for the high degree of pigmented tannin formation in the extended maceration wines may be that they were without SO_2 while on skins. Other wines had SO_2 added earlier during run-off and when racked.

The second principal component (PC2) is mainly influenced by tannin and total phenolics. The wines with the highest concentrations were the run-off and run-off/return wines, and those with added stems. Oaked wines had the lowest concentrations of tannin and total phenolics.

It seems logical that adding stems should increase tannin levels, along with juice run-off. However, adding juice back at the end of ferment also resulted in higher tannin than the control wines. Each of the treatments mentioned above had the same skin contact time, and when juice was returned the sugar was consumed within 24 hours at each step. A possible explanation – when juice was returned – may be the longer period of yeast activity, which then enhanced tannin extraction and/or stabilisation.

Another explanation may be that stationary-phase yeast, at the end of ferment, may absorb more tannin than active yeast. If juice run-off, or bleeding, is referred to as 'saignée', returning this juice could be described as 'transfusion'. This is a simple procedure that can have desirable effects in terms of tannin profiles. An added benefit is that it does not have the same impact on cost, due to volume reduction of a premium product, as is the case with saignée.

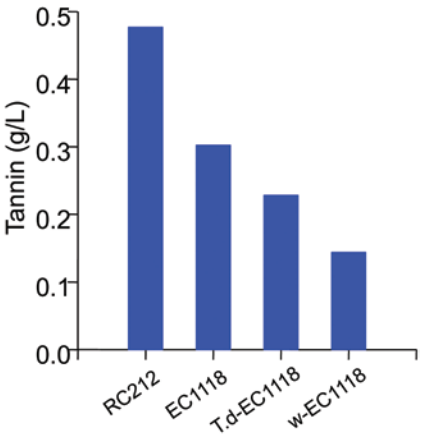

Figure 7. Tannin concentrations in Pinot Noir wines fermented with RC212, EC1118, *Torulaspora delbruekii* followed by EC1118 (T.d-EC11188) and wild ferment followed by EC1118 (w-EC1118).

Another unusual observation was that the addition of oak powder during fermentation appeared to cause a drop in tannin. This may be related to a tannin binding-effect of oak, which may become predominant when there is a high oak-particle surface-area-to-volume-ratio; a possible particle size effect requires further investigation. Oak barrels promote pigment stabilisation through slow oxygen uptake, but putting oak in wine (as opposed to wine in oak) is a different scenario.

Another important factor may be the choice of yeast strain. New World Pinot Noir producers appear to favour the Burgundy selection, RC212 (Haeger 2008). Figure 7 shows that RC212 resulted in significantly higher wine tannin than a commonly-used control strain, EC1118.

Wild ferments are also being used by an increasing number of Pinot Noir producers to create complexity and to express 'microbiological terroir'. Under controlled conditions, wild ferments finished with EC1118 showed lower tannin concentrations than RC212 and EC1118 mediated ferments. Similarly, an attempt to mimic wild ferments in a controlled way, by fermenting with the non-*Saccharomyces* strain *Torulaspora delbruekii* and finishing with EC1118, also resulted in lower tannin concentrations than RC212.

CONCLUSIONS

Pinot Noir grapes can have unusual phenolic profiles.

It is possible, however, to modulate these phenolic profiles and improve overall wine quality by applying various treatments during the winemaking process. Taking advantage of alternative tannin sources is one approach – for example, using stalks, as described here. Making simple modifications to the winemaking process or choosing the right yeast strain can also have a direct effect. Tannin levels can be increased four times over by using one or more of these strategies.

While individual producers may wish to target their own, unique styles of wine, year-to-year consistency of those styles can be achieved through carefully chosen maceration methods, combined with the appropriate measurement of grape and wine phenolic profiles.

This kind of analysis, together with intervention in the winemaking process, can provide a mechanism to compensate for the seasonal variations often seen in cool climate wines.

NOTE

Pinot Noir is the predominant variety for red wine production in Tasmania, and its production has been the focus of research at the first external node of the AWRI, based within the Tasmanian Institute of Agriculture (TIA). The work described here was recently reported at the International Cool Climate Wine Symposium held in Hobart, hosted by AWRI, TIA and Wine Tasmania. ▸

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Interpretation of tannin and modified Somers analysis

Total phenolics
- anything that absorbs UV at 280nm
- all forms of tannin, anthocyanins, phenolic acids, flavonols etc.

Tannin
- total tannin i.e., pigmented and non-pigmented
- increases slowly while wine is on skins (extraction needs alcohol and heat)
- skin tannin is more readily extracted than seed tannin
- decreases slightly with ageing.

Total pigment
- free anthocyanin and pigmented tannin
- increases while wine is on skins then decreases gradually with age.

Free anthocyanin
- increases quickly while on skins (freely soluble)
- decreases quickly off skins (after five years majority consumed).

Pigmented tannin - 'pigmented polymers', 'non-bleachable pigment'
- formation starts during fermentation
- gradual increase after wines taken off skins and during maturation
- formation promoted by yeast metabolites
- formation promoted by micro-oxidation and barrel maturation.

Colour density
- intensity of visual colour
- decreases slightly with ageing
- modified Somers method corrects for pH, alcohol, SO_2 and co-pigmentation effects.

Hue
- increases with age
- high hue = red/garnet/brown shades
- low hue = purple shades.