Murky winemaking: How juice solids affect the macromolecular composition and mouthfeel of white wine

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How do 'solidsy ferments' and the clarification method used to achieve a certain solids level affect the composition and resultant mouthfeel of white wine?

INTRODUCTION

Fermenting juices that contain some grape solids is an increasingly popular option among producers of fuller-bodied, complex white wine styles. Contemporary interpretations of wine complexity and overall quality generally include the contribution of mouthfeel or texture, which covers the stylistic attributes of viscosity, oiliness, creaminess, and astringency or dryness, and those that negatively affect quality perception such as metallic mouthfeel and hotness.

The probable influencers of white wine mouthfeel include phenolics, polysaccharides, organic acids, glycerol and ethanol. Their effects on mouthfeel both individually and through interaction have been investigated at the AWRI either by assessing the change in mouthfeel after adding them to either model or real wine, or indirectly by correlating mouthfeel attributes with wine composition. Current findings concerning the contributions of phenolics, polysaccharides, organic acids, glycerol and ethanol to white wine mouthfeel are summarised in Figure 1.

Solids consist of the insoluble grape debris, mostly pulp and skin fragments, that remain in the juice after grape crushing and draining (Karagiannis and Lanaridis 2002). They comprise 75% polysaccharides by weight (Alexandre *et al.* 1994) and also contain phenolic compounds making them a potential source of both polysaccharides and phenolics in white wine.

Polysaccharides are 'protective colloids' as they are capable of inhibiting tartrate precipitation and protein instability. The presence of polysaccharides in wine, therefore, has the potential to increase winery efficiency by lowering energy demands and reducing bentonite use. In contrast to the extent of reports on their technological benefits, the effect of polysaccharides on white wine mouthfeel are less understood, but their ability to cross-link to form macromolecular structures suggests that they could increase wine viscosity and, therefore, fullness. Grape solids also contain essential sterols needed for the production of glycerol by yeast, and phenolic compounds which could potentially be released into wine during settling and fermentation.

This article presents the results of two studies. The first compared both the non-volatile composition and the mouthfeel of wines made from high and low solids juices obtained using different methods of juice extraction. The second study compared the effects of juice solids level and the method of clarification on the non-volatile composition of wines using a single juice source.

SAMPLE PREPARATION AND ANALYSIS

Study 1

Chardonnay and Viognier grapes from the Barossa Valley and Riesling grapes from the Eden Valley were harvested by hand. Low solids juices were produced using three juice extraction methods:

1. whole bunch pressing
2. draining off free run juice before adding pectolytic enzymes and cold settling at 4°C for 36 hours before racking
3. from a hard (2 bar) pressing fraction also cold settled using pectolytic enzymes.

An equivalent high solids juice was collected after a coarse racking off gross lees (without enzyme addition). The juices were fermented in duplicate 20L lots using standard winemaking protocols. Polysaccharides were precipitated from the different wines using ethanol and then treated to remove low molecular weight compounds. The amount of polysaccharides present was measured by peak areas obtained from size exclusion chromatography. Total phenolics were determined by UV-Vis spectroscopy, and specific phenolics were measured by reverse phase C18 chromatography. The textural characteristics of the wines were profiled by 10 trained tasters experienced in rating the mouthfeel attributes of white wines. Full details of winemaking, analytical methods and sensory analysis can be found online (Smith and Waters 2012).

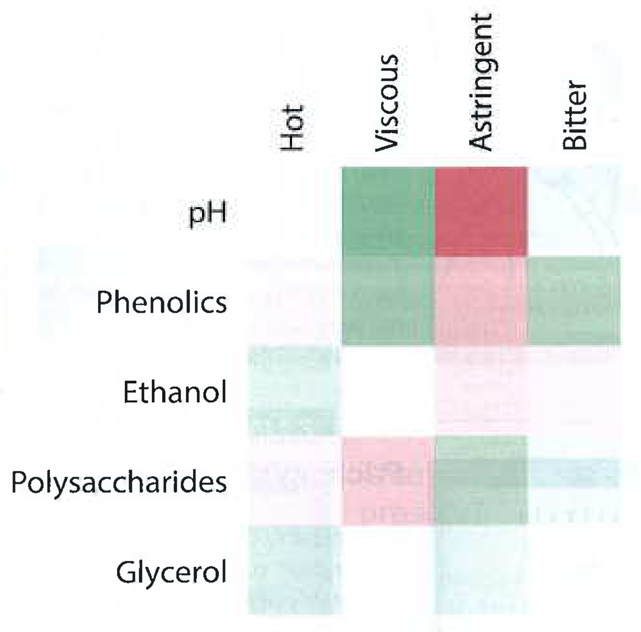

Figure 1. Summary of mouthfeel effects of white wine components. Green indicates a positive relationship, red indicates a negative relationship. Depth of colour indicates the strength of effect. For example, the dark red box indicates that pH has a strong negative relationship with astringency, meaning lower pH wines are more astringent (Gawel *et al.* 2008, 2013, 2014).

Study 2

This study compared the effects of different levels of solids (100ntu, 500ntu and full solids) from a single Chardonnay juice, obtained by three clarification methods (pectolytic enzyme [0.4g/L], bentonite [1g/L] and no clarifying agent). Controls for each solids level/clarification method combination were obtained by centrifuging to less than 40ntu. Ferments (*Saccharomyces cerevisiae*, strain EC1118, 18°C) were conducted in triplicate using 500mL fermenters simulating tank-like dimensions. Total polysaccharides from triplicate extractions were measured using the classic phenol-sulfuric method with mannose as the standard. Total phenolics were measured spectroscopically at 280nm, and glycerol concentration by HPLC.

WHAT WERE THE RESULTS?

Polysaccharides

Figure 2 shows the relative polysaccharide content of wines made from three varieties using 'low solids' ferments from juices produced by whole bunch pressing, free run and hard pressings followed by enzyme cold settling, compared with equivalent high solids ferments. High solids ferments produced wines with significantly more polysaccharides than low solids ferments regardless of juice extraction method and variety/juice source.

Results from the small-scale ferments of the same juice but using different solids levels clarified using enzymes, bentonite and without a clarifying agent (study 2) were consistent with those from the larger-scale winemaking trial. Higher solids content in juices resulted in higher wine polysaccharide concentrations (Figure 3). Clarification method also affected polysaccharide levels, with wines made from juice settled on bentonite being less rich in polysaccharides than wines made from juice that had been either enzyme-treated or simply gravity settled, with no clarifying agent. ▸

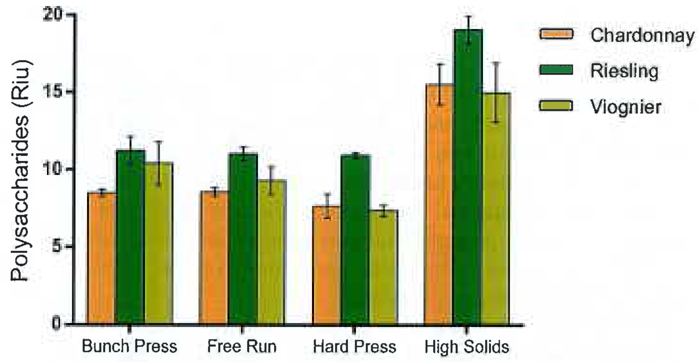

Figure 2. Polysaccharide content of wines made from high solids juice, and low solids juices produced using different extraction methods (study 1).

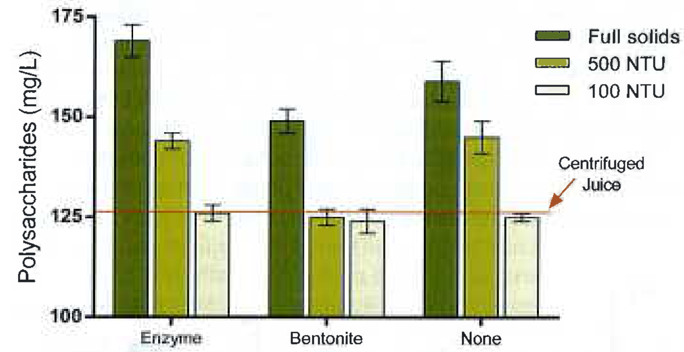

Figure 3. Effect of juice solids level and method of clarification on total polysaccharide concentration. Line represents the average level of polysaccharides from centrifuged juices from all three treatments (study 2).

Phenolics

The effect of juice solids on wine phenolics is less clear than that on polysaccharides. The results of study 1 show that the total phenolics of the solids wines did not differ from the free run wines (its logical control) in two of the three juice sources, while in the case of the Chardonnay juice, higher solids resulted in higher phenolic wines (Figure 4). As expected, the total phenolics in wines from bunch-pressed fruit was substantially lower and the hard pressing juices higher (albeit only marginally so) compared with the free run and solids wines.

The phenolics in white wine consist of a diverse group of complex monomeric compounds (benzoic acids, hydroxycinnamic acids, flavanols, flavanonols, flavanones, flavonols and flavononols), with most being in esterified forms with tartaric acid or ethanol, glycosylated by various sugars, or conjugated with amino acids. A more detailed HPLC analysis of individual phenolic compounds showed that the high solids wines had a different phenolic profile from the whole bunch pressed, free run and pressings wines made from lower solids. The high solids wines were richer in flavanols, flavanonols and caftaric acid, but less abundant in free hydroxycinnamic acids (data not shown).

Study 2 was designed to assess the influence of both the amount of juice solids and the method of clarification on wine phenolics. Control juices (i.e., effectively solid-free juices produced by centrifugation) were inoculated at the same time as juices containing solids (Figure 5). The total phenolic level of wine from full solids juice (no clarifying agent) was not different from those fermented on effectively zero solids (Figure 5). Earlier studies, in which high and low solids juices were simultaneously taken from the bottom and top of settling tanks and fermented, reached the same conclusion - higher solids ferments did not result in higher wine phenolics (Singleton *et al.* 1975, Ollivier *et al.* 1987).

While the act of adding a clarifying agent and then simultaneously inoculating the ferment is not a typical commercial practice (full bentonite and enzyme treatments, Figure 5), these combinations were included as controls. Their inclusion provided interesting insight into the extraction of phenolics into wine from grape solids. The total phenolics from full solids ferments were lower with bentonite added, but higher with enzymes added compared with wines from the same juice with solids removed just prior to fermentation (Figure 5). The authors speculate that the low density grape particles may have better mixed the bentonite into the ferment via the action of carbon dioxide, resulting in a loss of phenolics by absorption, and that the pectolytic enzymes aided the breakdown of the grape particle cell walls releasing phenolics. However, both of these explanations require further testing.

Notably, the full and low (100ntu) solids ferments resulted in wines with higher phenolics than the 'medium' (500ntu) solids wines regardless of the clarification method. The observation that total phenolic content is not linearly related to juice solid content suggests a complex mechanism of gains and losses by extraction and fining-like mechanisms by grape solids.

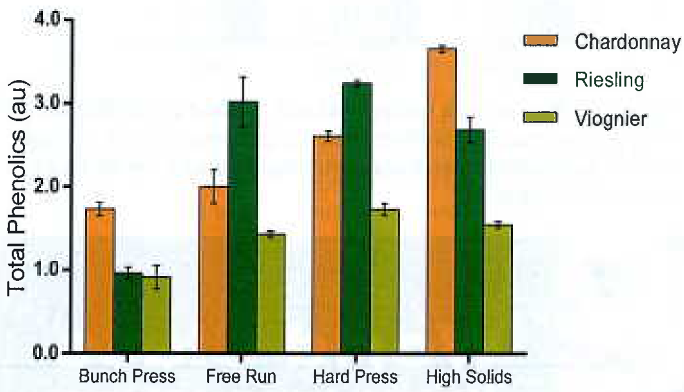

Figure 4. Total phenolic content of wines made from high solids juice, and low solids juices produced using different extraction methods (study 1).

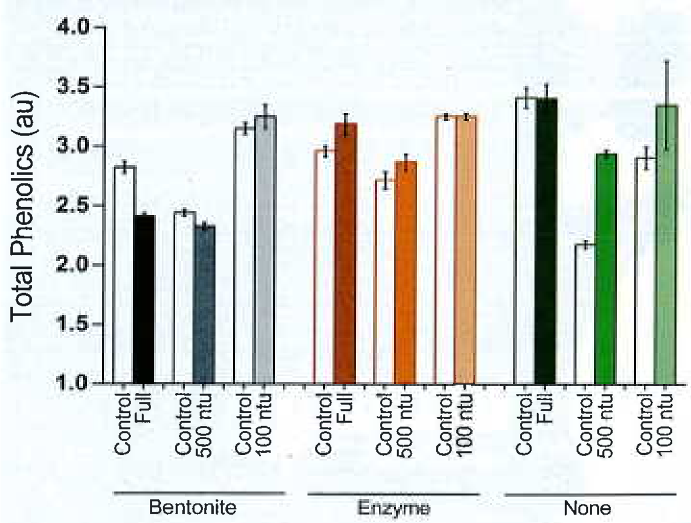

Figure 5. Effect of juice solid level and method of clarification on total phenolics. 'Control' represents wines made from juices settled to the corresponding ntu in the manner stated (bentonite, enzyme, no clarifying agent) but then clarified to <40ntu by centrifugation.

Glycerol

Fermenting on full solids resulted in wines with around 1g/L higher glycerol concentrations than the lower solids wines, regardless of the method of clarification (Study 2: Figure 6). Notably though, the moderately high juice solids level (500ntu) did not increase wine glycerol concentration when compared with wines made from centrifuged juices. While higher wine glycerol levels from higher juice solids is expected due to the greater nutritional status of the must, the results suggest that high solids levels are necessary to effect an increase in wine glycerol levels. However, given that glycerol production by yeast depends on a number of factors including strain and fermentation temperature, further work is required to establish the applicability of these results. While a 1g/L increase in glycerol can potentially increase perceived sweetness (as glycerol is as sweet as glucose in the concentration range found in wine), it is unlikely to produce an increase in the perception of viscosity (Gawel and Waters 2008).

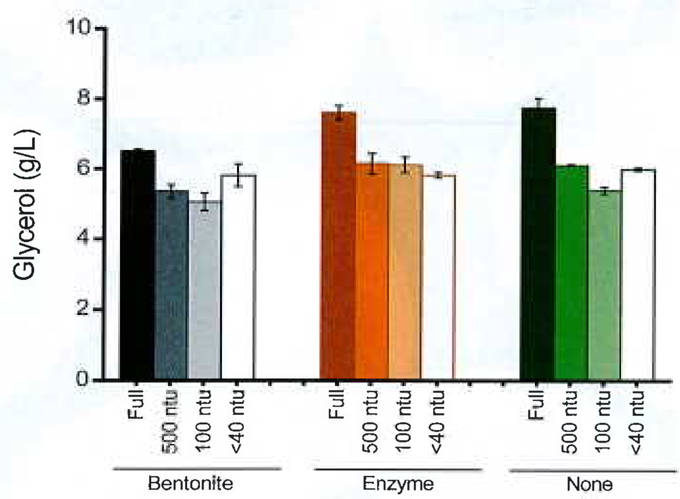

Figure 6. Effect of juice solid level and method of clarification on glycerol production.

The effect of solids fermentations on white wine mouthfeel

Forty years ago Singleton and co-workers measured the effect of fermenting on solids on the total phenolics and resulting astringency and bitterness of white wine (Singleton *et al.* 1975). They found that solids content did not affect total phenolic levels, but the high solids wines were perceived to be more astringent (equivalent to fermenting for two days on skins) and slightly more bitter. In the current work (Study 1), it was also found that the high solids free run juices produced wines with similar total phenolics, but the wines had a more 'oily' and 'metallic' feel (Figure 7). Using contemporary analytical methods we found that the high solids wines contained more flavanols (e.g. epicatechin) and flavanonols (e.g. dihydroquercetin) which are phenolic classes that have been associated with bitterness in both wine and other beverages such as tea. Juice solids content did not significantly affect wine astringency. All wines were pH adjusted before tasting to avoid confusion between the drying sensation from wine acidity and any possible phenolic-derived astringency which may explain the differences between studies with respect to this attribute.

The greater perceived 'oiliness' of solids wines could be attributed to both phenolics and polysaccharides. Recently, work has shown that phenolic compounds in white wine can contribute to oily texture (Gawel *et al.* 2014). In that study, the flavonol glycoside, quercetin glucuronide, correlated most strongly with oily mouthfeel. Perceived viscosity and oily mouthfeel were moderately correlated suggesting some overlap in their interpretation by tasters. Recent work at the AWRI indicates that differences in polysaccharides at wine realistic concentration ranges has a positive influence on white wine viscosity, and others have demonstrated a link between polysaccharide level and white wine 'fullness' (Okuda *et al.* 2007). Therefore, a link between greater oiliness in the higher solids wines and their polysaccharide content cannot be ruled out.

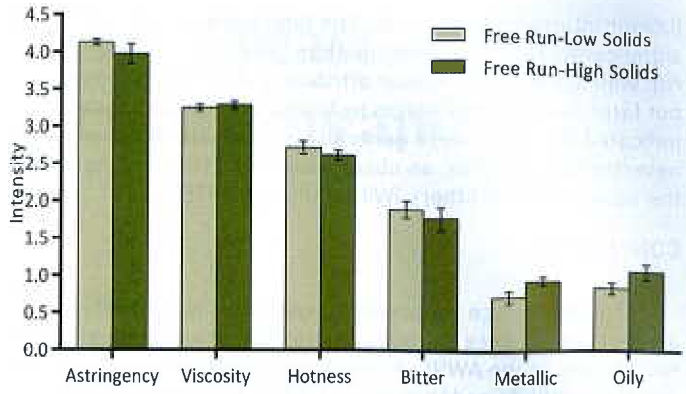

Figure 7. Mean intensity rating of mouthfeel characters of wines made from low and high solids free run juice. Average of three varietal juice sources.

The impact of juice solids on the composition of volatile compounds that affect the aroma and flavour profiles of white wines is well known - higher juice solids give rise to wines with lower concentrations of esters and greater concentrations of higher alcohols (Daragiannis and Lanaridis 2002), which logically should manifest in wines with less distinct varietal characters. While study 1 reported here focussed on mouthfeel effects, tasters were also asked to formally rate the overall flavour intensity of the wines. The high solids wines were significantly more flavoursome than the low solids free run wines. Individual flavour attributes were not assessed, but later informal evaluation by highly experienced tasters indicated the wines were generally less varietal but were nevertheless complex, an observation which is consistent with the assessment of others (Williams *et al.* 1978).

CONCLUSION

Fermenting juice containing grape solids is often done in an effort to enhance the body and texture of white wine. These two studies at the AWRI showed how the levels of juice clarity and the method used to achieve it affect the phenolic and polysaccharide profile and resultant texture of white wine. Key results were:

- higher solids increased wine polysaccharides and glycerol levels
- solids content modified wine phenolic profile but not total phenolics
- juice solids level affected the mouthfeel of white wine.

ACKNOWLEDGEMENTS

This work was supported by Australia's grapegrowers and winemakers through their investment body Wine Australia, with matching funds from the Australian Government. The authors also thank Pernod Ricard Winemakers for its support of the AWRI's research on white wine phenolics. The AWRI is a member of the Wine Innovation Cluster, in Adelaide.

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