Nature of Wine Lees

BY **Bruce Zoecklein**

Traditionally, only some white wines and sparkling wines were left in contact with yeast lees post-fermentation. This practice is now used frequently in many viticultural regions around the world today for both red and white wines.[20]

Lees are composed mainly of yeasts, bacteria, tartaric acid, polysaccharides, and protein-tannin complexes. Red wine lees have a relatively high concentration of protein and tannin. The composition is variable depending upon several factors including: fruit quality (incidence and type of rot), cultivar, processing techniques, timing of racking, malolactic fermentation (MLF) and timing and use of enzymes etc.

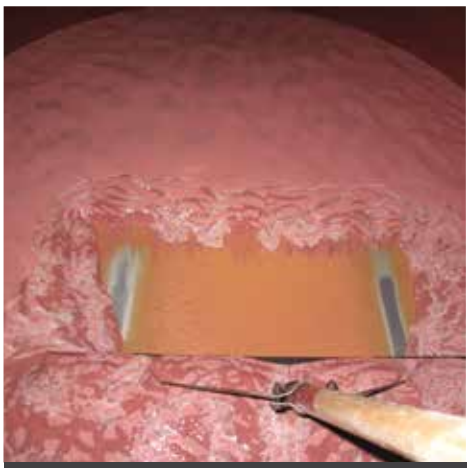
Lees contribute to colloidal macromolecules in wine which are derived from three general sources, polysaccharides, glucans and mannoproteins.[10] Mannoproteins are proteins with a high carbohydrate content including mannose sugars, hence the term.

During ageing *sur lie*, a breakdown of yeast cellular membrane components can occur, releasing intracellular constituents. These macromolecules can positively influence structural integration, phenols (including tannins), body, aroma, oxygen buffering and wine stability. Some macromolecules provide a sense of sweetness as a result of bridging the sensations among the phenolic elements, acidity and alcohol, aiding in wine harmony and integration.

Mannoproteins

Mannoproteins in yeast cell walls are bound to glucans (glucose polymers), and exist in wines as polysaccharides and proteins.[10] They are released from cell walls by the action of an enzyme, β-1,3-glucanase. β-1,3-glucanase is active during yeast growth and during ageing in the presence of non-multiplying yeast cells. Stirring increases the concentration.[9] Lees mannoproteins can impact the following:

- integration of mouthfeel elements by interaction between structural/textural elements,[3,10]
- reduction in the perception of astringency and bitterness,[5,11,19,23]
- increase wine body,[3]
- encourage growth of microorganisms,[13]
- impact bitartrate instability,[14,16,17,25]
- impact protein stability,[26]
- interact with wine aroma components.[15]



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Red wine lees remaining after Pinot Noir wine racked out of the fermentor.

Lees management considerations

Several methods of increasing mannoprotein levels in wine have been suggested,[6,10] including:

- must turbidity,
- selection and use of yeast which produce high levels of mannoproteins during alcoholic fermentation,
- yeast which autolyze rapidly upon completion of alcoholic fermentation,
- addition of β-1,3-glucanase to wines stored on lees,
- addition of exogenous mannoproteins (proprietary products), lysated (broken) lees.

The amount of mannoprotein released during yeast fermentation is dependent on several factors, including yeast strain. Large differences are noted among yeasts in the amount of mannoproteins produced during fermentation and released during autolysis. Generally, the more turbid the must, the lower the mannoprotein concentration in the fermented wine.[12]

Mannoproteins released during yeast fermentation are more reactive than those released during the yeast autolysis process in modifying astringency. This helps provide additional justification to measure the non-soluble solids of juice (NTUs) pre-fermentation.

In Burgundy and other regions, red wines are sometimes aged on their yeast lees in conjunction with addition of exogenous β-1,3-glucanase enzyme. This procedure is an attempt to release mannoproteins, which winemakers believe may enhance the suppleness of a wine, while reducing perceived astringency.

Wines aged on lees with no fining contain mannoproteins, while wines fined prior to ageing may have a large percentage of mannoproteins removed. Periodic stirring *sur lie* increases the mannoprotein concentration and increases the native β-1,3-glucanase activity. Generally, yeast autolysis is relatively slow (in the absence of glucanase enzyme addition) and may require months or years to occur, possibly impacting the mannoprotein concentration.[2]

Table I shows some important practical winemaking considerations regarding lees management.

Table I. Lees management considerations

- Must clarification, non-soluble solids level (NTU),
- Primary or heavy compared to secondary lees or light lees,
- Volume of lees,
- Stirring compared to non-stirring, method, frequency and duration,
- Type and size of vessel,
- Duration of lees contact,
- MLF, timing of MLF,
- Timing and type of racking (protective or aerative),
- SO_2 timing and level of addition,
- Frequency of barrel topping,
- Use of lysated compared to fresh lees, lees products.

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Photo caption

Juice clarification and non-soluble solids

Extensive crushing of red grapes can result in a high level of non-soluble solids mainly in the form of phenol compounds which remain in the fermenter. White juice is generally racked prior to fermentation to eliminate precipitated juice lees consisting mainly of grape particulate, tartaric acid, polysaccharides and protein tannin complexes.

During yeast fermentation, the level of macromolecules continually rises, peaking at approximately 270 mg/L.M. Guilloux-Benatier *et al* found a relationship between the degree of must clarification and the amount of yeast macromolecules recovered in the wine.[10] When the must was not clarified pre-fermentation, there was limited production of yeast macromolecules.[12]

However, mild must clarification, such as cooling for 12 hours, increased the amount of yeast-produced macromolecule production by an average of 76 mg/L, and heavier must clarification, such as bentonite fining, increased the production by about 164 mg/L. S. Boivin *et al* found that the amount of macromolecules produced varied between 230 and 630 mg/L, and they contain 20 – 30% glucose and 70 – 80% mannose.[1]

Heavy and light lees

Winemakers differentiate between light or secondary lees and heavy or primary lees. Heavy or primary lees can be defined as those that precipitate within 24 hours immediately post-fermentation,[4] and are composed of large particles (greater than 100 micrometers) consisting of grape particulates, agglomerates of tartrate crystals, yeasts, bacteria and protein-polysaccharide-tannin complexes. Light or secondary lees can be defined as those that precipitate from the wine more than 24 hours post-fermentation.[3] These are composed mainly of small particles (1 – 25 micrometers) including yeasts, bacteria, tartaric acid, protein-tannin complexes and some polysaccharides.

There is little value in storing red or white wines on primary lees. Such storage can result in off-aroma and flavors, and depletion of SO_2. Light lees storage, however, can have a significant advantage in structural balance, complexity and stability.

Bâtonnage

During lees contact, wine composition changes as the yeast commence enzymatic hydrolysis of their cellular contents. An important feature is the process of proteolysis, whereby proteins are hydrolyzed to amino acids and peptides. These compounds result in an increase in the available nitrogen content of a wine.[13]

Amino acids can act as aroma/flavor precursors and possibly enhance wine complexity. They may also help support the growth of microorganisms in wine.[13]

Lees stirring and duration

Lees stirring and frequency are important, both as practical and stylistic considerations. M. Feuillat *et al* demonstrated that periodic stirring of lees increases the mannoprotein level and amount of yeast-derived amino acids.[9] Red and white wines aged on their lees in barrel exhibit an increase in macromolecules.

Stirring is a stylistic tool that generates an oxidative process that can change the sensory balance between fruit, yeast and wood by enhancing yeast components, reducing the fruit and, to a lesser degree the perception of wood-derived aroma/flavor.

Stirring may have the effect of enhancing secondary chemical reactions, possibly as the result of oxygen pick-up. W. Stuckey *et al* demonstrated increases in sensory scores in Chardonnay wines stored for five months without stirring. Non-stirred wines had greater fruit intensity.[24]

Malolactic fermentation and lees

MLF reduces the harshness of new oak and aids in development of complexity. Traditionally, stirring is continued until MLF is complete. After that, lees are more dense, which aids in clarification. This regime may be changing with the increase in co-fermentation of yeast and lactic acid bacteria. As *Lactobacillus* spp. have proteolytic activity, there may be an increase in the mannoprotein components, polysaccharides and proteins in their presence.[20]

Sensory impacts

During *élevage* what is sought is slow, managed and controlled oxygenation. Some lees contact may allow for oxygenation, while limiting oxidation.

In Burgundy red wines have been traditionally racked off the lees in March, usually when MLF is completed. Frequently this is an aerobic racking, then back into oak on light lees, followed by an SO_2 addition. Light lees are said to help "nourish" a wine. A subsequent racking often occurs in early July, and is in the absence of air.

SO_2 additions

Timing of SO_2 additions, and the quantity of SO_2 are important stylistic considerations. Early addition increases the number of components that bind to subsequent additions of SO_2. The addition of too much SO_2 counters the wood flavors and limits oxidation reactions.

D. Delteil compared red wines barrel-stored on light lees for nine months and those racked several times to eliminate lees prior to barreling and stored for the same time period.[4]

Wines stored *sur lie* had a much lower perception of astringency and a greater integration of the phenolic elements. The *sur lie* wines also had a lower perception of oak character, resulting in a higher perception of fruit characters.

Lees components such as polysaccharides and proteins are known to react with phenolic compounds, thus reducing astringency. Such reduction can cause an increase in the wine's volume or body.

Lees contact is particularly effective at modifying wood tannin astringency by binding free ellagic tannins, thus lowering the proportion of active tannins. *Sur lie* storage can reduce the free ellagic acid by as much as 60%, while increasing the percentage of ellagic tannins bound by 24%.[18,22]

Addition products

Proprietary products or treatment of lees with β-glucanases may aid in the increase of mannoproteins and glucans in a wine. The mannoproteins in commercial addition products may be different than those produced by yeast. Unlike many commercial products, yeast-derived mannoproteins generally have a mannose/glucose ratio of 1 to 1 and a relatively high protein content. Thus, it is likely that yeast mannoproteins will react differently in wine than some commercial products.

Some winemakers age wines in the presence of lysated (broken) lees instead of fresh lees in order to reduce the time conserved on lees and to help avoid possible microbial and organoleptic risks.

O. Fernandez *et al* outlines the differences in wines produced with such treatments and fresh lees.[6] Addition of enzymes to wines in the presence of lees may increase the glucose concentration providing a carbon source for micoorganisms such as *Brettanomyces*.[13]

Summary impact of yeast lees:

Color and Mouthfeel — High lees concentration can reduce color, as a function of adsorption onto the yeast cell surface and possibly as a result of anthocyanin destabilization from β-glucosidase activity. Additionally, lees adsorb oxygen that

can limit the anthocyanin-tannin polymerization, impacting both color stability and resulting in an increase in dry tannin perception. Commercial mannoproteins may cause a greater color loss than yeast-derived mannoproteins.

Wine Aroma — Lees favor the synthesis of esters that can improve wine aromatics,[21] but also produce long chained alcohols and fatty acids, compounds that can detrimentally impact aroma.[7] Aroma stabilization is dependent upon the hydrophobicity (ability to repel water molecules) of aroma compounds.

The protein component of the mannoprotein fraction is important for overall aroma stabilization.[15] Such interactions can modify the volatility and aromatic intensity of wines.

When wine is aged on yeast lees with no fining, mannoproteins are present and fortify the existing aroma components. When wines are fined prior to *élevage*, mannoproteins can be removed and not be present to augment the existing aroma components.

Additionally, when wines are cross-flow filtered, eliminating a certain percentage of macromolecules, the loss of color intensity, aroma and flavor can occur.[8,21]

Yeast lees have been demonstrated to reduce the perception and concentration of 4-ethyl phenol and 4-ethyl guaiacol found in red wines as a function of Brett growth.[13] This effect is significantly impacted by autolysis state of the yeast lees, pH, temperature, ethanol content and other constitutes adsorbed by the lees.[20]

Oak Bouquet — Lees modify oaky aromas, due to their ability to bind with wood-derived compounds including vanillin, furfural and methyl-octalactones.

Oxidative Buffering Capacity — Both lees and tannins act as reducing agents. During *élevage*, lees release certain highly reductive substances that can limit wood-induced oxygenation. Wines have a higher oxidation-reduction potential in barrels than in tanks. Inside a barrel, the potential diminishes from the wine surface to the lees. Stirring helps to raise this potential.

This is a primary reason why wines stored in large volume tanks are often not stored on lees. Such storage can cause release of "reductive" or sulfur-containing compounds. If there is a desire to store dry white wines in tanks *sur lie*, it is recommended that the lees be stored in barrels for several months, then added back to the tank.[22]

Protein Stability — The greater the lees contact, the lower the need for bentonite for protein stability. It is not believed that lees hydrolyze grape proteins, or that proteins are adsorbed by yeast. Rather, lees ageing produces an additional mannoprotein, which adds stability. The production is increased with temperature, time and frequency of stirring.

Biological Stability — M. Guilloux-Benatier *et al* have studied the liberation of amino acids and glucose during *élevage* of red Burgundy wine on lees.[13] Their studies were done with and without the addition of exogenous β-1,3-glucanase preparations. Their most significant finding was an increase in glucose concentration, from 43 mg/L in the control wine, to 570 mg/L in wine stored on its lees, to 910 mg/L in wine stored on its lees with added β-1,3-glucanase. Thus, the growth of the spoilage yeast *Brettanomyces* in barreled wine may be stimulated by the availability of this carbon source.

Bitartrate Stability — Mannoproteins produced by yeast can act as crystal inhibitors. The longer the lees contact time, the greater is the likelihood of potassium bitartrate stability.

Removal of Mycotoxins — The volume of mycotoxins including Ochratoxin-A is less as a result of the use of lees which can act as a fining agent to both adsorb and, in some cases electrostatically-bind compounds and remove them from solution.

Reductive Strength — Longevity, or the ability to age, is an important quality attribute. The reductive strength of a wine is a measure of the uptake of oxygen. This is influenced by the phenol composition and lees, among other things.

The reaction of a young wine with oxygen can make that wine more resistant to later oxidation. This means that young wines can consume oxygen which increases the reductive strength by increasing resistance to later oxidation.

C. Smith noted that lees (and particularly suspended lees) in a young wine depletes the oxygen concentration.[24] As such they can impact the degree of oxidative phenol polymerization thus increasing astringency and possibly reductive strength.

Wine lees are an important tool for winemakers influencing mouthfeel, aroma, bouquet, oxidative, physical and microbiological stability. Additional research is needed to help clarify the influence of both yeast and bacterial lees on these and other wine features. PWV

This text was adapted from *Enology Notes* #162, available at: vtwines.info.

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