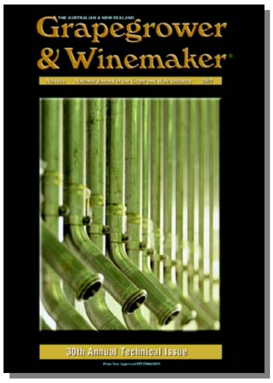

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Working with lees: key elements to wine maturing

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In this magazine, we already presented practical elements about good practices for mediterranean wines (*Australian Grapegrower & Winemaker, 28th and 29th Annual Technical Issues*). The two chronological steps were maceration management (Delteil, 2000) and malolactic fermentation (Delteil, 2001).
Next logical step is wine maturing.

For all markets segments, wine maturing is a key step.
Tank or barrel size, contact with oak or not, length of maturing, oxygen addition, wine movements and lees are the main practical parameters for mastering wine maturing.

Lees are a very trendy topic in all wine growing countries … but it seems that every winemaker has his own idea of what "lees" are.

This paper gives some elements in view of sharing the same language when speaking about the lees of Mediterranean and Rhone Valley wines.

1. Lees. What are they?

1.1 Definition of heavy lees

Heavy lees are the particles that are deposited within 24 hours when it comes to wine without pectin.

A wine without pectin (that is after pectin of the grape cell walls has been completely hydrolysed) is obtained by the efficient addition of enzyme to the grapes or juice or to the wine when it's draining or during pressing.
The size of heavy lees: from 100 microns to a couple of millimetres.

1.1.1 What are heavy lees in reds ?

Just after draining and pressing, the heavy lees are:

- Vegetal particles,
- Agglomerations of tartaric crystals + yeast + colouring matter and precipitated tannins
- Flakes derived from reactions between proteins, polysaccharides and tannins during maceration

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During maturing (at least 2 rackings already carried out) heavy lees are:

- Agglomerations of tartaric crystals + yeast + lactic bacteria + colouring matter and precipitated tannins.

These agglomerations were formed since the last racking, coming from reactions of crystallisation and polymerisation between elements that were soluble in wine.

1.1.2 What are heavy lees in whites and rosés ?

At the end of the alcoholic fermentation, the heavy lees are:

- Vegetal particles, if the juice clarification has left (voluntary or not) over 200 NTU in the juice before fermentation,
- Agglomerations of tartaric crystals + yeast + precipitated colloidal matter,
- Particles of eventual treatments during the fermentation: bentonite, casein, PVVPP, etc.

During maturing (following at least one racking) the heavy lees are:

- Agglomerations of tartaric crystals + yeast + precipitated colloidal matter: formed since the preceding racking

Note: Heavy lees continually form in wine. They are never really interesting because of their composition. They could either diffuse herbaceous characters (e.g. the vegetal particles) or they are not diffusing anything that is to say useless (e.g the polymerised agglomerated polyphenols). At each stage of maturing, it's therefore important to evaluate their presence and to regularly eliminate them. In view of their formation (see above), the frequency of their elimination diminishes with time. It's rarely coherent to programme a systematic elimination every three months.

1.2. Definition of light lees

Light lees are particles which remain suspended 24 hours after the wine has been moved

Movements include: draining, racking, stirring, pumping, etc.
The size of light lees: from a micron to a couple of dozen microns.

For reds, whites and rosés: the light lees are constituted of yeast (towards the end of alcoholic fermentation), then by yeast and lactic bacteria (towards the end of malo-lactic fermentation).

1.3. An operational definition of the lees

This definition of "heavy lees" and "light lees" is an operational definition to organise good winemaking practices.

Heavy and light lees are defined objectively: by their presence or not at the bottom of the vat or at the bottom of the barrel after an easy to measure delay of 24 hours.
Whether they rapidly deposit or not depends on their forming mechanism and therefore of their technological properties.
With such criteria, the lees are segmented not only according to their weight but also according to their oenological properties.

From these very practical elements, from information on their composition, from information about the risks they entail and exploitation opportunities, it's possible to build separating procedures or not, and procedures to work on the lees left in the wine.

Note : “Small lees” is a concept for someone with a microscope in hand. Usually not a winemaker at work !

1.4. A definition no longer valid in certain condition

In the case of wines that are still rich in pectin or wines with glucanes produced by *Botrytis cinerea*, this definition of light and heavy lees is no longer valid.
Indeed, these polysaccharides keep all of the particles in suspension.

The first action is therefore to carry out the hydrolysis of the pectin (classic pectolitic enzymes with a dose lasting 24 hours: in relation to the temperature and the quality of the pectin under hydrolysis) and the hydrolysis of the glucanes if the price is acceptable for the wine in question (glucanases enzymes).

2. The risks associated with the different lees

2.1 Risks associated with heavy lees

2.1.1 Vegetal particles and flakes:

- Risk of bad smells and grassy flavours.
- Combining SO2. Binding of the active and free SO2 on the particles. The bound SO2 on the vegetal particles is no longer present in the mass of wine to play anti-microbial and antioxidant roles.

2.1.2 Agglomerations of colouring matter, tannins, yeast, bacteria and tartar.

- Combining SO2 and protection of certain germs entraped in the agglomerates. There, these germs aren't affected by the addition of SO_2. This systematically concerns the yeast and the bacteria that ensured the alcoholic and malo-lactic fermentation. This isn't unimportant. Once a microbial population has filled its technological use, it shouldn't survive. The paper published in the 29th AG&W Annual Technical issue (Delteil, 2001) describes the risks provoked by malo-lactic bacteria once the malic acid has been fermented. In the case of a cellar lacking in hygiene, high risk germs are protected from the effects of SO_2: *Brettanomyces*, *Pediococcus*, *Lactobacillus*. The higher the pH, the higher the risks.

Alcoholic and malo-lactic fermentation rapidly completed + Rapidly eliminating heavy lees and rapidly sulphiting the wines: the best way of preventing *Brettanomyces*

- Release of bitter tasting substances in white or rosé wine.

- Preservation or even release of inhibiting substances for the yeast (in the case of a new inoculation for a struck fermentation) or for lactic bacteria. These substances are absorbed on the surface of dead yeast implicated in the agglomerations.

2.1.3 Bentonite, casein and PVPP particles in whites and rosés.
Release of undesirable substances absorbed in the fermenting juice. The ethanol in solution can release elements that were absorbed at the beginning of the alcoholic fermentation.

2.2. Risks associated with light lees

2.2.1 Yeast

2.2.1.1 Risk of the apparition of sulphur odours produced by the *Saccharomyces* yeast that carried out the alcoholic fermentation.

The risk with static light lees is they can create sulphur odours and metal tastes

When the cells of the yeast are stacked up and compacted, they release sulphur and bad smelling compounds.
This is the main factor of risk for sulphur odours during wine maturing.
The phenomenon is quasi identical when the *Saccharomyces* yeast are alive or dead. The risks are even higher when the juice has manifested sulphur odours during the alcoholic fermentation.
The quantity of light lees isn't a factor of risk by itself as far as they are properly stirred. Note : after stirring the lees or pumping, the more light lees the quicker there is a critical quantity stuck at the bottom of the vat.

The more light lees are left to benefit from certain advantages (see further on), the more it is necessary to regularly and completely stir them.
It is also necessary to more frequently eliminate heavy lees as they increasingly grow in quantity because of the great mass of reactive light lees.

2.2.2.2 Risk of sulphur odours and animal odours (sweat, rotten meat) produced by contaminating living yeast like *Brettanomyces sp.* and *Pichia sp*.
These yeast come from insufficiently disinfected harvesting and cellar equipment.

The causes of their survival are the following:
- active SO_2 is more rapidly combined by the great mass of *Saccharomyces* cells. This is amplified when the light lees are concentrated to work separately with them.
- dead cells of *Saccharomyces* release nutrients used by these germs of contamination.

The development and the survival of *Brettanomyces sp.* are favoured by the presence of a large quantity of light lees

At the beginning of maturing, a specific microbiologic analysis is recommended to find out if there's an initial risk of *Brettanomyces*.

2.2.2 Lactic bacteria

The risk of metabolism of the citric acid and of different amino acids with the production of acetic acids and biogenic amines.
Only the living lactic bacteria carry risks.
It's important to properly sulphite even when it comes to selected lactic bacteria that have been directly inoculated.

Add sulphite rapidly, just the right dose, spreading evenly to kill the bacteria that produced the MLF

3. Exploiting the possible advantages of different lees

3.1 The advantages associated with heavy lees

Quite simply there are none.
In the best of cases, they don't compromise working with light lees.

All of the interesting elements in the solid parts of the grape have been taken and put into the solution during the maceration and during the pressing, whatever the colour of the wine.

3.2 The advantages associated with working with light lees

There are between 30 and 100 grams of yeast per litre of wine at the end of alcoholic fermentation.
It's a very important source of polysaccharides (mannoproteins and non-filling glucanes) amino acids, nucleic acids and esters.
All these elements are well known for their strong flavours. This is illustrated by tasting a stock cube: it's essentially made of yeast.
Of course, in wine we aren't trying to reach such an extreme concentration in taste. It just confirms the fact that such a mass of yeast isn't neutral.

3.2.1 Polysaccharides.

They represent the outside envelope of the yeast cell: the wall.
There are differences between oenological yeast for the polysaccharide release. This is quite known since the early 90's (Delteil and Jarry, 1992).
Enzymes with a glucanase activity accelerate these phenomena.

The yeast polysaccharides play four main roles:

1. A direct sensorial effect on structure : roundness, volume, and coating. In the food industry, polysaccharides (of different origins) are added to numerous products (sweets, dairy desserts) to achieve this smoothness.

To liberate the yeast polysaccharides, time is essentially required along with regular movements

2. A physical effect of colloidal network which slows down or blocks the reactions of tartaric crystallisation. This is behind most of the tartaric stability of wines made with light lees.

3. A chemical effect associating tannins, pigments and volatile compounds. The polysaccharide network stabilises certain compounds by rendering them unavailable for reactions of polymerisation and depositing. This sort of reaction partly explains the great proteinic stability of whites and rosés that have been well made using light lees: the yeast polysaccharides prevent the coagulation of these grape proteins.

4. A sensorial effect of persistance in the aromatic sensations. The “length” on the palate of wines is essentially due to the late liberation on the palate of certain volatile compounds "included" in the polysaccharide network coming from the grapes and from the yeast.

3.2.2 Amino acids and nucleic acids.

The cell content of yeast is rich in amino acids and nucleic acids (ADN and ARN). These compounds are well known in the food industry as flavour enhancers (see stock cubes).
In wine, when naturally released at the right level, they participate in amplifying the intensity of taste sensations and complex aromas at the end of the palate.

When they die, yeast cells gradually distribute their contents into the wine

3.2.3 Esters.

They are liberated with the cell content of dead yeast.
It's especially the esters of fatty acids with sweet and spicy aromas (ethyl hexanoate, ethyl octanoate, etc.).
Their release also corresponds to the moment when the esters with a floral/chemical aroma under go hydrolysis (isoamyle acetate, hexyle acetate, etc.).
On a sensorial level, this results in grape aromas joined by sweet and spicy aromas from the dead yeast.

In the case of the oak ageing of white, rosé or red, all of the elements liberated by the use of light lees play an important role in integration of wine and wood

Note: when the amino acids, the nucleic acids and the interesting esters are liberated by dead yeast, there's at the same time the liberation of other inside cell compounds: bad smelling sulphur compounds.
Complete and regular agitation of light lees increases the liberation of interesting compounds and also avoids the concentration of sulphur compounds and their stabilising in a reductive zone at the bottom of the vat or barrel.
This takes on even more importance when separately working with concentrated light lees, in order to reintroduce them afterwards.

Dead yeast also result in the release of bad smelling sulphur compounds: regularly stir the light lees to minimise the risks

Conclusion

Taking into account all of these elements, a winemaking programme is elaborated in function of:

- objectives concerning the product and the profile of the wine at the end of fermentation,
- the cellar's technical means (vats, barrels, etc.) and human means (hygiene, stirring, etc.)
- mastering the risks associated with sulphiting, associated with heavy lees, associated with light lees,
- advantages associated with sulphiting and light lees.

There isn't a universal answer.
There are numerous possible options for all segments of the market as long as the technical aspects remain coherent, and as long as the work and follow up are precisely carried out, as well as the organisation of the work and hygiene.

An experimental illustration: working with lees in red wine
An experiment monitored by the ICV R & D department in 1995 and 1996

A Languedoc red Syrah wine (Shiraz) was separated into two homogenous batches during the running off after 3 weeks of traditional maceration. Fermentation was done with the yeast ICV D254. This is an important information: this yeast has demonstrated to be one of the higher parietal polysaccharide producer during fermentation (Rosi *et al*, 1998 ; *in* Revue Francaise d'Oenologie).

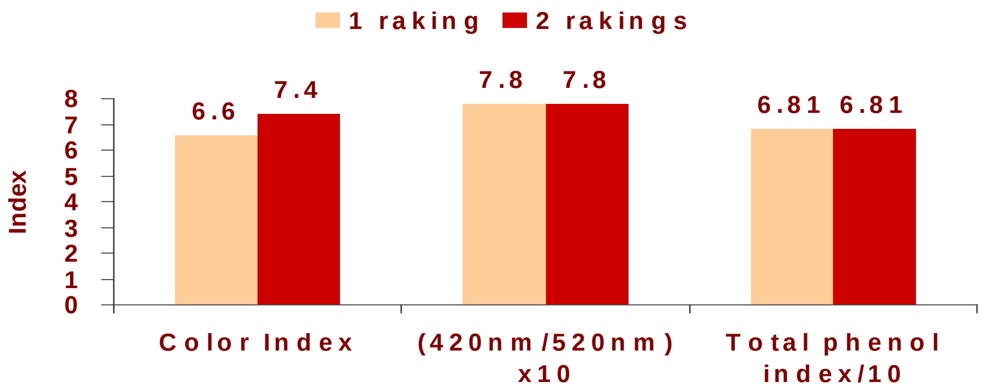
- The batch "1 racking" was racked after 24 hours, eliminating the heavy lees and put in new barrels, then immediately inoculated with selected lactic bacteria.
- The batch "2 rackings" was racked after 24 hours, eliminating the heavy lees. 48 hours afterwards, the wine was again racked and put into new barrels, then inoculated with lactic bacteria as with batch n°1.

The wines were all conserved at 20°C during the malo-lactic fermentation with a weekly stirring. Right after the malic acid was completely fermented, the wines were sulphited with 3 g/hl and immediately stirred.

During 2 months the wines were conserved at 15°C and stirred once a week. After this delay, the wines were racked 24 hours after stirring to eliminate heavy lees and immediately put back into barrels with all their light lees.
During the following 4 months, the wines were stirred every 15 days.
The wines were racked and bottled after this period. After 6 months the bottles were opened and the wines were analysed and tasted.

Aside from the polyphenolic profile, the wines didn't show any analytic differences when it comes to classical parameters; in particular the volatile acidity were identical.

Figure n°1: polyphenolic wine profiles

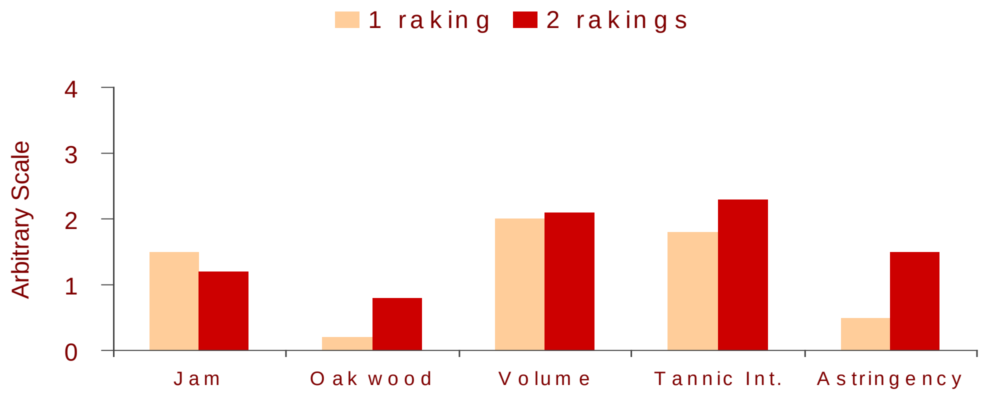


The different maturing procedures modified the polyphenolic profile of the wines.
The wine that conserved the most light lees had a slightly lighter colour.
It remained in the same range of intensity.
On the other hand, this drop in intensity wasn't accompanied by a change in nuance (420 nm/520 nm ratio).

This experiment illustrates the possible interference between pigments, tannins, and light lees.

The sensorial consequences are also notable (figure n°2).

Figure n°2: sensorial wine profiles



The sensorial profiles were different.
Woody aromas and intense sensations on the palate dominated the batch "2 rackings" before MLF.
The other wine had more of a coated profile on the palate : lower “tannic intensity” and lower “astringency”.

This experiment illustrates the possible impact of the quantity of light lees on the wine/oak integration, all of the other parameters being similar.

Both wines are quite adapted to upper premium wine market because light lees good practices were applied in both processes.
The two procedures adapt them to new barrel ageing:

- precisely adjusting the light lees,
- precisely scheduling the elimination of heavy lees before and after the malo-lactic fermentation,
- mastering of the micro-biology by directly inoculating with selected lactic ferments,
- precisely targeted sulphiting,
- regularly adapting the movement of the lees.

The two wines have obvious style differences because their light lees levels were different due to different raking programs before filling the barrels.

This experiment's objective is to illustrate that the details in the maturing procedures can provoke notable changes in their styles.
One can profit from these slight adaptations when everything is in place to master the main risks : microbial, unpleasant odours of sulphur and hard tannins.

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