



News Flash - Vintages Special Business Edition



Malolactic Fermentation – October 2006

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The Special Business Edition News Flash revisits certain points covered in previous News Flashes distributed to ICV's oenologist consultants. This practical summary covers the main aspects of the vinification and ageing of Mediterranean and Rhone wines. Past News Flashes covering the same subject matter are cited in the text. All News Flashes are available for downloading at the ICV website: www.icv.fr

This document is based largely upon a presentation given by ICV at California State, Fresno's International Wine Microbiology Symposium in April 2006.

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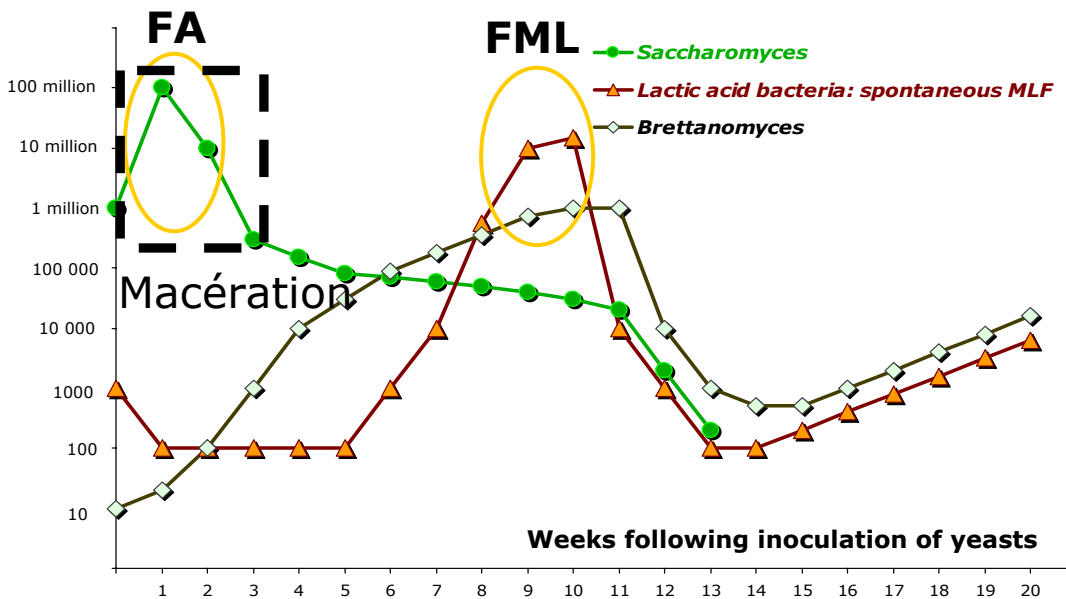
Malolactic fermentation (MLF) is an important step in vinification because of its impact on the organoleptic and analytical profile of a wine. Despite this fact, winemakers usually leave MLF "in the hands" of bacteria already present in the wine towards the end of alcoholic fermentation (AF).

This Special Edition Business News Flash provides a few **keys** to understanding the mechanisms and equilibriums brought into play, as well as a few methodological **tools** for analyzing various fermentation situations. In addition, the validated **results** here presented are helpful for better managing the MLF process.

The microbiology of wines during "classic" fermentation

It's useful to consider the different fermentations that succeed one another in a spontaneous or controlled manner **from a microbiological perspective**, in order to understand what is happening and so better control the process by making carefully reasoned decisions.

The diagram below illustrates the fermentation of a red wine not inoculated with lactic acid bacteria:



As can be seen in the graph, the different populations of yeast and bacteria succeed and overlap one another. Here are some important data and figures to keep in mind:

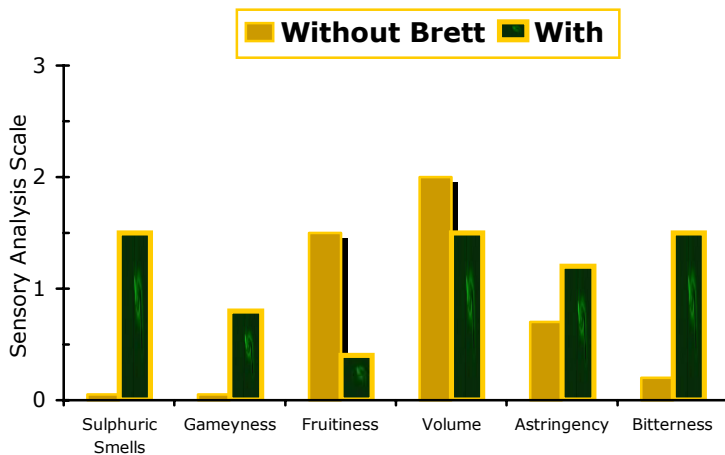
- The yeasts multiply to reach a population level of between 100 and 150 million cells/ml, the final density dependent upon such factors as the nutritive characteristics of the must, the inoculation (and, in this case, the strain of yeast used), and the AF conditions (temperature, O₂, nitrogen, etc.).
- Towards the end of AF, the population of lactic acid bacteria, reduced by the initial sulfiting and maintained at a low level by the competing yeasts, numbers a few hundred to a few thousand cells/mL. Their population level must reach some 1 million cells/mL before malolactic fermentation can take place. In the absence of active SO₂, the speed of growth depends principally upon the amount of sulfiting undertaken between harvesting and the end of AF (see the chapter on managing SO₂), the nutritive conditions of the environment and the temperature. Environmental nutrition is mainly determined by the bioavailability of amino acids, both residual and those released during yeast autolysis. From this perspective, *Oenococcus oeni* is a demanding species and not all strains are equal: MLF, even when



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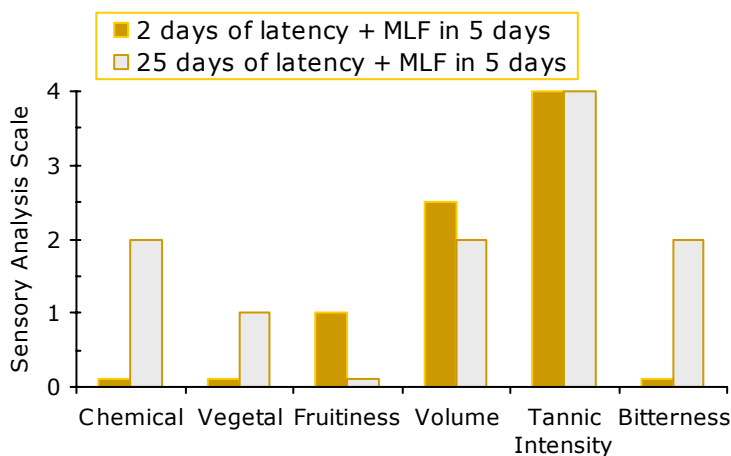
inoculated, will sometimes fail, most probably due to nutritive deficiencies. Given unrestrictive nutritive conditions with a pH greater than 3.5 and a temperature of 20°C (68°F), **the generation time (the time necessary for a doubling of the population) is approximately 20 hours.** Under these conditions and with an initial population of between 100 and 1,000 cells/ml (in the case of a non-inoculated MLF), 10 to 15 days are needed after AF for MLF to begin. If, after 15 days, MLF still hasn't begun, one must consider the possible risks being run, in particular microbial spoilage.

- Spoilage organisms are little affected by the initial sulfiting and the competition resulting from AF. These are mostly lactic acid bacteria, some of which are inactive or only slightly active for malic acid degradation (in particular, *Pediococcus*), acetic bacteria and yeasts (mostly *Brettanomyces*). Their population level depends, for the most part, on the hygienic conditions (from the vineyard to the cellar), the control of AF, the nutrients present, the available oxygen, and, **above all, the time allowed for their development.** The minimum goal is to control the microbial contamination risk that results in organoleptic deviations (see the ICV R&D Department experiment opposite), the production of biogenic amines, and greater volatile acidity.



The situation of a white or rosé wine is very similar to that of a red, with two differences: the pre-fermentation sulfittings are generally greater than for the reds and the pH levels are often lower. The overall effect is a dramatic decrease, even the quasi disappearance of spoilage yeasts and lactic acid bacteria, which explains the difficulty of spontaneous MLF for white and rosé wines.

Under such ecological conditions, careful monitoring by the winemaker is essential to ensure the correct succession of populations and the shortest possible lag phase between the two fermentations (when both are desired). The graph opposite - from an ICV R&D Department experiment in which the lag phase was lengthened by cold and a delayed inoculation - illustrates the impact of passively maintaining a red wine on the lees (despite the two "classic" rackings at the end of AF carried out by the R&D Department) for a little more than three weeks following AF.



However, the benefits of a reduced lag phase are debatable, particularly when micro-oxygenating between AF and MLF is

desired. Of course, it's no longer a question of the wine being maintained on the lees. Adapting to this type of situation means replacing one requirement (the rapid succession of the two



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fermentations) with another: if a delayed MLF is desired to enable micro-oxygenation, the risks of spoilage must be limited in order to safeguard the expected benefits of micro-oxygenation.

The 5 groups of key points for mastering MLF

Managing MLF starts in the vineyard, in particular in monitoring the health of the grapes, more-or-less important carriers of spoilage organisms but also, in the case of an attack of grape-worms or of *Botrytis*, a source of nutrients easily accessible to micro-organisms present on harvesting materials, at the reception site and in the cellar. This often leads to increasing the dosages of SO₂ which, even if no longer present at the end of AF, have an impact on the MLF process.

Another often-neglected point is the maturity level: during normal maturation, an increased pH is favorable for MLF, but an increased alcoholic content and a decreased concentration of malic acid are two unfavorable factors. Therefore, harvesting grapes that are "very ripe" necessitates a more fine-tuned approach to the entire vinification process, particularly the inoculation of bacteria.

Apart from those special (though increasingly frequent) cases of on-the-vine concentration, it's important to choose the correct maturity: is it always necessary to await full polyphenolic maturity? Numerous product goals, combined with a proper mastery of the extractions and vinification, render this unnecessary.

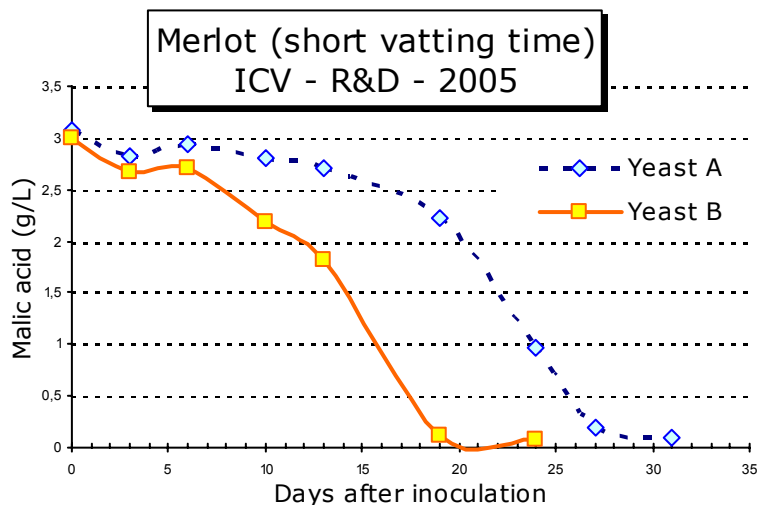
Proper management of MLF calls first and foremost for a proper management of the AF. Indeed, during this stage most nutrients are available to spoilage organisms: a consistent and complete AF is necessary to limit these risks. The various tools are well-known: the yeast and its fermentation capacities, its adaptation to Mediterranean and Rhone musts, the quality of the yeasting (dose, controlling rehydration, etc.), the provision of sugars (crushing, enzymes, extractions, etc.), controlling temperature, etc.

Proper management of AF

The MLF with sugars is a possible risk; this can often have a strong impact on the volatile acidity and can allow for the growth of *Brettanomyces* which not only lead to organoleptic deviations but also enter into competition with the lactic acid bacteria and delay or even prevent MLF.

In addition, the MLF's lag phase is in part dependent upon the yeast used for the AF, most likely according to its autolysis speed, production of SO₂ and impact on the pH. Significantly longer MLF durations have also been noted for certain yeasts (+10 to 15 days in comparison to the "better" yeasts). The opposite graph illustrates a concrete example taken from the last vintage year, with inoculation.

One first notices that while the lag phase is effected, there is no noticeable effect on the kinetics of degradation of the malic acid once started. It should also be





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pointed out that for this experiment, an inoculation of 1 million lactic acid bacteria cells/ml was undertaken. We freed ourselves of the necessary cell multiplication in spontaneous MLF conditions. Therefore, here the bacteria adapt and once again multiply during the lag phase.

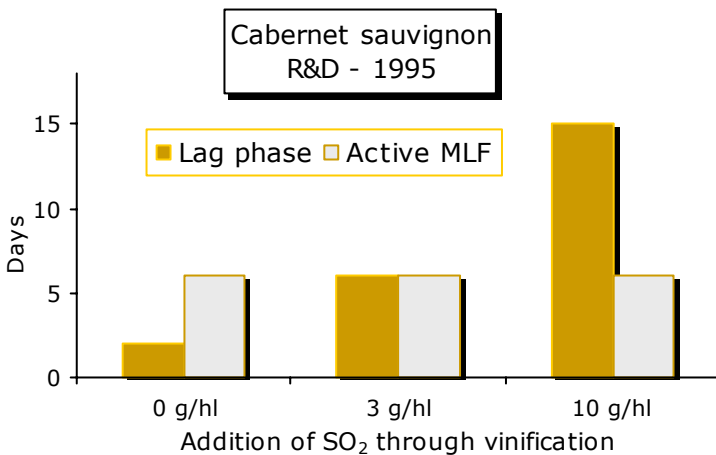
In controlled trials, without inoculation, the lag phase intervals are twice as long: the hierarchy of yeasts remains the same, but their impacts are rather more pronounced.

SO₂ is an antimicrobial agent that affects lactic acid bacteria and other microorganisms *via* its activity which is measured in our laboratories (levels of free SO₂, pH and alcohol). In most instances, virtually no free SO₂ remains at the end of AF (indeed, often none remains), even if large quantities were added during harvesting.

The role of SO₂

However, SO₂ can have two negative effects on MLF:

- It reduces the initial population of lactic acid bacteria, which is an important point when no inoculation is carried out. At 20° C, with favorable pH and amino acid levels, three days are needed for the bacteria population to increase tenfold. If the initial SO₂ reduces the population by a factor of 100, more than a week will be added to the lag phase if no inoculation is made. Careful consideration must therefore be given to the SO₂ added during harvesting and at the end of AF during extended macerations, as well as to choosing the correct **combination of process – yeast - type of nitrogenous nutrients**. For example, a yeast little favorable to MLF added to a clarified thermovinification juice, with AF at 14° C and diammonium phosphate as the only source of nitrogen, can result in an SO₂ concentration of up to 50 mg/L (total SO₂). By slightly increasing the temperature, with FermaidE® as the source of nitrogen and oxygen at the appropriate stages, very low levels of total SO₂ are attained (<20 mg/L) and the MLFs follow a "classic" schedule.



- Sulfates and sulfur compounds have an impact on the lag phase. This is confirmed by both experiments and practical experience, even if no exhaustive physiologic study has uncovered the underlying mechanisms. The case opposite is a perfect example: the total SO₂ at the end of AF was below the sensory threshold (it should be noted that the yeast was D254®). Once again, despite inoculation, the lengthened lag phase demonstrates the difficulty with which bacteria must adapt to the environment. The sulfur atom

can be considered toxic for lactic acid bacteria, whatever the molecule in which it's found (though SO₂ is more toxic than the sulfates, of course). Though this question hasn't been specifically studied, it can be assumed that the effects would be still greater in the case of a non-inoculated wine, since the initial population of indigenous bacteria would be lower, thereby necessitating greater cell multiplication.



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Following devatting and towards the end of AF, ICV has long recommended at least two rackings at 48-hour intervals for red wines.

Racking and oxygen

While some winemakers fear that these rackings deplete the wine of its lactic acid bacteria, in fact, the procedure is effective for several reasons:

- Sulfur off flavors are lessened by limiting the tamping down of lees which releases them in great quantity, thereby limiting those molecules responsible for significant lag phases (see above). To effectively eliminate these vegetal lees, it is often necessary to degasify during the rackings with the use of a vat. This degassing allows the heavier lees to sink to the bottom more rapidly for a second, more effective racking.
- The wine is oxygenated. A well-carried-out open-air racking raises the O₂ content to 4 mg/L. This oxygen reduces sulfur off flavors and can be assimilated by the lactic acid bacteria. We now know that *Oenococcus oeni* is micro-aerophilic, meaning it takes advantage of small quantities of dissolved oxygen for its development and activity. In addition, in the field we've noticed that micro-oxygenation, contrary to the opinions of some a few years ago, favors MLF, undoubtedly for the above-mentioned reasons.

From a technical perspective - knowing that the lag phase lasts 5-10 days and that micro-oxygenation can be carried out as long as malic acid is >0.8 g/L - it makes sense to inoculate at the beginning of the last week of micro-oxygenation.

Therefore, **micro-oxygenation** aids, rather than hinders, MLF and the inoculation of lactic acid bacteria. The goal is to provide, for a given time period, an established dose to achieve the desired organoleptic objectives.

Additionally, and even in the absence of any sulfur off flavors, it has been observed in the field that rackings favor both MLF and aromatic neatness. The movements of the wine most likely accelerate the breakthrough of compounds resulting from the autolysis of dead yeasts having undergone AF and therefore having fed the lactic acid bacteria. This has been shown by INRA to be the case during barrel ageing and there is no reason to doubt that the same is true for wine in tanks at the end of AF.

It should be remembered that rackings eliminate only part of the yeast, more than 50 million cells/mL of which remains after two rackings. Therefore, rackings are more than compatible with ageing on the lees.

In the absence of a bacterial inoculation, the only parameters that can be managed following the rackings are temperature and acidity.

Implementation

Impact of temperature on MLF



Regarding **temperature**, comparative results show that the ideal range is somewhere between **20°C (68°F) and 22°C (71,5°F)**, due to the wine's alcohol content and at times unfavorable pH levels.

In practice, lower temperatures within this range are preferable for wines with high alcohol content, while higher temperatures are preferable for the other wines.

ICV experiments conducted in 2005 on wines that did not undergo spontaneous MLF in wineries confirmed the crucial importance



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of temperature: in the R&D study, almost all non-inoculated wines underwent spontaneous inoculation. Two essential differences from the wineries: an extra racking (the sampling) and a perfect temperature (20°C = 68°F), constant and homogeneous for the entire volume of wine (no day-to-day variations).

What to do after MLF

The pH is another factor that can be influenced by de-acidification. Below 3.4, conditions become difficult for all lactic acid bacteria and especially *Oenococcus oeni*. A pH of > 3.6 is no longer considered as a limiting factor. Therefore, it is sometimes necessary to de-acidify, in accordance with the regulations in place. The only viable tool for calculating the appropriate dose is the pH meter.

When MLF drags on for more than 3 weeks, cleaning the medium by centrifugation and filtration, then inoculating with an addition of nutrients (at ICV, Optimalo+® accelerated MLF in experiments on white wine in May 2005) is the absolute minimum if one hopes to achieve MLF.

It is essential to ensure the proper conditions for a successful inoculation: **bacterial inoculation does not eliminate all risks**. In addition, **there is a problem with any wine that has not begun spontaneous MLF two to three weeks after AF and without sulfiting**: either the population level of indigenous lactic acid bacteria is insufficient, or the competition with other microorganisms is too great, or the nutritive conditions are unfavorable to lactic acid bacteria.

These elements can also be combined: it must not be believed that inoculation will automatically solve the problem. A universal lactic acid bacteria has not yet been discovered, even if it's being worked upon.

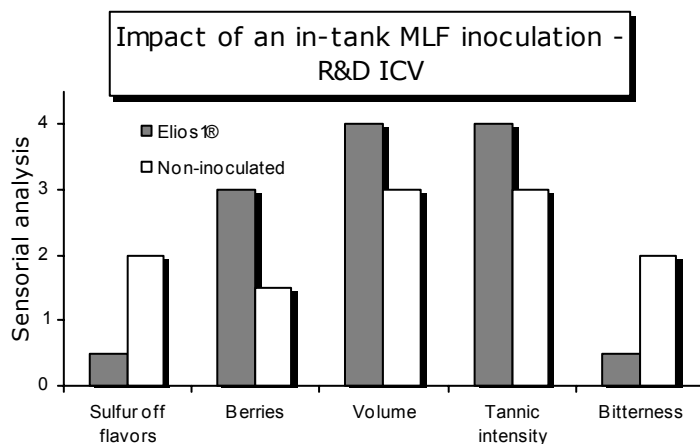
Inoculation is a **tactical manoeuvre** that consists of spreading a known, manageable microorganism, so as to limit the development of *Lactobacillus*, *Pediococcus* and *Brettanomyces*. These spoilage organisms can result in a "closed" aroma and produce sulfur off flavors, volatile acidity and biogenic amines.

One of the following chapters proposes an evaluation method for assessing the level of difficulty, which should help you deal with various situations in the field. Another chapter discusses alternative techniques that have proven themselves in R&D Department experiments and are currently being tested in the field.

The lactic acid bacteria that are chosen usually have the same needs as indigenous bacteria: one must also carefully manage racking, SO₂, temperature, pH, etc.

Inoculation can be carried out in the liquid phase or under the pomace, while being careful not to spread the bacteria to tanks that have not yet completed AF.

Deciding which inoculation to carry out (besides direct economic considerations) is a **commercial and organoleptic choice** (see the graph below):



- A commercial choice, because it's easier to sell a wine that is neater and ready earlier.
- An organoleptic choice, because a shortened on-the-lees maceration, allowing the spoilage organisms significantly less time to develop, and the choice of bacterium all influence the wine's profile, beyond the biogenic amines, even in the case of a barrel MLF.



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Whatever the choice (spontaneous or inoculated), once MLF is complete, the lactic acid bacteria must be eliminated. Malic acid is not the only substrate that they consume, even if it's the first targeted: sugars and citric acid are also consumed, producing acetic acid. In three days, under the pomace and without sulfiting, volatile acidity can easily climb to over 0.2.

Lysozyme has no effect on acetic acid bacteria or *Brettanomyces*. It's used at the end of MLF to reduce the SO₂ used. Lysozyme is above all considered a preventative tool.

One possibility for eliminating lactic acid bacteria is by adding lysozyme (usually along with a sulfiting of at least 3 g/hL). It should be pointed out that lysozyme is an enzyme, which costs around €150/kg. Effective doses (ITV study results) are above 20 g/hL, and usually closer to 50 g/hL. The cost, therefore, is considerable.

Taking into consideration the pH level, how the particular vinification is carried out and the hygienic condition of the cellar, we recommend a sulfiting that allows for an active SO₂ of between 0.5 and 1 mg/L.

For red wines, sulfiting is carried out immediately after racking, which allows for the elimination of the heavy lees, which can harbor both spoilage organisms and SO₂ fixatives.

For white and rosé wines, it is preferable to first add SO₂, so the free SO₂ acts as protection during the following racking.

An evaluation method for measuring MLF difficulty

As in alcoholic fermentation, it's possible to assess the difficulty of pursuing MLF by measuring the key points cited above. ICV's Biotechnology Group has established two evaluation steps **for red wines** which, together, give an assessment of this

difficulty.

The parameters considered "independent factors" are: the pH, the alcohol concentration, the level of malic acid, the accumulated doses of SO₂, the yeast used for AF and the vinification technology used.

The first step considers those independent aspects that are, at least in part, outside the winemaker's control. Under current regulations, these points are directly linked to the product's goal: maturity level, population health and sulfiting, vinification process, choice of yeast, grape variety, etc.

Each factor is divided into classes. Then, a value from 0 to 3 is attributed to each factor, according to its influence on MLF: 0 for a negligible impact, 3 for a strong impact.

Consider the example of alcohol concentration at the end of AF. Drawing from our experience (R&D and in the field), we've established 4 classes:

Alcohol	< 12%	12-13%	13-14.5%	> 14.5%
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A value of 0 is given to the first class and a value of 3 to the last class. Each parameter in the box is treated in the same manner. This methodology is universally applicable: validate (or complete) the list of recorded factors, divide each factor into classes, and attribute a level of difficulty resulting from each class.

To assess the intrinsic difficulty, once the classes have been established and each factor measured, the **values are simply totaled**.

Three levels of difficulty have initially been defined: **easy** MLF for a total score of 0-5, of **average difficulty** for a score of 6-12, and **very difficult** for a score greater than 12.

The limits of each level can be modified, drawing upon ICV's field-based expertise. But it is already possible to characterize the MLF difficulty of each cuvée (practically at the same time



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as one is preparing its vinification) and to thereby anticipate the appropriate actions so as to limit the various risks and allow the grapes to express themselves.

This is precisely the goal of the second step: it considers those factors that may be influenced by the winemaker without significantly altering the wine's organoleptic profile. The procedure is exactly the same: identify the key factors, divide them into classes, and attribute values to each class.

The parameters considered "variable factors" are: the mean temperature, its homogeneity in the tank, its variations over time, the rackings, the sulfur off flavors and the inoculation.

Temperature homogeneity measures differences in temperature within a given volume of wine: for example, between the top and bottom of the tank.

Variations are changes in mean temperature from one day to the next: to simplify matters, the measurement taken Friday afternoon can be compared to that taken Monday morning.

By totaling all values for both steps, one should (theoretically) obtain a total score of between 0 and 34.

Four levels were defined: MLF is considered easy between 0 and 7, somewhat difficult between 8 and 14, difficult between 15 and 20, and extremely difficult for totals above 20.

However, it must be pointed out that **up to 14 points (!) can be saved by perfectly mastering all factors deemed "variable"**.

Difficult cases

Despite taking all due precaution, difficult cases sometimes remain to be solved; these are usually linked to the grape:

- **Merlot** is, for unknown reasons, a variety for which MLF is often difficult, particularly following thermovinification. This is not limited to the Mediterranean region. The same problem is found in South Africa, Chile, California and even Bordeaux! One possible explanation is that this grape variety is particularly deficient in one or several amino acids needed by lactic acid bacteria.
- Water stress, a frequent climatic situation these past eight years, results in **abnormally concentrated grapes**. The combination of a high alcohol concentration and low pH explains most difficulties encountered.

Faced with these difficulties, few solutions present themselves: de-acidifying (when possible and in a reasonable manner according to the level of tartaric acid), changing the process (without significantly altering the organoleptic profile), or opting for a functional alternative (see the following chapter).

Viable options

For at least eight years, ICV has studied, at both the experimental and industrial level, alternatives to classic MLF management: co-inoculation, lactic acid bacteria yeast starter, and under-the-pomace MLF.

Co-inoculation should be understood as adding lactic acid bacteria the day following yeasting. Under these conditions, the initial sulfiting in usual doses plays a moderate direct role.

Co - inoculation

ICV has also tested (for white wines) inoculation at the beginning of the final quarter of AF, a practice that apparently originated in Australia: the idea makes sense, since the bacteria are allowed 3 to 5 days to become acclimatized and temperatures are usually allowed to increase at this stage of alcoholic fermentation to somewhere between 20° and 22°C.



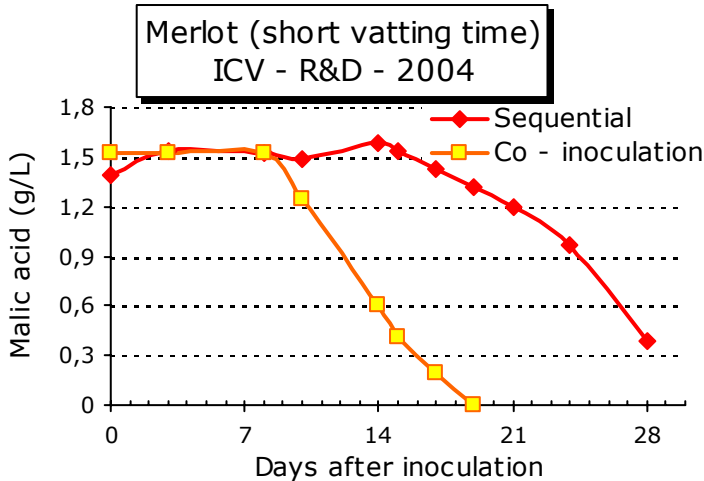
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For red wines, co-inoculation works systematically. The following graph shows that bacteria seem to take advantage of the eight days of AF to become acclimatized: actually, this lag phase remains the same as during sequential inoculation. The MLF kinetics are then almost identical for both situations.

For **white wine**, co-inoculation (or inoculation during the final quarter of AF) is less effective than sequential inoculation following the racking at the end of AF: it does not always occur and, when it does, the resulting wines are aromatically less neat and more aggressive.



It therefore represents an interesting solution to a difficult situation, chosen by certain clients previously unable to carry out MLF, even with sequential inoculation.

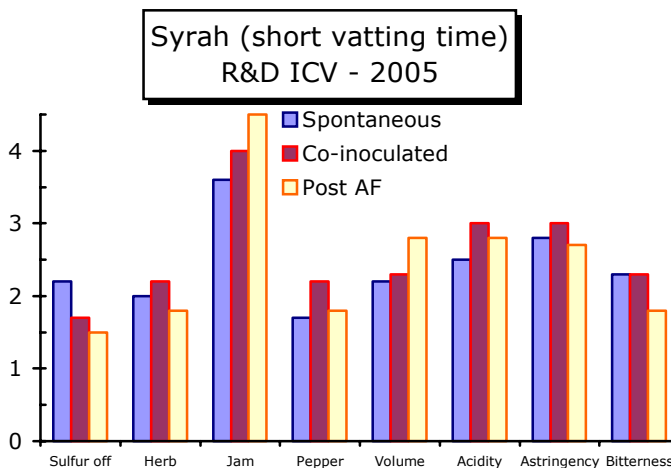
In addition, from an industrial point of view, all fermentations are completed three weeks after harvesting. Normally, five to six weeks are needed. In certain situations (primeur wines, for example), the time thus gained can represent a real commercial advantage.

In 2005, the R&D Department tested this co-inoculation on a long vatting time of a top-of-the-line Carignan. MLF occurred at the same time as AF: in this sort of situation, there is no problem about sulfiting. We must await the results for 2006 and 2007 to know if the MLF must be managed in such a way as to finish before the AF.

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From an organoleptic point of view, the results should be considered from two perspectives (see the Syrah 2005 graph below and p. 11 for Carignan):



- When, despite sequential inoculation, MLF fails, co-inoculation represents a real step forward, in particular for limiting sulfur off flavors and for improving the fruity sensations and mouth volume.
- When sequential inoculation works, the organoleptic results obtained by co-inoculation are less interesting than those resulting from the normal AF-MLF sequence.

Therefore, it makes sense to propose co-inoculation as either an innovative tool or as a possible solution to a difficult situation in which MLF fails to occur, even with "classic" inoculation. The approach of diehard co-inoculation fans is often more commercial than technical in nature. Three years of objective experimentation and analysis allows us to be more nuanced in our approach.

Therefore, it makes sense to propose co-inoculation as either an innovative tool or as a possible solution to a difficult situation in which MLF fails to occur, even with "classic" inoculation.



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In 2005, ICV tested the concept of a 24-hour yeast starter. This consists of carrying out a preculture over a certain period of time to allow the bacteria population to double in size. To reduce the adaptation phase, the bacteria are rehydrated in non chlorinated water and after 15-20 minutes the volume is doubled by adding wine: the

24-hour yeast starter

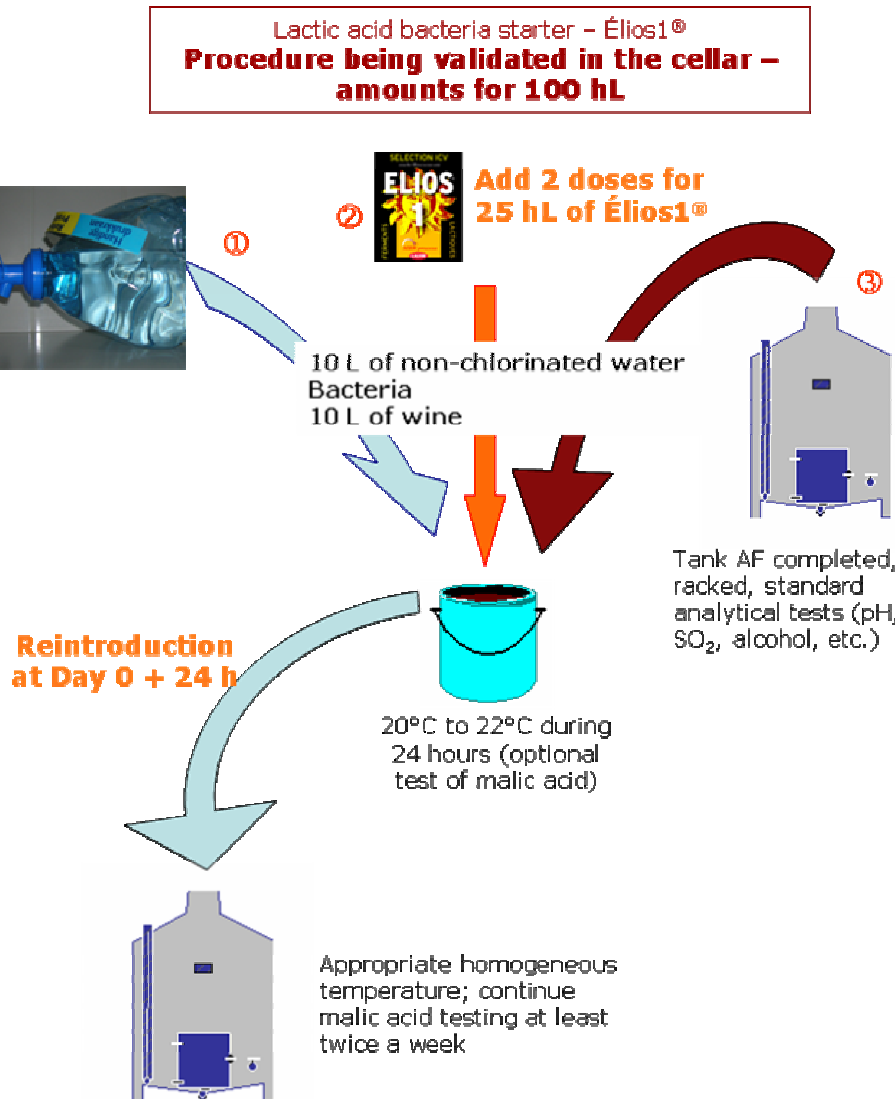
resulting pH and alcohol concentration are considerably more favorable than would be the case for a starter prepared only with wine.

The process is illustrated in the opposite diagram. Before beginning the process, it is important to check the various parameters in order to readjust the pH if necessary and inform the client of the risk level.

Indeed, the **cost remains significant even if halved (the bacteria dose divided by 2)**, particularly compared to other biotechnologies.

In nine studies conducted by ICV's R&D Department, this type of starter worked more quickly than classic inoculation 3 out of 9 times and was just as effective the rest of the time. In one case, all of the techniques tested failed to trigger MLF.

It is especially important to respect the implementation schedule. In all the tests, the starter completed its MLF after 24 hours. In this type of situation, if one waits to reintroduce the bacteria into the tank, there's a risk that the population of lactic acid bacteria not only adapts physiologically by targeting substrates other than malic acid, but also starts to decline.



In the case of any analytical-parameter nonconformity, take the necessary and legal corrective actions (e.g., de-acidification) for the starter and the tank

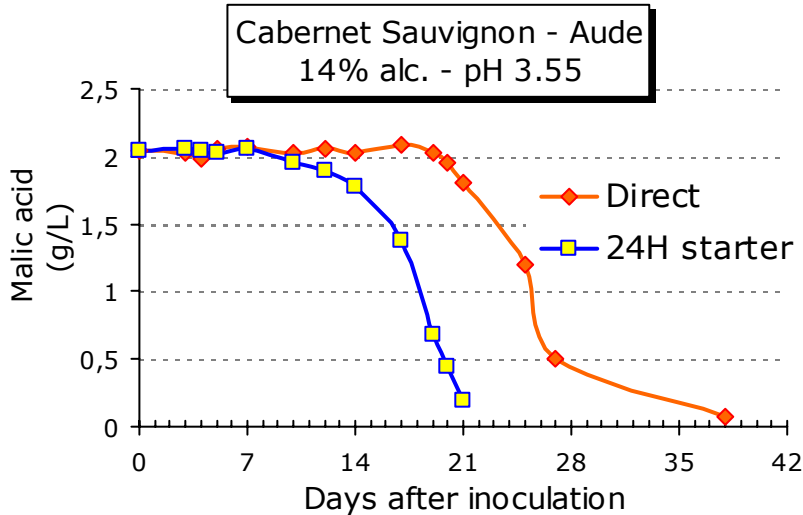
Moreover, following the initial protocol at an industrial site, a delay of 12 hours for the



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reintroduction of the starter resulted in a lag phase of around 5 days, the same as for a classic inoculation.

ICV oenologists have successfully tested this protocol in the cellar. Adaptations are possible and will be studied with high alcohol concentrations (> 15% vol.), the idea being to limit the stress during reintroduction of the bacteria into the tank. In this type of situation, we will experiment with 1/3 water mixed with 2/3 wine.

The opposite graph illustrates a clear-cut situation in which the starter works better than direct inoculation: the malic acid's kinetics of degradation are very similar, the differences being found in

the lag phase and at the end of MLF. In this case, the wine was taken from a cellar in Languedoc and the starter was supplemented with Optimalo+® (half dose).

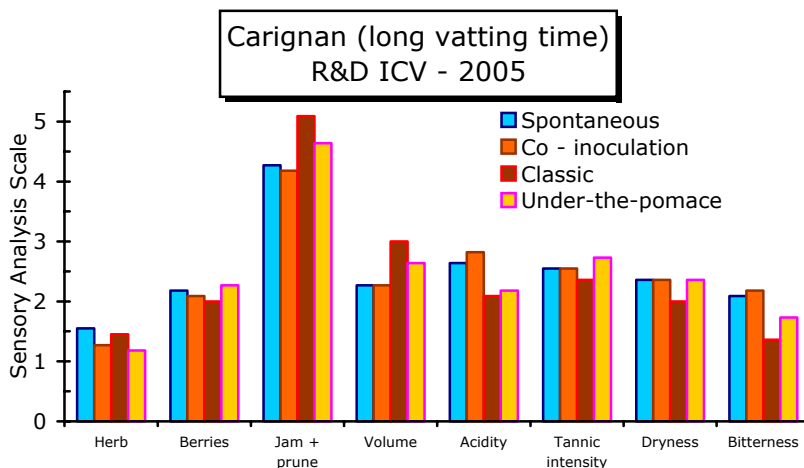
Compared to others who also develop this type of starter, ICV's technique has **several advantages**:

- We know the bacterium being introduced, in particular its organoleptic effects.
- We can work with volumes of 50 hL and up, since Élios1® is available in bags for 25 hL and we use half doses.
- The final cost is in fact halved, allowing us to treat twice the volume for the same cost. The final cost for the cellar is approximately €0.8/hL.

More than ten years ago, ICV tested and validated under-the-pomace MLF. The initial goal was either to lengthen the maceration period by avoiding an MLF that is spontaneous or occurring too long after AF and could result in organoleptic deviations, or to rectify the negative effects of an overly-long maceration of insufficiently mature or concentrated grapes.

Under-the-pomace MLF

Some wineries in Languedoc have been practicing under-the-pomace MLF with several tanks on a regular basis since 1999 and have met with good results.



The opposite graph illustrates the organoleptic results obtained during a trial using Élios1®. The differences are small but significant for the descriptors "berries", "pepper" and "tannic intensity" for which under-the-pomace MLF is more intense than classic inoculation. For the descriptors "herbaceous" and "prune", it's less intense than classic inoculation.

In the cellar, under-the-pomace MLF lends the organoleptic profile



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fresher, less vegetal overtones and often a smoother mouthfeel. When the extractions have been poorly positioned (late and violent) or when maceration has been overextended (onset of dryness before the coating of tannins, for example), under-the-pomace MLF can significantly reduce a wine's aggressiveness.

From a technical point of view - besides the "classic" elements that must be monitored (pH, alcohol, added and residual SO₂, temperature, etc.) - several additional aspects should be mentioned:

- Obviously, one must ensure that the AF has been completed with at least 2 consecutive tank analyses, with a "délestage" between analyses.
- SO₂ must not be added; rather, the tank should be completely filled as in the case of a long maceration.
- If micro-oxygenation is carried out, one must schedule the inoculation to take place 5-10 before the end of micro-oxygenation and monitor whether or not a spontaneous MLF is triggered.
- A liquid-phase inoculation must be carried out during a complete release and the temperature must be maintained at the appropriate level.
- One must be particularly careful (specific material, cellar organization, hygiene) not to spread the bacteria to other tanks that have not yet completed AF.

Cost considerations

The principal arguments put forward by winemakers who do not wish to inoculate are both technical and economic in nature.

From a technical perspective, "spontaneous MLF is rarely a problem". However, the end results do not always meet initial expectations: this is economically detrimental, in particular for top-of-the-line wines. In addition (see page 7), the lactic acid bacterium that carries out MLF has a direct impact on the organoleptic profile of the wine, as does the yeast on AF. Therefore, does it not make sense to try to control this phenomenon, especially for quality cuvées (e.g., top-of-the-line wines) that risk losing a number of their organoleptic advantages?

It should also be pointed out that MLF does not always take place and that a causal analysis (see "evaluation method") can allow the winemaker to target those cuvées for which inoculation should be considered.

From the economic perspective, only direct costs are taken into account. Rarely does one also consider the costs of temperature control, let alone the delayed or lost markets (primeur wines), considering that, in general, market prices tend to decrease during the year.

Total biotechnology cost for a top quality wine (not including bacteria) is €0.012-0.013/bottle: very close to the cost of bacteria.

However, it's not a question of forcefully making inoculation the rule; this is especially true for a nervous market. Yet, it should be pointed out that for wines produced for the bottle market, the bacterium's direct cost remains moderate (around €0.015/bottle), while the risk of organoleptic deviations is high.

Finally, the cost of bacteria can be halved, thanks to the use of an easily-controlled starter.

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