Malolactic Fermentation

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This *MoreManual!™* has been written to provide winemakers with a comprehensive guide to understanding the exact steps needed to successfully carry out a malo-lactic fementation. We will begin by first looking at a series of individual elements that each have an effect on successfully completing an MLF, then we will focus on how these elements can best be brought together into a unified protocol. Let's get to it!

Recognizing the 5 keys to success

Malolactic bacteria have a reputation as being decidedly more difficult to work with than yeast, however many of the problems often encountered stem from a lack of understanding the appropriate conditions necessary for the bacteria to successfully complete its job. One reason this might be the case is that there really isn't a single variable that can be controlled to ensure success, à la: "make sure you don't sulfite until after the MLF has completed and all will be well". In fact, the real answer to better being able to successfully complete an MLF is a bit more complex than that and actually lies in understanding the synergistic relationship between the following five elements: **A)** alcohol (ethanol), **B)** temperature, **C)** pH, **D)** SO_2 (sulfite), and **D)** nutrients and lees management:

A) Alcohol (ethanol)

Alcohol, at the levels desired in most finished wines (usually around 12%–14%) is in itself toxic to most organisms, including ML bacteria. However, unlike most other organisms, with the proper nutrition and environmental conditions, ML bacteria can adapt to successfully survive in this medium.

B) Temperature:

Yet, an important factor to note is that higher temperatures aggravate this alcohol toxicity, and even ML bacteria adapted to the wine will start to feel the effects of alcohol toxicity if the wine's temperatures become too elevated. On the other hand, if the wine's temperature becomes too cool, then the ML bacteria stop reproducing and the secondary fermentation will slow and potentially shut-down altogether (until the wine warms-up again). Therefore, the answer to "what is the ideal temperature to conduct an MLF" lies in a compromise:

- **Red wines:** have an optimum temperature for a favourable MLF of around 70° F (20° C), which is cool enough to limit alcohol toxicity and yet warm enough to maintain full activity.
- **White wines:** are often fermented at the same temperatures as the reds, but some strains will allow the winemaker to work at the even cooler temperatures of around 58° F (15° C). This might make it easier to maintain the cooler handling conditions often desired for white winemaking, but it will cause the process to work at a slower pace and therefore the fermentation will take longer to complete.

***Note** that if the temperature of the wine will be falling colder than the recommended range before the MLF has finished (for example: it is not temperature controlled and the cellar temperature drops during the winter), it is important that the ML bacteria has a chance to at least establish itself as the dominant strain in the wine at the recommended temperatures before the wine gets cold. In other words, having one or two weeks at 70° F and then having the temperature slowly drop is better than trying to get the MLF under way at 57°–60°F right from the start.*

C) pH:

The pH of the wine and how it affects ML bacteria is actually one of the most straightforward of the five elements. Basically, if the wine has a pH that is too low, it will exacerbate the already harsh conditions of the wine and it will inhibit the bacteria's survival. However, if the pH of the wine is too high, then while the bacteria have an easier time thriving, the wine also becomes more susceptible to a greater number of spoilage bacteria. So, the ideal pH range recommended for a wine undergoing an MLF is therefore based on a compromise between ideal sanitary conditions on the low end and levels that are high enough to facilitate growth and survival on the upper end, and this usually equates to a range of between 3.1 pH* and 3.6 pH.

***Note** that these thresholds are strain dependent and therefore may differ slightly between different cultures. Some strains may indeed be able to work at a pH of 3.0/3.1, albeit not as comfortably as it would at a pH of 3.2.*

D) SO_2:

Most winemakers know that a high "free" SO_2 level can inhibit ML bacteria, and that if you want to carry out an MLF then you usually don't sulfite the wine until after the fermentation has completed. However, it is crucial to realize that "bound" SO_2 also has a negative affect on the bacteria. This is because while "bound" SO_2 is 5 to 10 times less active than "free" SO_2, at high enough levels it too can hinder bacterial growth. So, if you want to do an MLF on a particular wine not only do you need to be aware of how much "free" SO_2 is in the wine, you also need to keep tabs on the portion that is "bound" as well. These two portions combined are referred to as "total" SO_2 and the following SO_2 levels are recommended by Lallemand

as being favourable MLF conditions: **0–10ppm "free", and 0–30ppm "total".**

***Note** that in general, if you crush and add a single 50ppm "total" SO_2 addition up front, by the time the fermentation is over you will usually have around 20–25ppm as "total" and 0–10ppm as "free". In other words, you should be well within the recommended ranges. (Keep in mind, however, that this amount will vary with different must compositions and fermentation temperatures).*

E) Nutrients and Lees Management:

While it is true that ML bacteria convert malic acid into lactic acid, they do need a nice, rounded set of nutrients in order to remain healthy throughout the entire fermentation process. Winemakers provide this nutrition by first adding nutrients to the hydration water, and then by maintaining a small amount of leftover yeast ("light lees") in the wine for the bacteria to feed off during the fermentation. Let's take a closer look at each of these steps.

Adding nutrients during hydration

Recent research from Lallemand has shown that, just as we now know to use Go-Ferm during the yeast's hydration, ML bacteria also benefit from the use of nutrients during the hydration process. Therefore we recommend adding Acti-ML to the hydration water in order to ensure that our bacteria get the best start possible. (Complete instructions for doing this will be covered a little later.)

Nutrients in the lees

In addition to the Acti-ML addition during hydration, a major source of nutrients is found in the spent yeast at the bottom of the vessel, i.e.: the "lees". Beginning towards the end of the alcoholic fermentation and continuing on until the wine is racked from the lees, the spent yeast cells begin to autolyse (or burst open on their own) and release their innards into the wine. This not only releases a series of polysaccharides which gives the wine a greater mouthfeel and complexity, it also contains a rich variety of nutrients and minerals that the bacteria can use as a complete nutrient set, and for the majority of most fermentations this is all that they need*. The only trick is that, over time, both the lees and the bacteria can settle-out and compact on the bottom of the vessel, effectively burying the bacteria alive and lowering the ratio of working bacteria to wine volume. This does neither the winemaker, nor the bacteria any good. So, in order to counteract this phenomenon, the lees (along with the bacteria) need to be stirred back up into the wine 1–2 times a week until the MLF comes to a completion. This process is called "bâtonnage", in French (for the stick, or "baton", used to stir) and will ensure that the highest percentage of food and working bacteria will remain suspended and in contact with the wine at all times. Obviously, strict sanitation and oxygen management (i.e.: flushing with inert gas) are a must during the stirring period.

***Note** that there are indeed times when the lees may not have enough of the nutrients that the ML bacteria need during fermentation and the winemaker will need to add a nutrient-set that has been expressly designed for them ("Acti-ML", for example). Yet, this should only be done if you know that the situation warrants it up-front, for example:*

· You know from past experience or through lab analyses that the vineyard/must has some nutritional deficiencies.

*· You have started the ML fermentation and all of the other parameters are within the correct levels, yet the fermentation is very slow or stops. In this case we can add another dose of Acti-ML to the wine at a rate of: **.75 – 1.0 grams per gallon** (possibly along with some yeast hulls as well).*

· You had to rack off of the lees for some reason (maybe a H2S problem) and you need a new, clean source of nutrients for the ML bacteria.

These are all good times to add the ML food. However, the reason why one doesn't just add it arbitrarily at it the beginning of every ML fermentation is because while the goal is to have enough nutrients for the ML bacteria to comfortably finish their fermentation, the winemaker ideally wants the wine to be as nutrient depleted as possible once they're done. Any nutrient source left over after the ML bacteria have finished is available to any spoilage organism that may possibly find its way into the wine. A nutrient-desert is a great insurance policy, and while it may not be completely practical for all winemaking styles, it still is worth keeping in mind when deciding about nutrient additions for an MLF

***A final nutritional note:** ML bacteria do not take up DAP; so do not use it as a part of an ML nutritional regimen. The DAP will only be available to potential spoilage organisms, as well as give the wine a salty taste at high enough concentrations!*

Putting it all together: a complete protocol!

Now that we have a better understanding for what is needed and "why" for each of the five, key elements, it is now possible to tie them all together and come up with the following complete, general set of recommended guidelines:

1) Garbage in garbage out! *Get the must dialed-in at crush, so that the subsequent wine will be in good shape post alcoholic fermentation for receiving the ML inoculation. A clean, healthy alcoholic fermentation means your ML bacteria will have an easier time getting started and finishing their job when it's their turn to work in the wine*:

- Clean-out any moldy or raisined clusters (the mold makes toxins that can inhibit both yeast and ML bacteria, raisins will reconstitute in the must, boost the °Brix, and lead to higher finished alcohol levels).
- Get your sugars and ph/TA% in line so that the finished wine will not have a final alcohol above 15% (around 14% is better), and so that the pH will not be lower than 3.1/3.2 (3.2 is better).

- Make sure that the initial SO_2 addition is around 50ppm "total", or so (ideally you want to finish the fermentation with a maximum of 25–30ppm "total", and 0–10ppm "free". Less is better).
- Take care of the yeast during the alcoholic fermentation (feed them and keep fermentation temperatures in line (below 85° F, 28° C), this limits their production of compounds that can later be possibly responsible for antagonizing the ML bacteria: H2S and VA, for example. Recent research shows that MLFs actually finish quicker and with less problems in wines made with yeast that are fed a complete set of nutrients during the alcoholic fermentation compared to those that are not. So remember: healthy yeast ultimately means healthy ML bacteria down the line.)

2) Post Alcoholic Fermentation:

- Wait until the must has reached 0° Brix before inoculating with the ML bacteria. ML bacteria, in the presence of residual sugars will also use this as a food source and one of the by-products of this pathway is VA. Ironically, high levels of VA in a must or wine can actually interfere with the bacteria's ability to complete a Malolactic fermentation; regardless if they are the one's who made it in the first place! And, of course, VA in detectible levels is considered a serious wine flaw. This possibility can therefore be greatly reduced by eliminating most of the sugars in the environment before they gain access to it.
- Rack-off of the "gross" lees 24 hours post-press before inoculating the wine with the ML culture (As mentioned earlier, there is nothing helpful in the "gross" lees. Remove them and remove potential problems, as well. There will be enough "light" lees remaining to feed the ML bacteria and you will keep the "being buried alive in the lees" factor to a minimum for the bacteria).

3) ML inoculation preparation & handling: Prepare the ML culture: Some bacteria are labeled "direct-addition" and can be added to the wine directly from the pouch, while others require a 15–minute hydration period in clean, chlorine-free water before inoculating the wine. However, regardless of these differences all ML bacteria, including the "direct addition" and liquid ones, will benefit from a brief Acti-ML nutrient soak before going into the wine. Therefore we recommend treating any form of ML bacteria you may be working with as if it required a 15–minute hydration before inoculation. This means that:

For every 1 gram of bacteria being added to the wine, you will be adding 20g of Acti-ML to 100mL of distilled water at 77°F (25°C). After sitting for 15 minutes gently, yet, thoroughly stir this solution into your wine. The following example will use the 2.5g (66 gallons of wine) size ML bacteria packet to illustrate this.

A) In a sanitized container: dissolve 50g of Acti-ML into 250mL of distilled water at 77°F (25°C).

B) Add the bacteria (2.5g) to the solution and gently stir/swirl to break up any clumps if needed. Wait 15 minutes.

C) Add the entire bacteria/nutrient solution into your wine and mix it throughout the entire wine volume. (Note: it is a good idea to stir the bacteria starter solution just before adding it into the wine to make sure that any of the nutrients and/or bacteria that may have settled-out during the 15 minute soaking period do not get left behind in the hydration vessel).

Inoculation and handling should take care to limit any oxygen exposure (the bacteria are anaerobic and depending on the strain may react negatively to various amounts of oxygen that may be introduced into the wine. In short, don't splash when stirring the MLF and flush pumps and lines with inert gas before running a wine undergoing MLF through them. In general, it's recommended not to rack a wine until the MLF is complete, however).

4) During the ML Fermentation:

- Make sure the wine's pH is at least around 3.1/3.2 (3.2 is better), if not adjust accordingly (Information on adjusting pH can be found in our Red (BK598) and White (BK597) Winemaking Manuals).
- Keep the wine temperatures at around 70° F (20°C) until the fermentation is complete (see **section 5** below).
- Stir the lees 1–2 times a week until completion (keep vessels topped-up and avoid oxygen. Flush any headspaces with inert gas).

5) Testing for Completion: Monitor with chromatography* (MT930), and once it seems to be finished, then run the first test. Often a MLF can slow or stop temporarily. If everything in the five elements checks out (alcohol, temperature, pH, SO_2, and nutrients) and there is still no more progress within the week, then it's time to consider adding an ML nutrient (such as Acti-ML) to the wine at a rate of ***.75–1.0 grams per gallon*** (possibly with a dose of yeast hulls, as well).

***Note** that the sensitivity-threshold for the standard vertical test kit is around 70 mg/l, but it takes around 30 mg/l to be considered truly done. So, a good rule of thumb is to just wait an extra week or two after the test shows that you are done and that should be sufficient for a true completion.*

6) Upon completion of the MLF: As soon as the MLF has completed, it is also a good idea to add SO_2 immediately in order to stabilize and protect the wine. At this time, the wine should also be re-checked and the pH/TA% adjusted, if needed. If you are working with a red wine, then it is important to rack the wine at this point to counteract any of the reduction that may be remaining from the secondary fermentation. If you are doing a white, however, then you may choose to remain on the lees for more depth and complexity but continue to stir the lees once every 1–2 months.

In Summary

Hopefully, the information presented here was helpful and even though it is in an abbreviated form, it should make the process a little easier to understand and therefore carry out. However, as convenient as a paper like this is, it does not take the place of a more precise and detailed look at the topic of Malolactic fermentation. The following sources were referenced for this paper and are highly recommended:

1. *Ribéreau-Gayon P., Dubourdieu D., Donèche B., & Lonvaud A. HANDBOOK OF ENOLOGY, VOLUME 1. West Sussex: John Wiley & Sons, LTD. 2003.*
2. *Boulton, R.B., V.L. Singleton, L.F. Bisson, & R.E. Kunkee. PRINCIPLES AND PRACTICES OF WINEMAKING. New York: Chapman & Hall (Aspen Publication). 1998.*
3. *Lallemand: both the 'The Book on Malolactic Fermentation" and the "Fermentation Product catalogue" and are great sources for information regarding MLF Contact www.lallemand.com to obtain your own copies.*