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Relationship between lactic acid bacteria, malolactic fermentation and wine colour

>>> Some phenolic acids can either inhibit or stimulate the growth of *Oenococcus oeni* and other lactic acid bacteria (LAB) in wine. It has been observed that some LAB metabolism could have an influence on wine colour. In this article, some of the relationships between LAB, malolactic fermentation (MLF) and phenolic compounds are summarised; these relationships are important for the selection of LAB to make starter cultures and are of interest for wineries in terms of its effect on wine colour. <<<

Why allow MLF in a wine?

MLF is much more than the decarboxylation of L-Malic acid to L-lactic acid. In many red and white wines, and base wines for sparkling wines, MLF is a desirable bioprocess, because it:
i) decreases wine acidity, especially in red wines from cool climates or white wines with elevated acidity,
ii) improves the organoleptic quality of the wine due to the production of secondary metabolites, and
iii) increases microbiological stability.

Furthermore, the LABs involved in MLF have an influence on the colour and astringency of red wine, although most of these claims are based more on the experience of the winemaker than on scientific evidence[1].

Phenolic compounds as MLF inhibitors

Besides sulfur dioxide (added during the winemaking process), pH, and alcohol content, certain phenolic compounds from grapes have been described as inhibitors of MLF development.
Several studies have shown that, whether studied individually or in a mixture, some phenolic acids and polyphenols (polymers of phenolic compounds) inhibit MLF development. It is currently accepted that there are compounds that can inhibit the growth of LAB while others activate them, depending on their concentration.
For example, among the hydroxybenzoic acids, gallic acid was found to activate *Oenococcus oeni* (*Leuconostoc oenos* IB8413) cell growth and to stimulate MLF at 100 mg/L[2]. No inhibition was detected at concentrations below 1000 mg/L in *O. oeni* strain CECT 4100[3], although other authors have found that gallic acid causes a slight inhibition of *O. oeni* VF at concentrations of 100, 200 and 500 mg/L[4].
When investigating hydroxycinnamic acids, 1000 mg/L of caffeic, ferulic and p-coumaric acids were found to inhibit the growth and MLF yield of the *O. oeni* strain CECT 4100, while 25 or 100 mg/L did not affect the increase in the population except for 100 mg/L of p-coumaric acid[3]. These same acids inhibited the growth of the *O. oeni* VF strain at concentrations of 100, 200 and 500 mg/L[1].

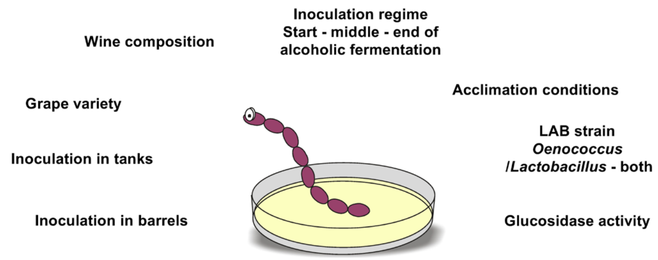

Figure 1. What to consider when inoculating LAB for a successful MLF.

Additional comparisons between these types of compounds and their relationship with MLF can be found in a recent review[5]; for example, the effect of catechins, free anthocyanins, and tannins on the viability of different species and LAB strains.

Influence of MLF on wine colour

In general, it is believed that MLF reduces the colour of wine, although there are some results that prove the opposite. A study carried out on wines of the Chancellor variety showed that the malolactic culture X3 improved the intensity of wine colour and redness[6].

When studying the MLF in Cabernet sauvignon wine, different bacterial strains were associated with a different polymeric pigment content and total anthocyanin concentration, suggesting that the metabolic activity of each strain affects the colour composition according to the wine matrix[5]. More information on the relationship between MLF and wine colour can be found in a recent review[1].

In our working group, we recently carried out an experiment using two strains of *O. oeni* (*O. oeni* ATCC 27310 and UNQOe19), two strains of *Lactobacillus plantarum* (*Lb. plantarum* ATCC 14917 and UNQLp11), and two varietals of *Vitis vinifera L.*: Pinot noir and Merlot[7]. The aims of the experiment were to evaluate the behaviour of the different LABs strains used and the possible colour changes produced after MLF. Our results show that the survival of bacteria and the decarboxylation of L-malic acid differ depending on the LAB strain inoculated and the variety of wine. Furthermore, we found that *O. oeni* can survive in wine even when L-malic acid is not consumed.

Regarding the chromatic characteristics, we found some correlations between MLF and colour-related parameters in Pinot noir, but not for Merlot[7], which would agree with what was proposed by other authors as mentioned above; i.e., the colour changes may be due to the LAB strain and its behaviour in a certain variety (or matrix), which will also depend on the technological process carried out in the vineyard and winery.

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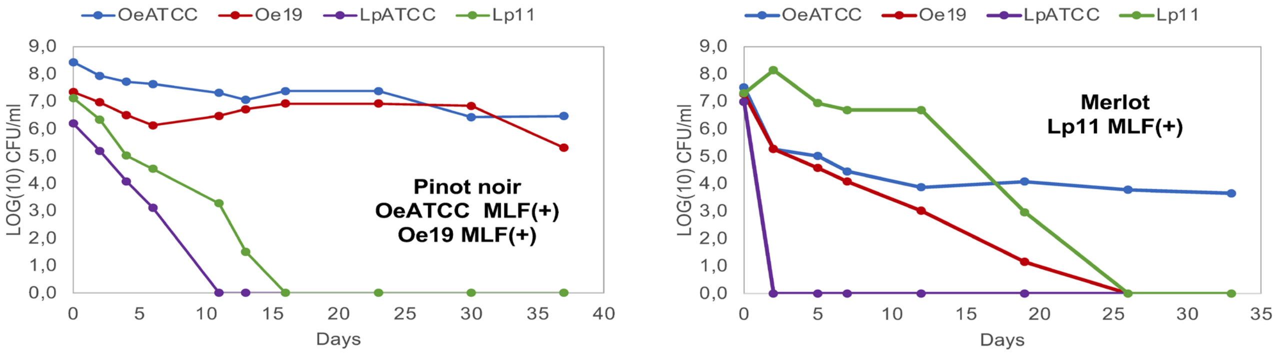

	Pinot noir			Merlot	
	MLF(-)	MLF(+)		MLF(-)	MLF(+)
Total Polyphenolic Index	-	↑		↑	-
Total Anthocyanins (mg/L)	-	↑		↑	-
Colour Intensity	nc	↑		↑↑	↑

Figure 2. Malic acid consumption (FML(+)) or not (FML(-)). Effects on some determining parameters of colour. nc = unclear effect[7].

All these factors could be optimised as we gain more knowledge about the relationships between LAB metabolism and the phenolic compounds present in grapes. In fact, a recent study showed that some strains are better suited to white wines, while other strains seem to be more suitable for red wines[8]. Therefore, it would be interesting to know if some LAB strains are better suited to certain varietals of *Vitis vinifera L.*; for instance, varieties with a short vegetative cycle, such as Pinot noir, or varieties with a long vegetative cycle and with a higher phenolic content, such as Cabernet Sauvignon.

In recent years, a new strategy has emerged to investigate the influence of MLF on the colour and aromas of wine, using the whole matrix and not only ideal or culture media. It has been shown that the changes that occur after MLF depend in part on the container in which MLF is carried out, such as stainless-steel containers or barrels[1]. The micro-oxygenation that occurs in the barrels favours the polymerisation reactions between the anthocyanins. Under these conditions, acetaldehyde is generated, which acts as a link for the formation of polymeric compounds. The result is colour stabilisation and decreased astringency[1]. It would be interesting to analyse what happens when MLF is carried out in other containers; for example, concrete eggs or barrels with a capacity greater than 225 L.

■ Conclusion

We have reviewed some of the interactions that exist between LAB, MLF, and wine colour. It has been observed that the inhibitory or stimulating effect of some phenolic acids depends on their concentration and the inoculated LAB strain. Some results have also indicated that colour will vary depending on the LAB strain used and the variety of *Vitis vinifera L.* with which the wine has been made. The vinification conditions and the maturity of the grapes are probably related to LABs behaviour. Studying the relationship of phenolic compounds and LABs in real conditions is challenging. In general, most of the studies have been carried out in culture media and with specific quantities of the investigated compounds. Increasing knowledge about LABs metabolism in relation to phenolic compounds could help wineries in determining the best moment for LABs inoculation and in using commercial starters or starters selected from the same terroir. ■

Nair Temis Olguin[1,2], Lucrecia Delfederico[1], Liliana Semorile[1,3]

1 Laboratorio de Microbiología Molecular, Instituto de Microbiología Básica y Aplicada (IMBA), Departamento de Ciencia y Tecnología, Universidad Nacional de Quilmes, Roque Sáenz Peña Nº 352, (B1876BXD) Bernal, Buenos Aires, Argentina

2 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Godoy Cruz 2290 (C1425FQB) CABA, Argentina

3 Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC-BA), Argentina

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