The Australian Wine Research Institute

Fact Sheet
WINEMAKING

Using malolactic fermentation to modulate wine style

This fact sheet provides practical information on a range of approaches that may be considered to modulate aroma and flavour of wine using MLF. The information is based on winemaking trials and review of the scientific literature. Please note that how to ensure an efficient MLF is not included in the scope of this fact sheet.

Malolactic fermentation

Malolactic fermentation (MLF) is a critical process in wine production, impacting on operational efficiency, product quality and safety. It is conducted in virtually all red wines, numerous white wines and in sparkling wine bases. The role of bacterial-driven MLF is three-fold: reducing wine acidity; stabilising wine through removal of a potential energy source L-malic acid; and shaping aroma and flavour.

Oenococcus oeni, a member of the lactic acid bacteria (LAB) family, is the main bacterium responsible for conducting MLF, due to its ability to survive the harsh conditions of wine (high alcohol, low pH and low nutrients) and its production of desirable wine sensory attributes.

MLF can ensue from the natural bacterial flora or can be induced via the inoculation of a selected bacterial strain. Timing of MLF inoculation can be at any time during alcoholic fermentation (AF), including with yeast (co-inoculation), mid-AF, at pressing, or most commonly, post-AF (sequential inoculation).

In addition to the important conversion of L-malic acid to L-lactic acid, MLF is associated with a broad range of other metabolic processes that impact on a wine's sensory profile.

What sensory outcomes can MLF modulate?

Wine aroma and flavour are affected by volatile compounds, while non-volatile compounds influence the palate or mouth-feel of wine. Sensory terms such as 'buttery', 'vanilla-like', 'nutty', 'spicy', 'fruity', 'vegetative', 'toasty', 'fuller' and 'rounded' are used to describe MLF influences on wine.

MLF and winemaking variables which can be used to modulate sensory attributes include:

- Choice of bacterial strain
- Timing of MLF inoculation
    - Sequential (i.e. after alcoholic fermentation)
    - Simultaneous with yeast (co-inoculation)

Sensory attributes that can be modulated via MLF and bacterial metabolism include:

- Buttery character
- Fruity characteristics
- Mouth-feel
- Oak character

Diacetyl – buttery aroma

One of the major compounds produced by *O. oeni* during MLF is diacetyl which contributes to the buttery or butterscotch aroma and flavour of wine. Diacetyl is formed through the metabolism of citric acid and is produced at concentrations which are often above sensory threshold (white wine 0.2 g/L; red 0.9-2.8 mg/L).

The sensory perception of diacetyl is dependent not only on concentration (high concentrations will be overtly buttery and considered undesirable) but also on the presence of other wine compounds – butteriness can be masked by strong oak or very fruity characters.

The formation of diacetyl during winemaking is well understood and can be relatively easily managed with various winemaking techniques. These are outlined in Table 1.

Table 1. MLF winemaking techniques that can be used to enhance or diminish diacetyl concentration in wine.

Winemaking factor	Effect on diacetyl in wine
Choice of *O. oeni* strain	Variable; some strains able to produce high concentrations
Inoculation rate	High *O. oeni* numbers – lower concentration Low *O. oeni* numbers – higher concentration
MLF duration	Longer MLF – higher concentration
Temperature	18°C – higher concentration 25°C – lower concentration
Oxygen	Anaerobic – lower concentration
pH	Lower pH – supports formation
Yeast lees contact	Long contact – lower concentration

Fruity character

The berry fruit aroma characteristics of red wine vary according to grape variety and winemaking style. Descriptors that are associated with MLF include red berry (e.g. raspberry, strawberry, red cherry) and dark berry (e.g. mulberry, blackberry, plum).

Red wine berry fruit aroma is a complex interaction between fruity esters, norisoprenoids, dimethyl sulfide, ethanol and other components. Strains of *O. oeni* have been shown to vary in their ability to generate or release these compounds. Certain *O. oeni* strains consistently enhance the fruity/berry characters in red wine. Recent trials have demonstrated that wine matrix composition, especially pH, can influence *O. oeni* metabolism during MLF, resulting in the production of different concentrations of these crucial esters in wine.

Timing of MLF inoculation – effects on fruity and buttery properties

Trials in Shiraz and Cabernet Sauvignon have established that timing of MLF inoculation can influence the fruity characters of the wine. Red wines produced using co-inoculation of MLF with AF were rated as more fruity by a sensory panel. This was consistent with higher concentrations of the esters which contribute to red wine fruity characters. Recent research in other varieties (Malbec, Chardonnay and Riesling) has also shown that co-inoculated MLF resulted in wines with a fruitier character than in wines produced with sequential MLF.

Co-inoculated MLF would be expected to produce wines with lower buttery character, as yeast are able to metabolise diacetyl to acetoin and 2,3-butandiol, which have high sensory thresholds. In addition, a faster MLF tends to result in lower diacetyl concentrations.

Choice of *Oenococcus oeni* strain

Even though a range of wine-associated LAB species are able to convert L-malic acid to L-lactic acid, *O. oeni* is the preferred LAB species for conducting MLF. *O. oeni* is known for the production of desirable sensory characters whereas other wine LAB tend to be associated with wine spoilage. However, recent trials in Cabernet Sauvignon and Malbec have shown that some strains of *Lactobacillus plantarum* are able to conduct an efficient MLF and also produce desirable sensory attributes in red wines.

Table 2. *Oenococcus oeni* strain characteristics that impact on wine aroma and flavour.

Strain descriptor	Wine sensory impact
Neutral	Minimal influence on flavour impact compounds
Buttery	Production of diacetyl
Fruity	Enhanced ester and norisoprenoid production
Mouth-feel	Impact on components affecting wine 'body' and astringency
Glycosidase	High activity can result in liberation of fruity, floral notes, and enhance oak character (when oak is used)

Summary

Through ongoing research, there is a better understanding of how to use MLF to influence wine style. Choice of *O. oeni* strain, as well as timing of bacterial inoculation can be used to modulate MLF character in wines, including buttery or fruity/berry aromas and mouth-feel attributes. A summary of the ability of different strains to influence aroma and flavour characteristics during MLF is available on the AWRI website.

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