MATURATION OF CIDER BY MALOLACTIC FERMENTATION

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The making of the original type of cider sometimes includes a maturation process. Originally, this maturation appeared naturally in the oak vats, but now pure cultures are available for this so-called malolactic fermentation (MLF). A short literature review is given and results from trials in product development of a Danish cider are presented.

Traditional cider is often matured in oak vats, which contain the lactic acid bacteria responsible for the malolactic fermentation

Like in wine, traditional cider often undergoes a secondary malolactic fermentation, whereby lactic acid bacteria convert malic acid into lactic acid. The sharp acidity of malic acid from the apples is substituted by the more soft acidity of lactic acid. The dicarboxylic acid malic acid is decarboxylated into the monocarboxylic acid lactic acid and carbon dioxide. The reaction is catalysed by the enzyme MLE (malolactic enzyme). In *Lactobacillus collinoides*, the enzyme is found to have a pH-optimum of 4.9 and was repressed by apple sugars. Other organic acids play an important role during maturation. Quinic acid and shikimic acid are converted to dihydroshikimic acid and acetic acid and succinic acid are produced by the lactic acid bacteria. Even a decrease in lactic acid has been observed.

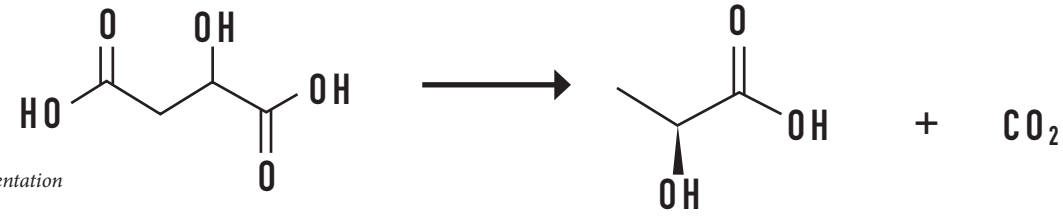
The lactic acid bacteria responsible for the MLF are found in the oak vats. The predominant lactic acid bacteria are found to be *Lactobacillus plantarum* in English cider vats and *Oenococcus oeni* (former *Leuconostoc oenos*) in French cider. In Spanish cider, *Oenococcus oeni* (*Leuconostoc oenos*) and *Lactobacillus* species have been found responsible for MLF. Other lactic acid bacteria belonging to the genera *Lactobacillus*, *Leuconostoc* and *Pediococcus* have also been identified. The MLF is reported to appear above 1 million cells/ml of lactic acid bacteria. Application of a malolactic starter culture of *Oenococcus oeni* on an industrial scale was performed with success in production of Spanish cider.

In English and French cider making, the MLF takes place after the alcoholic fermentation. In Spanish cider, it is reported to take place simultaneously with the alcoholic fermentation. Inoculation with pure yeast and bacterial cultures in Spanish cider shows that sequential fermentations are preferred to simultaneous fermentations. Yeast extract and fermentation lees are reported to have a positive impact on MLF. The maturation normally takes from one to four months, but up to two years is practised.

The optimal storage temperature for English cider was found to be 15 °C and to be 22 °C for Spanish cider. In England, the cider is normally matured at room temperature, while in France, the temperature is lower at 10-15 °C. Dissolved oxygen in the cider during storage was found to give undesirable oxidation flavours. Re-constituted concentrate was found not to promote the desirable flavour changes as fresh apple juice did, due to the lack of MLF.

Continuous culturing of lactic acid bacteria for malolactic conversion has been made with success. Differences in growth kinetics were found between *Oenococcus oeni* and *Lactobacillus brevis*.

In laboratory scale, successful trials have been performed with immobilisation of yeast and lactic acid bacteria in order to obtain simultaneous alcoholic and malolactic fermentation. *Saccharomyces cerevisiae* and *Lactobacillus plantarum* have been co-immobilised on a sponge-like matrix, *Oenococcus oeni* (*Leuconostoc oenos*) has been immobilised in Ca-alginate and *Saccharomyces bayanus* and *Oenococcus oeni* (*Leuconostoc oenos*) have been co-immobilised in a Ca-alginate matrix. However, a lower content of higher alcohols and a higher content of diacetyl have been found. Immobilisation of *Oenococcus oeni* in alginate beads showed better flavour characteristics than free cells. Immobilisation in general improves separation.

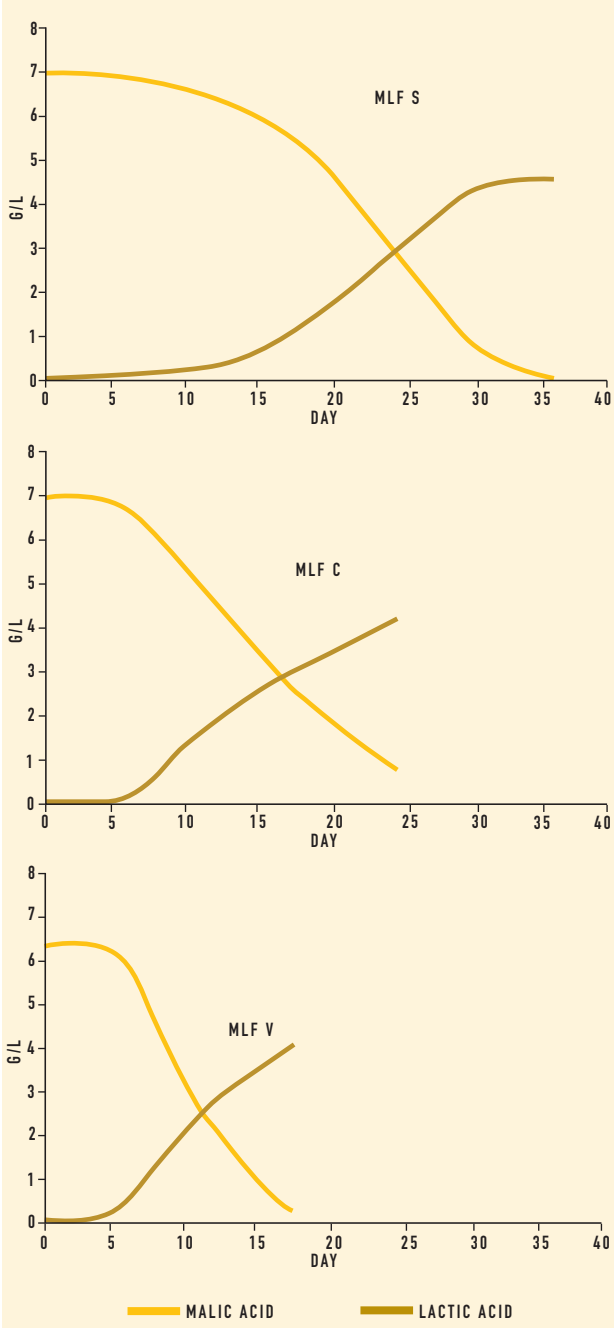


The process of malolactic fermentation

In a previous paper, an overview of the entire process of cider making has been given.

PURE LACTIC CULTURES

In trials at the author's private premises, MLF was obtained applying pure cultures of *Oenococcus oeni* added after the main fermentation. The conversion took 11 days without sulphiting the juice before the main fermentation and up to 21 days if up to 60 ppm sulphite was added before the main fermentation. →



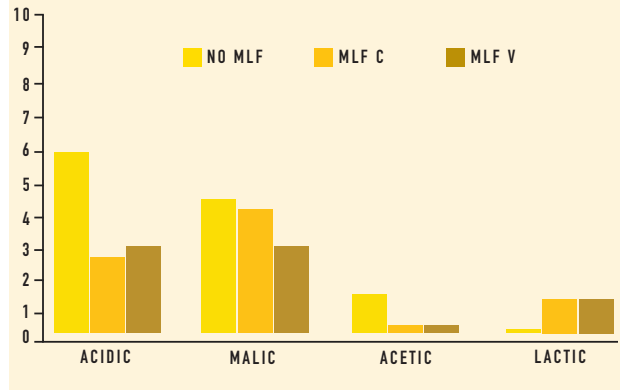
Conversion of malic acid to lactic acid by 3 different strains of Oenococcus oeni

During the product development of a Danish medium dry cider, trials were made to establish whether a malolactic fermentation were to take place in order to improve the flavour of the product. Trials were made with three different strains of a pure culture of the lactic acid bacteria *Oenococcus oeni*:

- MLF S: a lactic culture used only for trials – not commercially available
- MLF C: a lactic culture for maturation of cider
- MLF V: a lactic culture for maturation of white wine

An apple juice at 11.5 °Brix was added a pure yeast culture and fermented to dryness at 15 °C. The cider was then split into three batches, to which each of the three pure lactic cultures was added. The conversion of malic acid to lactic acid was followed during the maturation.

The trials showed that MLF V was faster in converting malic acid than MLF C, which again was faster than MLF S. A similar situation can be seen for initial lag period before the fermentation begins. MLF V was selected for production, during which the MLF takes two to three weeks.



Sour taste sensations for cider with and without malolactic fermentation (scale 0-10)

The trials and later productions have all showed that a quantitative conversion of malic acid into lactic acid takes place. In the apple juice, there is typically 7.0 g/l malic acid, which is converted into 4.7 g/l lactic acid (52 mM). During the conversion, pH raises from typically 3.0 in the fermented juice to 3.5 in the matured cider.

TASTE TESTING

Triangular taste testings were performed to establish if the MLF had any effect. The tests showed a significant difference between no MLF and MLF C with a preference for MLF C. Triangular tests also showed a significant difference between MLF C and MLF V, but with no preference.

A profile tasting was performed by a panel of trained beer tasters. The sour taste sensations malic (apple), acetic (vinegar), acidic (citric, sour) and lactic are pictured above.

The taste is significantly more acidic and slightly more acetic without MLF when compared to the two lactic cultures MLF C and MLF V. The lactic acidity in the MLF treated ciders is at a low level. The difference in malic acidity is not significant.

CONCLUSION

The product development can be concluded as follows:

During the malolactic fermentation, malic acid is quantitatively converted into lactic acid. The rate of conversion depends on the strain of lactic acid bacteria. There is an increase in pH during the MLF.

It is possible to taste if the MLF has taken place due to a decrease in acidity. Cider with MLF is preferred to no MLF. There is a difference between the pure lactic acid culture strains.

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REFERENCES

The author of this article has a complete list of references for the background statements and results referred to in this article which can be obtained by contacting the author.