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Pre-fermentation heat treatment: a multitool technique to keep the pot boiling

>>> First industrially developed in the 1970s to process botrytised grapes, the pre-fermentation heat treatment of grapes is becoming more and more popular to produce fruit-driven wines. Several conditions, such as the time and the temperature of heating or the conditions of fermentation itself, have been proposed to modulate the aroma of thermovinified wines and adapt their profile to consumer demand. Based on research results obtained during the last decade, this article provides a short, up-to-date review of the impact of this technique on wine aroma. <<<

■ Thermo or not thermo?

Pre-fermentation heat treatment is best known as thermovinification. However, for the purists, this term only refers to heating performed for a short period, typically for less than 1 hour. If the heating is extended over a longer period - up to 24 hours - it is known as hot pre-fermentation maceration. Heating conducted at a temperature of between 70 °C and 85 °C allows phenolic compounds - mainly anthocyanins and to a lesser extent hydrophobic tannins - to be rapidly extracted in the aqueous phase. In practice, this low tannin/anthocyanin ratio in thermovinified wines can often lead to colour instability, especially when the heat is not maintained for long enough[1]. To enrich the must in tannins, and therefore to improve colour stability, winemakers frequently add fresh oak chips or oenological tannins to the grapes before heating. Heating also helps extract grape polysaccharides, which are responsible for the roundness of wine[2].

Pre-fermentation heat treatment is often followed by pressing, clarification and fermentation of the liquid phase at temperatures generally below 20 °C. This heat treatment was originally used on *Botrytis*-infected grapes to eliminate laccase activity. Another advantage of the maceration heat treatment is that it quickly removes grape skins and therefore decreases the need for fermentation vessels. Heated musts are characterised by high-solids content, which can lead to clarification difficulties. Nowadays, the traditional rotary-vacuum drum filter is still the most frequently used technology by winemakers to clarify thermovinified musts (< 100 NTU). However, other technologies such as cross-flow filtration, centrifugation and flotation are growing in popularity. A variant of the maceration heat treatment, used to obtain a higher extraction of polyphenolic compounds, consists of fermenting grapes after heating with pomace as a standard vinification process[1].

The heat treatment can also be combined with specific technologies, such as flash release or thermo-release. The former consists of heating the grapes, often using the steam produced from the water present in the grapes, and then placing them under a strong vacuum (≈ 50 mbar) which results in rapid vaporisation.

Figure 1. Example of an opened thermovinification equipment with a large surface of evaporation that enables the elimination of a substantial amount of 3-isobutyl-2-methoxypyrazine (©Claude Cruells).

This vaporisation induces a cooling of the grapes to 30-35 °C and a disruption of the cell walls, which results in greater extraction of phenolic compounds. For the thermo-release process, grapes are heated, put into a pressure chamber and subjected to overpressure (≈4 bars), followed by quick depressurisation to atmospheric pressure. This fast reduction in pressure contributes to disruption of the grape cell walls, thus favouring extraction.

■ Towards a better understanding of the aroma of such wines...

The pre-fermentation heat treatment is often reputed to result in wines that have a standardised sensory profile described as "banana yogurt" by winemakers. The impact of the technique on wine aroma is complex as several mechanisms are potentially involved such as extraction, evaporation, likely degradation of aroma precursors and/or free compounds, denaturation of enzymes involved in the release of glycosidically bound fractions or changes in must and notably nitrogen composition[1, 3, 4, 5]. In most cases, such impacts are hard to predict and to generalise, because the heat extraction of compounds from the skin (i.e., aroma or precursors) is strongly dependent on the cultivar and the vintage conditions[1, 5].

For example, maceration heat treatment has been shown to significantly reduce, through evaporation, the amount of the green pepper compound 3-isobutyl-2-methoxypyrazine (IBMP), which has a boiling point of about 50 °C[5]. Some industrial equipment, opened and with a large evaporation surface, have been developed to take advantage of this physical property and remove a considerable amount of IBMP (Figure 1). Pre-fermentation heat treatment conducted in the aqueous phase does not favour the extraction of the hydrophobic sesquiterpenoid rotundone responsible for the peppery character of red wines, as its extraction requires the solvent effect of ethanol[6]. Heating followed by pressing at a high temperature, usually just below 70 °C, induces a greater

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extraction of amino acids from the berry skins: from + 101 % to + 200 %, depending on the grape cultivar in a 2-hour treatment at 70 °C (Figure 2). This leads to an enhanced formation of fermentation aroma compounds, such as fatty acids, thus imparting lactic notes, fruity esters, and acetates, while limiting the production of fusel/higher alcohols[1]. In most cases, the technique has resulted in a loss in monoterpenols and norisoprenoids associated with the floral and fruity characters of wines, and some volatile phenols. This decline in concentration is coupled to an increase in known degradation products of these latter molecules, suggesting the involvement of thermal degradation[1, 5]. Other varietal compounds, such as volatile varietal thiols (responsible for passionfruit, grapefruit and tropical fruit aromas particularly in white and rosé wines), have shown no significant differences between heat treatments and traditional vinification with the pomace[1].

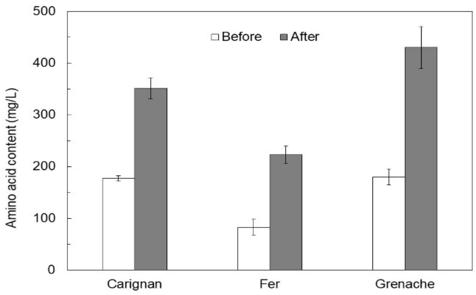

Figure 2. Amino acid content of the must before and after a 2-hour pre-fermentation heat treatment of grapes at 70°C followed by a pressing at hot temperature for 3 grape varieties. Means of 4 replicates. Adapted from Geffroy *et al.* (2015)[1].

■ And towards a better tuning of the sensory profiles of thermovinified wines

The modulation of the sensory profile of thermovinified wines towards a fruiter varietal character is a frequently expressed demand by winemakers. To reach that objective, two levels of must clarification (150 and 800 nephelometric turbidity units or NTU) and fermentation temperature (18 °C and 25 °C) were previously investigated[8]. Both factors had an overall limited impact on the aroma composition of the wines. However, wines fermented at 25 °C had a less intense banana aroma and were judged to be more complex in the sensory analysis. Minor differences limited to mouthfeel and taste perception were observed between wines made at different clarification levels.

Limiting the heating temperature to 50 °C appears to be a more promising strategy for restricting amino acid extraction, thermal degradations, and the volatilisation of aroma compounds. To achieve a similar phenolic compound content to a standard heat treatment, this obviously involves extending the duration of heating. In most cases wines made from grapes treated at 50 °C contained larger concentrations of monoterpenols, norisoprenoids and volatile varietal thiols in comparison with a 75 °C treatment (Figure 3)[5]. Nowadays this strategy is seen as conceivable as thermovinification is mainly employed on healthy grapes without *Botrytis cinerea*. Another advantage is that it reduces the environmental impact and the cost of the process by saving energy when heating the grapes and cooling down the musts after pressing.

Based on a similar principle, partial flash release is another interesting approach[7]. After a heat treatment at between 70 and 85 °C, this variant of flash release consists in applying only a partial vacuum (≈700 mbar), which quickly drops the grape temperature to 50-55 °C. Pectolytic enzymes are then usually added and maceration with the pomace is maintained for up to 12 hours.

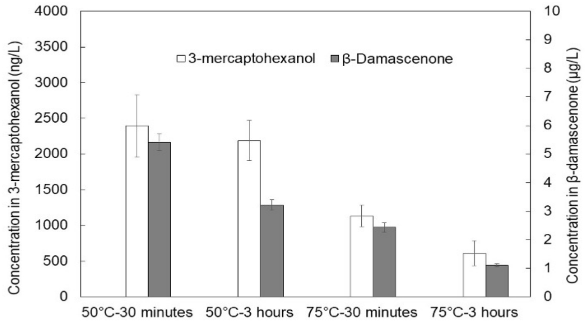

Figure 3. Impact of two temperature levels (50°C and 75°C) and heating times (30 minutes and 3 hours) on the concentration in 3-mercaptohexanol and β-damascenone of Carignan wines. Means of 2 replicates. Adapted from Geffroy *et al.* (2018)[5].

In comparison with a simple heat treatment at 50 °C, it has the advantage of being suitable for processing botrytized grapes and maximising the extraction of anthocyanins and proanthocyanidins.

Alternatives to the pre-fermentation heat treatment, such as nanofiltration, pulsed electric fields, ultrasound and microwave technologies, have been the subject of much research over the past few years[8]. Even if some industrial equipment is already available, the poor penetration rate and the limited use of these technologies in wineries tends to show that pre-fermentation heat treatment still has a bright future ahead. ■

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