Ask the AWRI - Carbonic maceration

During the 2016 and 2017 vintages, the AWRI made small-lot Pinot Noir and Shiraz wines from single batches of fruit, demonstrating the effects of changing one winemaking variable at a time. During tastings of these wines presented across Australia, many winemakers have asked why there are such large sensory differences between wines made with 100% pure carbonic maceration and those made with the more common semi-carbonic maceration treatment or whole bunch fermentation. This column explores what is happening during carbonic maceration.

What is carbonic maceration?

Carbonic maceration involves placing 100% intact whole bunches of grapes, with absolutely no free grape juice, in a closed fermentation vessel filled with carbon dioxide. A range of intracellular reactions occur within grape berries that are treated in this way. These reactions are conducted by enzymes in the complete absence of oxygen, and independent of any yeast or microbial activity. The enzymatic reactions occur over approximately a week at temperatures up to 35°C, after which time they cease due to the small amount of alcohol produced. The fruit is then destemmed and crushed and fermented with yeast under normal winemaking conditions.

Why do it? What impact does it have on wine?

Carbonic maceration wines have a distinctive aroma which often polarises tasters. The aromas can be described as 'fruity' or 'musk-like', with 'strawberry/raspberry' and 'cherry/kirsch' aromas (particularly in Beaujolais wines), but also with 'vanilla', 'spice', 'almond', 'cinnamon', 'sandalwood' or 'oak-like' characters. These characters often override any varietal fruit character, but conversely can also add aroma to wines with low varietal or fruit character.

The wines are generally softer, less acidic and have lower extraction of phenolic compounds. They are reported to mature faster than traditionally fermented wines. As such, historically the technique has been recommended for lighter bodied/fruity wines intended for early consumption. There are reports that Australian winemakers are experimenting with carbonic maceration or partial whole bunch ferments in Pinot Noir and Shiraz to produce more elegant and perfumed wines, and to aid as blending options.

How do you do it?

Michel Flanzy invented the original technique in 1934. A modified version, patented by Stephen Hickinbotham in 1986, involves whole grape bunches placed into a plastic bag supported by a pallet box, into which a small quantity of dry ice in an insulated container has already been placed. The plastic bag is then sealed and sometimes fitted with a one-way valve to allow carbon dioxide to escape but to prevent entry of air.

Carbonic maceration character and structure occur best if grapes are kept at temperatures around 30-32°C for 5-8 days. At lower temperatures, more subtle and short-term aromas are produced, but the intensity of the character can vary depending on grape variety or wine style. Carbonic maceration takes place more readily in a gaseous atmosphere, so the volume of juice released by the berries is often inversely proportional to the degree of carbonic maceration flavour (Sneyd 1989). With increased juicing, and more aerobic conditions, fermentation by yeast and bacteria can occur, with the resulting flavours, and those from stem contact, limiting or overriding those from the carbonic maceration.

What reactions are happening within the berry and how do they affect flavour?

Carbon dioxide is absorbed by the grape berries, filling the berry to around 50% of its volume. Reactions within the berry, which is still a living entity whilst intact, shift from a respiratory to an anaerobic metabolism.

The enzyme malic dehydrogenase plays a key role in carbonic maceration, by metabolising malic acid into ethanol, succinic acid and aminobutyric acid but without producing any lactic acid (Flanzy et al. 1987). This results in a decrease in titratable acidity and an increase in pH.

Grape alcohol dehydrogenase transforms sugar into ethanol and carbon dioxide. Only 0.5-2.2% of ethanol is produced, possibly because at this concentration the ethanol begins to disrupt the cell membrane integrity. The quantity of carbon dioxide produced during the first 24 hours is approximately the same as that absorbed.

Glycerol and shikimic acid are produced, with shikimic acid accumulating within the berry, and then degrading to cinnamic acids, and further to the three main aroma compounds associated with carbonic maceration: benzaldehyde (‘cherry’, ‘kirsch’, ‘almond’), vinylbenzene (‘styrene’, ‘plastic’) and ethyl cinnamate (‘cinnamon’, ‘strawberry’, ‘honey’) (Ducruet 1984). Other enzymes can produce volatile aromas that may also contribute to carbonic maceration flavour, including ethyl and methyl vanillate (‘vanilla’), ethyl 9-decenoate (‘sweet’, ‘fruity’, ‘quince’) and 1-octanol (‘almond’/’buttery’).

Carbonic maceration wines often exhibit lower primary fruit flavours, and this could be because the concentrations of some common wine esters are lower in these wines. For instance, hexyl acetate (‘fruity’, ‘green’, ‘pear’) only forms in an oxygen-rich environment during crushing, so its production would be limited in the anaerobic environment of carbonic maceration.

What are the effects on phenolics?

The extraction of phenolics, such as anthocyanins and tannins, from grape skins is different during carbonic maceration compared to standard winemaking. While in both methods ethanol acts as a solvent for the extraction of phenolics, in standard fermentations, a greater proportion of skin and seed contact time occurs at higher alcohol concentrations than with carbonic maceration, resulting in greater extraction of anthocyanins and tannins. Etaio et al. (2008) suggest that with carbonic maceration, anthocyanins diffuse from the skin into the pulp, which can be seen to turn the flesh pink. Extraction of any tannin into the pulp at low alcohol concentrations would also more likely be skin tannin rather than seed tannin, which could lead to a perception of softer tannin in the wine.

Are there any risks involved in carbonic maceration?

Risks of spoilage by acetic acid bacteria and Brettanomyces yeast are increased during carbonic maceration due to the higher pH, elevated temperatures and absence of sulfur dioxide. Additionally, if a carbon dioxide-rich environment is not adequately maintained, aerobic microorganisms can quickly take over, again causing wine spoilage.

For further information contact the AWRI helpdesk on (08) 8313 6600 or helpdesk@awri.com.au

References

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