AVOIDING "GREEN" CHARACTERS IN CABERNET SAUVIGNON

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Many grape growers possess the ability to produce fantastic Cabernet Sauvignon fruit. However, even for the best viticulturists each new season presents challenges with respect to the reproducibility of a characteristic flavour and aroma spectrum.

Cabernet Sauvignon is believed to be a close relative to the wild *Vitis vinifera* varieties (McGovern et al. 2000). It can grow rapidly and loves to put its carbohydrates into shoots, which may lead to shading of the grape bunches. The grapes have thick skins full of colour and phenolics with a high seed to pulp ratio of 1:12 (compared to eg Semillon having a ratio of 1:25). Due to a generally higher number of seeds and also a high skin to pulp ratio, it is important to pay attention to seed and skin maturity.

Cabernet Sauvignon has a tendency, generally more so than other reds, to produce a strong "green" herbaceous character, which, when in excess, is likely to impart an unpleasant flavour and aroma to red wines. It can be influenced by management practices, if the origin of this flavour is understood.
The herbaceousness can be caused by methoxypyrazine (predominantly green pepper type herbaceous), certain unripe monomeric phenolics (mainly bitter-herbaceous) or polyunsaturated fatty acid derivatives like hexanal and hexenal (hay type herbaceous).

Green Pepper type herbaceous notes:

The compound methoxypyrazine, which is the primary cause of a green pepper type herbaceous aroma in Cabernet Sauvignon wine, has a very low perception threshold of 2 ng/l (Ribereau-Gayon et al. 2000), which is equivalent to 2 berries in a million tons of grapes. Only a few laboratories in the world are equipped to measure methoxypyrazine, but the human nose can easily detect it at e.g. 15 ng/l. French researchers have found methoxypyrazine to be very water-soluble, so extraction in the vat happens very quickly. Pressing time, skin contact or pumping over had very little influence on final concentration (Roujou de Boubée et al. 2002).

In the vine plant, methoxypyrazine content can be very high in stems and leaves. A large proportion of leaves in the crush, or stems being exposed to significant extraction could lead to higher levels of methoxypyrazine. The content of methoxypyrazine in the parts of the berry changes with time. Unripe seeds contain methoxypyrazine, so if seeds are still unripe at harvest they can impart green pepper-like aroma to the wine. After veraison, seed contents of methoxypyrazine decline and may be negligible at harvest, whereas the compound may still be present in the skins. Skin methoxypyrazine levels naturally decline, however this decline depends on the mesoclimate, soil and management practices.

Australian research has shown that in cloudy locations, or in shaded clusters, the natural methoxypyrazine degradation during ripening is slower. There was a linear relationship between layers of leaves over bunches and methoxypyrazine concentrations at harvest. Highest contents were found under 3 leaf layers and lowest in fully exposed bunches (Allen et al.1995). Thus, bunch exposure assists in getting lower capsicum characters in Cabernet Sauvignon, but in warm regions there is always a danger of excessive heat loads and sunburned fruit in fully exposed bunches.

In Bordeaux, Roujou de Boubée and colleagues (2000) found that, under similar light exposure of bunches, better-drained soils led to a faster decline in methoxypyrazine levels than less well-drained soils. It would be of interest to investigate the effect of hormonal signals in response to abundance or lack of water and nitrogen and their effect on methoxypyrazine decline.

The group in Bordeaux also found in a two-year study that on the same soils, despite more sunshine during the second year, methoxypyrazine was higher at harvest. They attributed this to the higher rainfall before and after veraison in that year. These researchers also made an interesting discovery for practical viticulture as they found that the decline of methoxypyrazine in berries followed almost exactly the same curve as the decline of malic acid, which can, in contrast to methoxypyrazine, be more readily measured in a lab or with test sticks.

Summary - avoiding high methoxypyrazine levels at harvest:

- High water contents in soils before and after veraison seem to delay or offset methoxypyrazine degradation — soil moisture monitoring is important to ensure neither too much nor too little moisture at this crucial phase.
- Sun exposure of bunches speeds up natural methoxypyrazine decline. It is very important to check vine balance before veraison eg in the form of leaf area to expected fruit weight ratios (Winter and Whiting, 2004) to prevent excessive canopy development which leads to fruit shading. Some trellis structures are more beneficial than others in this respect (Smart and Robinson, 1991)
- Removal of leaves, which shade clusters, when done well before veraison, can be used to decrease methoxypyrazine concentrations. In order to avoid sunburn in warmer areas, it has been shown to be beneficial to have some canopy shade from the midday sun but exposure to morning and late afternoon light (Winter and Whiting, 2004). This works best with N-S row orientation.
- The decline of methoxypyrazine after veraison follows the decline in malic acid. As malic acid is decomposed faster as night temperatures increase, warm nights may assist in reducing methoxypyrazine levels.
- Unripe seeds have high methoxypyrazine levels. Seed ripening seems to need continuous warmth on bunches but no excessive heat loads (maintaining bunches at less than 35^{o}C) and optimum soil moisture. Berry sensory analysis before harvest can reveal lack of seed ripeness (Winter et al. 2004).
- Duration of skin contact in the vat does not appear to be crucial, but avoiding leaves and stems in the crush is important.

Bitter herbaceous flavour:

Phenolic compounds can impart bitter tasting herbaceous flavours to grapes and wine. Monomeric, dimeric and trimeric phenolics in grapes and wine may evoke herbaceous bitterness as a taste sensation in the mouth. Phenolics in seeds and skins serve as building blocks for seed encasement, and other protective purposes (Winter, 2001). These compounds increase rapidly in the seeds and skins about two to three weeks before veraison (Blouin and Gimberteau, 2000, Downey et al. 2003). Viticultural practices may well influence their quantity and quality. Ripe skins have a high proportion of polymeric phenolics which either have associated with anthocyanin to become tannins which possess an astringent mouthfeel and no bitterness or have bound to polysaccharides or proteins inducing a softer mouthfeel sensation. Ripe seeds have very few bitter phenolics left and contain high amounts of tannins which taste like dark toasted bread or coffee beans when ripe.

Drought stress after veraison, lack of functional leaves or uneven shoot growth with too few leaves on some shoots resulted in an increased proportion of bitter phenolics in Cabernet Sauvignon wines from an Australian tannin research project (Iland, 2003).

Regulated Deficit Irrigation (RDI) after fruit set shortens the cell division phase (McCarthy, 2003). This mainly reduces berry size. However, if this stress is extended for too long (well into veraison) or is too harsh, phenolic production (Kennedy et al. 2000) or development may be disturbed. Cabernet Sauvignon, which has high levels of phenolics in skins and many seeds, may need a different RDI treatment compared to, for example, Shiraz (pers. comm. McCarthy).

The influence of vine balance on phenolic development of Cabernet Sauvignon possibly warrants special attention. Desirable phenolic and sugar levels were achieved only when a relatively high leaf area to fruit weight (14 cm^2/g) was ensured in Italian Cabernet Sauvignon (Poni and Giacino, 2003).

The effect of degree of bunch exposure and "hang time" on phenolic ripening is currently being investigated in several countries. Monitoring biologically active degree hours (a summation of optimum temperature time for grape bunches) may provide a new tool to monitor phenolic development (Hamilton et al, in prep.).

Summary — enhancing phenolic maturity:

- Extremes of water availability before and after veraison may cause imbalances in the phenolic development of the fruit. Measurement of vine and soil water status is important, in particular if RDI is practised.
- Vine balance is crucial. Low leaf area to fruit weight seems to have a negative effect on phenolic mouthfeel in the wine.
- Bunch temperature seems to influence phenolics. Bunch exposure can be influenced through vine vigour, foliar management, trellis type, row orientation and spacing. Berries should be in the optimum range for enzyme activity (15-35^{o}C) as many hours of the day and as may days during the year as possible. Thus, open canopies and leaf removal in the fruit zone are beneficial in cooler winegrowing areas as they provide more hours of warmth on fruit. During hot spells or in warmer areas, clusters may need additional foliage-wire manipulations providing dappled midday light on bunches.

"Hay-like" herbaceous flavour:

Little is known about viticultural practices that influence the formation of grape lipids, the precursors of these herbaceous aromas. They are produced in green tissue such as stalks and unripe berries. Formation of these herbaceous flavours involves the activity of lipoxygenases and hydrolases before and during fermentation.

The quantity of these enzymes depends on the amount of green matter at harvest, the enzyme inhibition by SO_2 after harvest, and contact of the berries with oxygen. Post-harvest handling of grapes, which reduces oxygen contact, is a preventative measure against hay type green characters (Flanzy, 1998).

Concluding Comment:

In concluding this account of the links between viticulture and "green " wine flavours it is interesting to note that in a study of Cabernet Sauvignon wines from 6 sites in New Zealand, the two wines with the highest tasting scores had very low (5.7 ng/L) and very high (15.9 ng/L) methoxypyrazine levels (Tesic et al. 2002). The distinguishing sensory traits of the two outstanding wines compared to the wines from other sites were the fine tannins (and blackberry notes). In both wines, the high tannin scores were positively correlated with the rate at which malic acid levels in the berries decreased. The faster rates of malic acid decline may have been due to the relatively drier soils of the two sites in that year. Such fast decline of malic acid and such high tasting scores could not be achieved on the same sites in the subsequent year with high rainfall before veraison.

Water management is one of the big tools in grapevine quality management. Soil moisture monitoring should be accompanied by plant internal indicators of water status. Malic acid decline in bunches may be used as a new marker, in particular for methoxypyrazine decomposition and phenolic ripening. The French authors, Blouin and Guimberteau (2000) note that, in Bordeaux, observed over 74 years, malic acid levels in Cabernet Sauvignon were a good indicator of the ripening characteristics of each year.

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