Technical notes

Exploring the effects of extended post-fermentation maceration

Since 2016 the AWRI has conducted an annual winemaking trial where a single batch of grapes is divided into smaller lots and one winemaking variable is changed in each fermentation. This produces a range of wines with differing sensory qualities, which are presented in workshops staged across Australia. One of the treatments included in the 2016 and 2017 trials (on Pinot Noir and Shiraz) was extended post-fermentation maceration. This involves leaving the grape skins, seeds and any stalks in contact with the wine for a length of time after the primary fermentation has ended, with the goal of optimising colour, flavour and tannin structure. The technique is essentially only used in red winemaking and increases the extraction of phenolic compounds from the skins and seeds. This article reviews some of the literature available on the effects of this relatively common winemaking treatment.

Varieties and length of time

Post-fermentation maceration can be applied to many red varieties and is a traditionally used in several European wine regions including Burgundy with Pinot Noir, Bordeaux with Cabernet-family varieties, Piedmont with Nebbiolo, and to a lesser extent the Rhône Valley with Shiraz and associated varieties. In Australia, the technique is most commonly used with Cabernet Sauvignon, followed by Shiraz, Merlot and Pinot Noir, and to a much lesser extent with other varieties (Joscelyne 2009).

The optimal length of maceration depends on the variety and the season, with the initial concentration of grape phenolic compounds and their extractability being two key variables. However, there is no clear formula for determining the ideal length of the maceration, which in the literature varies from a few days (Schmidt and Noble 1983) to two months or more (Yokotsuka et al. 2000). Previous winemaker experience with the variety and region, as well as recognition of seasonal differences in fruit composition, appear to be important factors in determining the ideal length of maceration.

Changes in wine composition caused by extended maceration

Anthocyanins and phenolics

The greatest changes in wine composition as a result of extended maceration are an increase in total phenolics and a decrease in anthocyanins, as they are incorporated into non-bleachable pigments including pigmented tannins. Scudamore-Smith et al. (1990) demonstrated a negative correlation between the concentration of anthocyanins retained in the finished wine and the length of maceration. During fermentation, anthocyanin extraction is found to

occur rapidly up to days four or five, with little increase in anthocyanin concentration seen after day 10 (Sacchi et al. 2005). Work by Kudo and Sodeyama (2002) demonstrated that Cabernet Sauvignon wines made with 44 days of maceration contained a higher concentration of molecules of a higher molecular weight after 21 months of bottle ageing than wines made with 14 or 23 days of maceration, suggesting that they contained more polymeric pigment. Yokotsuka et al. (2000) reported that during maceration of Merlot, total phenolics increased from 724 mg/L on day one to a peak of 1,733 mg/L on day 32, with a concurrent increase in polymeric pigment. These authors concluded that extended contact with pomace (32 and 64 days) produced wines with the colour characteristics of aged wines. As Casassa and Harbertson (2014) point out, the evolution of colour in all wines, from purple in young wines due to monomeric anthocyanins, to orange and brick red tones in aged wines, is caused by the formation of anthocyanin-derived polymeric pigments over time.

Decreases in anthocyanins during extended post-fermentation maceration have also been partially attributed to oxidative degeneration, as well as adsorption onto fermentation solids. However, while it was once hypothesised that the major reason for anthocyanin loss was reabsorption onto grape solids during extended maceration, many researchers have subsequently shown that the reduction in anthocyanin concentration is mainly due to incorporation into pigmented tannins. Skins and seeds analysed after extended maceration have been found to contain only slightly more anthocyanins than skins and seeds from standard-length macerations (Casassa et al. 2016).

The incorporation of anthocyanins into polymeric pigments may mean that the colour of young wines made using extended post-fermentation maceration appears more advanced than wines which have not undergone the technique. However, the polymeric pigments are a more stable form of colour than anthocyanins, so their increased concentration might be considered positive. Regardless of the colour effects in young wines, Scudamore-Smith et al. (1990) found minimal differences in colour between extended maceration and control wines after 400 days of bottle storage.

pH

Another commonly reported change in wine composition with extended maceration is an increase in pH. Yokotsuka et al. (2000) reported steadily increasing pH (in a range between 3.58 and 3.75) and decreasing ethanol concentration (in a range between 12.6% and 11.0%) in seven maceration treatments of Merlot, ranging from 1 to 64 days. Explanations for the fall in ethanol were inconclusive but the authors speculated that aerobic consumption (by microorganisms) might be the cause. A steady increase in volatile acids was also seen in this study, to a concentration of 0.52 g/L after 64 days.

Polysaccharides

The concentration of polysaccharides has also been shown to be affected by extended maceration, and these compounds are important because they can modulate astringency and bitterness (Vidal et al. 2004). A study of Cabernet Sauvignon and Tempranillo by Gil et al. (2012) found increases in polysaccharide concentration when maceration length was increased from one to four weeks in wines harvested at three different fruit maturity levels. However, opposite trends were seen between the two varieties in terms of the effect of increasing maturity on increases in polysaccharide concentrations during maceration. The increases between the one- and four-week treatments for Cabernet Sauvignon were 46% at the earliest harvest date, 35% with the second harvest and 16% with the third harvest, whereas with Tempranillo the increases were 21% with the first harvest, 31% with the second harvest and 63% with the third harvest. The authors concluded that the polysaccharides were both grape and yeast derived.

Other compositional variables

Another wine compositional change seen with extended maceration relates to the concentration of the black pepper aroma compound rotundone, with Geoffroy et al. (2017) reporting a reduction of 23% when the length of maceration of Duras wine was increased from 8 to 14 days.

An additional study by Francesca et al. (2013) examined both chemical and microbial variables during extended maceration. Working with the variety Aglianico di Taurasi, they found that total yeast concentration increased until day 40 of a 90-day maceration, with neither *Dekkera/Brettanomyces* nor acetic acid bacteria being detected at any stage. Populations of lactic acid bacteria remained active until day 90, with consequent decreases in malic acid and increases in lactic acid, and slight increases in ethanol and glycerol were attributed to the microflora.

Sensory changes

While it might be inferred from the wine compositional changes that wines made using extended post-fermentation maceration would exhibit more advanced colour and changes in mouth-feel due to higher pH and increased polysaccharides, the major sensory effects reported in the literature relate to changes in phenolic profile.

Extended maceration wines have been rated higher for bitterness during formal sensory evaluation in a number of studies. While this does not appear to be widely reported for commercial wines, it is clearly a potential risk of using the technique. Such increases in bitterness are largely attributable to a group of phenolics called flavan-3-ols. These occur

mainly in the seeds, but because they are water soluble, the portion located in the grape skins is readily extracted during the first two days of fermentation. The portion in the seeds is extracted more slowly, but extraction continues throughout extended maceration, as demonstrated by many studies including Gil et al. (2012) working with Cabernet Sauvignon and Tempranillo.

While the contribution of flavan-3-ols to wine astringency is unclear, they are believed to form the building blocks of a group of compounds called proanthocyanidins (Casassa and Harbertson 2014), which are primarily responsible for astringency. In a further study with Merlot, Harbertson et al. (2009) reported on a winemaking treatment which involved 16% juice run-off with the same quantity of water added-back pre-fermentation, followed by a 20-day post-fermentation maceration. This resulted in significantly greater seed extraction compared with other treatments and wines which were rated as significantly more drying during sensory evaluation. Further studies by the same team report similar trends, with Casassa et al. (2013b), finding a shift towards greater astringency in Merlot wines after a 30-day maceration and Casassa et al. (2013c) reporting that a 30-day maceration increased astringency in Cabernet Sauvignon wines compared to a 10-day maceration control, and that the increased astringency was correlated with the concentration of flavan-3-ol and oligomeric proanthocyanidins.

A sensory evaluation technique known as temporal dominance of sensation was applied by Frost et al. (2016) to Merlot wines which had undergone zero-, one-, two-, four-, six- and eight-week post fermentation macerations. The study found that astringency in Merlot wines only increased with eight weeks of post-fermentation extended maceration, or with submerged cap fermentation coupled with an eight-week period of submerged-cap maceration, compared to a non-extended maceration control and wines which received up to six weeks of post-fermentation maceration. In addition, there was no difference in bitterness among the treatments with one- to eight-week post-fermentation maceration, but these treatments were rated as significantly more bitter than controls which did not receive any post-fermentation maceration. Analytically, maceration from one to six weeks resulted in higher tannin concentrations compared to the control, but again, no differences were seen among the one- to six-week treatments, whereas the eight-week maceration resulted in a higher tannin concentration. A reduction in anthocyanin concentration was also correlated with increasing maceration length.

The proportion of tannins removed from Cabernet Sauvignon grape skins and seeds by various winemaking treatments was studied by Casassa et al. (2016). Tannin measurements were made of the starting concentrations in the grapes, the amount in the wines, and the

amount remaining in the skins and seeds after pressing. It was found that in a control wine (10-day maceration) there was an 'equivalent proportion' of skin and seed tannins, but in a 30-day extended maceration treatment, seed tannins accounted for 73% of the tannins extracted. Interestingly, two other studies by the same team reported the percentage of seed tannins as 79% in Merlot wines after a 20-day maceration (Harbertson et al. 2009) and 73% in Cabernet Sauvignon wines after a 30-day maceration (Casassa et al. 2013a).

Yokotsuka et al. (2000) reported the outcomes of seven maceration treatments ranging from 1 to 64 days for Merlot. Sensory evaluation of the wines revealed steeply increasing colour intensity, astringency and bitterness between 1 and 8 days, and a further gradual increase between 8 and 32 days, with sharp increases in colour hue, aroma intensity and body up to day 16. Overall flavour gradually decreased between day 16 and day 64, leading to the conclusion that the 32- and 64-day treatments resulted in poorer quality wine. The wines that received maceration for approximately 10 days after the end of alcoholic fermentation were rated the highest quality overall during sensory evaluation.

Summary

It appears from these studies that the chemical basis for differences in phenolic profiles caused by extended maceration and the consequent sensory effects are reasonably well understood. However, the differing outcomes achieved across different varieties, seasons, ripeness levels and maceration times highlight the difficulties of applying extended post-fermentation maceration in a commercial setting. Winemaker experience in recognising seasonal differences in the initial concentration of grape phenolic compounds, and their extractability, seems to be the key to success.

In summary, there are several risks associated with extended post fermentation maceration, which include the potential development of bitterness and overly astringent tannins and the possibility of spoilage by undesirable yeast or bacteria. Consequently, it is advisable to take a cautious approach when trialling the technique, by starting with a small batch and assessing the results over time. Blending trials can also be conducted, to ascertain the proportion of extended maceration wine required to achieve the desired sensory effects.

Peter Godden, Manager - Industry Engagement and Application,
peter.godden@awri.com.au

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References

Casassa, L.F., Harbertson, J.F. 2014. Extraction, evolution, and sensory impact of phenolic compounds during red wine maceration. Ann. Rev. Food Sci. Technol. 5: 83–109.

Casassa, L.F., Larsen, R.C., Beaver, C.W., Mireles, M.S., Keller, M., Riley, W.R., Smithyman, R., Harbertson, J.F. 2013a. Impact of extended maceration and regulated deficit irrigation (DRI) in Cabernet Sauvignon wine: characterization of proanthocyanidin distribution, anthocyanin extraction, and chromatic properties. J. Agric. Food Chem. 61: 6446–6457.

Casassa, L. F., Beaver, C. W., Mireles, M., Larsen, R. C., Hopfer, H., Heymann, H., Harbertson, J. F. 2013b. Influence of fruit maturity, maceration length, and ethanol amount on chemical and sensory properties of Merlot wines. Am. J. Enol. Vitic. 64(4): 437–449.

Casassa, L.F., Larsen, R.C., Beaver, C.W., Mireles, M.S., Keller, M., Riley, W.R., Smithyman, R., Harbertson, J.F. 2013c. Sensory impact of extended maceration and regulated deficit irrigation on Washington State Cabernet Sauvignon wines. Am. J. Enol. Vitic. 64(4): 505–514.

Casassa, L.F., Larsen, R.C., Harbertson, J.F. 2016. Effects of vineyard and winemaking practices impacting berry size on evolution of phenolics during winemaking. Am. J. Enol. Vitic. 67(3): 257–268.

Francesca, N., Romano, R., Sannino, C., Le Grottaglie, L., Settani, L., Moschetti, G. 2013. Evolution of microbiological and chemical parameters during red wine making with extended post-fermentation maceration. Int. J. Food Microbiol. 171: 84–93.

Frost, S.C., Blackman, J.W., Ebeler, S.E., Heyman, H. 2016. Analysis of temporal dominance of sensation data using correspondence analysis on Merlot wine with differing maceration and cap management regimens. Food Qual. Pref. 64, 245–252.

Geoffroy, O., Siebert, T., Silvano, A., Herderich, M. 2017. Impact of winemaking techniques on classical enological parameters and rotundone in red wine at the laboratory scale. Am. J. Enol. Vitic. 68(1): 141–146.

Gil, M., Kontoudakis, N., González, E., Esteruelas, M., Fort, F., Canals, J.M., Zamora, F. 2012. Influence of grape maturity and maceration length on color, polyphenolic composition, and polysaccharide content of Cabernet Sauvignon and Tempranillo wines. J. Agric. Food Chem. 60: 7988–8001.

Harbertson, J.F., Mireles, M.S., Harwood, E.D., Weller, K.M., Ross, C.F. 2009. Chemical and sensory effects of saignée, water addition, and extended maceration on high Brix must. Am. J. Enol. Vitic. 60(4): 450–460.

Joscelyne, V. L. 2009. Consequences of extended maceration for red wine colour and phenolics. Adelaide, SA: University of Adelaide; 246 p. PhD thesis.

Kudo, M., Sodeyama, M. 2002. Weight distribution of red wine polyphenols affected by length of maceration. Am. J. Enol. Vitic. 53: 332A.

Sacchi, K.L., Bisson, L.F., Adams, D.O. 2005. A review of the effect of winemaking techniques on phenolic extraction in red wines. Am. J. Enol. Vitic. 56(3): 197–205.

Scudamore-Smith, P.D., Hooper, R.L., McLaren, E.D. 1990. Colour and phenolic changes of Cabernet Sauvignon wine made by simultaneous yeast/bacterial fermentation and extended pomace contact. Am. J. Enol. Vitic. 41(1): 57–67.

Schmidt, J.O., Noble, A.C. 1983. Investigation of the effect of skin contact time on wine flavour. Am. J. Enol. Vitic. 34 (3): 135–38.

Vidal, S., Francis, L., William, P., Kwiatkowski, M., Gawel, R., Cheynier, V., Waters E. J. 2004. The mouthfeel properties of polysaccharides and anthocyanins in a wine like medium. Food Chem, 85, 519–525.

Yokotsuka, K., Sato, M., Ueno, N., Singleton, V.L. 2000. Colour and sensory characteristics of Merlot red wines caused by prolonged pomace contact. J. Wine Res. 11(1): 7–18.