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Impact of exogenous tannin additions on wine chemistry and wine sensory character

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ABSTRACT

Tannins are an important part of wine quality and are frequently added during winemaking. Tannin additives and their impact on wine are poorly documented. This work sought to characterize a range of enological tannins and their contribution to wine quality. Enological tannins were analysed for protein precipitable tannins and iron reactive phenolics. One tannin product was added to a Merlot wine during barrel ageing, at a range of concentrations from 60 to 300 mg/l. Condensed and hydrolysable tannins were added to Cabernet Sauvignon wine post-pressing at a recommended and excessive rate. Wines were analysed for anthocyanin, small and large polymeric pigment, precipitable tannin, iron reactive phenolics and sensory character. Enological tannins contained 12–48% tannin and recommended additions had little impact on wine tannin. High tannin additions were readily measured in the wines and were discriminated in sensory analysis with lower intensities of most parameters except brown colour, bitterness and earthy character. Recommended addition rates are too low to impact the measured tannin concentration of Merlot and Cabernet Sauvignon wines from Washington (USA). High enological tannin additions had a measureable impact on final wine had a negative impact on sensory character. Tannins are added to wines for a range of reasons and represent one of many input costs in an industry increasingly seeking efficiencies in response to global economic circumstances, over-supply and an ongoing price point squeeze. This research suggests many tannin additions may be unjustified and have limited or negative impacts on quality.

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1. Introduction

Wine tannins are an important component of wine quality contributing to both perceived mouthfeel and long-term colour stability (Malien-Aubert, Dangles, & Amiot, 2002; Singleton, 1988; Somers, 2003; Vidal et al., 2004). Tannins are primarily derived from the seeds and skin of the fruit during winemaking. As a result, wines made with little or no skin contact such as white and sparkling wines have low tannin levels, while red wines that are made with periods of skin contact ranging from a few days to several weeks can have quite variable tannin concentrations, that have been observed to range 32-fold (Harbertson et al., 2008; Singleton & Noble, 1976). Grape seed and skins tannins are commonly called "condensed tannins" being composed of oligomers and polymers comprised of subunits analogous to the flavan-3-ols including, catechin, epicatechin, epicatechin-gallate and epigallocatechin (Haslam, 1998).

While the concentration of tannin in grape seeds is usually greater than that of the skin, seed tannins tend to be less readily extracted into the wine, thus skin tannins play a greater role in wine composition (Cerpa-Calderòn & Kennedy, 2008; Harbertson, Mireles, Harwood, Weller, & Ross, 2009). The concentration of tannin in grape skins has been shown to vary considerably with site and season as well as between variety and with some viticultural management practises (Downey, Dokoozlian, & Krstic, 2006). Despite some fruit having high tannin concentrations in the skin of the berry, it has often been observed that the wine does not always have a similarly high level of tannin at the end of winemaking (Adams & Scholz, 2007; Hanlin & Downey, 2009; Harbertson, Kennedy, & Adams, 2002; Harbertson et al., 2009). To overcome this, exogenous tannins are frequently added to wines during the winemaking process either in the form of grape seeds or lyophilized extracts (Kovac, Alonso, Bourzeix, & Revilla, 1992; Kovac, Alonso, & Revilla, 1995; Main & Morris, 2007; Parker et al., 2007).

Exogenous tannins can be added for a range of reasons, at different times, during vinification and in a number of forms. In a review of the current industry practise conducted Australia in 2007, Hill

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and Kaine (Hill & Kaine, 2007) identified six industry segments based on their utilisation of exogenous tannins. These segments ranged from winemakers who added no tannin because they felt that their fruit already had sufficient, or in some cases excessive, endogenous tannin, to winemakers who added tannin, to all products, as a risk management strategy. Other industry segments included winemakers who added tannins to stabilise colour, to modify mouthfeel, to mask green characters or other faults, or to differentiate their wines from similar products, or a combination of these motivations (Hill & Kaine, 2007). These strategies vary between wineries and winemakers, as well as between wines from an individual producer. In some cases, tannin additions are made in accordance with manufacturer recommendations, or addition rates are informed by sensory evaluation of small-scale addition trials in winemakers tasting room or laboratory. In other cases tannins are added to various products according to a recipe, historical precedent or based on the winemakers knowledge or experience, a practise one contributor described as the dark art of tannin addition (Hill & Kaine, 2007).

Commercially available tannin additives take a number of forms, the most common being referred to as "oenotannins" or "enological tannins" and are mainly dry powders. However, tannin addition can also be achieved through the addition of oak chips or staves and through ageing in oak barrels. The tannins derived from barrels, chips and staves are not condensed tannins, as are found in the grape skins and seeds, but rather hydrolysable tannins (Haslam, 1998; Mayer, Gabler, Riester, & Korger, 1967). Hydrolysable tannins, such as gallotannins are comprised of a central glucose molecule substituted with gallic acid moieties, for example pentagalloyl-glucose. Hydrolysable tannins also occur as gallic acid dimers, such as ellagitannins, and as polymers and complexes of gallotannins and ellagitannins (Haslam, 1998; Mayer et al., 1967; Okuda, Yoshida, & Hatano, 1990). The two most abundant oak ellagitannins are vescalagin and castalagin (Mayer et al., 1967) and both are capable of precipitation of proteins. Although found in oak aged wine they are not generally found in large enough quantities to contribute to astringency directly (Puech, Feuillat, & Mosedale, 1999).

Commercial preparations of hydrolysable tannins are sourced from a wide range of plant materials including the bark of the South American Quebracho tree (*Schinopsis balansae* and *Schinopsis lorentzii*), the Australian Wattle (*Acacia mearnsii*), and the acorns (caps) and galls of the genus *Quercus* (Rautio, Bergvall, Karonen, & Salminen, 2007). Several species, such as *Acer, Acacia* and *Quercus* contain both hydrolysable and condensed tannins (Bate-Smith, 1977; Ishimaru, Nonaka, & Nishioka, 1987; Mueller-Harvey, Hartley, & Reed, 1987). Some enological tannin products are relatively pure extracts from single species, while others are mixtures from several species and may include both hydrolysable and condensed tannins (Obreque-Slíer, Peña-Neira, López-Solís, Ramírez-Escudero, & Zamora-Marín, 2009). Furthermore, significant variation between batches of the same tannin preparations have also been reported (Makkar, Blümmel, Borowy, & Becker, 1993).

As discussed earlier, the condensed tannins in grape berries have been reported to have considerable variation, particularly in grape skins (Seddon & Downey, 2008). Elsewhere, researchers have reported comparable variation in the condensed and hydrolysable tannin content and composition of other plants, e.g. trees (Foo & Karchesy, 1991; Salminen, Roslin, Karonen, Sinkkonen, & Pulkkinen, 2004; Shure & Wilson, 1993; Wagner, 1988), and forages (Acuña, Concha, & Figueroa, 2008; Fahey & Jung, 1989; Li, Tanner, & Larkin, 1996). Variation in the hydrolysable tannin content and composition of plants, including those used as sources for enological tannin preparations, have also been reported and in some cases have been cited as problematic (Obreque-Slíer et al., 2009; Rautio et al., 2007). Thus, it is likely that considerable batch-to-batch variation exists in enological tannin preparations, making it difficult to predict the impact of the addition of any particular product. A recent characterisation of commercial enological tannin products revealed that there were several discrepancies between the labelling of the products and their actual content (Obreque-Slíer et al., 2009), although the authors did not analyse different batches of the same product.

To date enological tannins have received little attention from researchers (only about 10 products evaluated), despite their widespread usage within the international wine industry. As a result there are few publications on the efficacy of enological tannin addition to wine and little published knowledge of the effectiveness of the available products. Studies have been conducted for the addition of enological tannins pre- and post-fermentation (Bautista-Ortín, Fernández-Fernández, López-Roca, & Gómez-Plaza, 2007; Main & Morris, 2007; Parker et al., 2007). An experiment was conducted on Monastrell wines where condensed tannins were added at a rate of 400 mg/l after crushing and de-stemming (Bautista-Ortín et al., 2007). At bottling the tannin treated wine had significantly more tannins than the control, but the tannin concentration was only 113.7 mg/l greater than the control and after eight months in bottle the tannin concentration diminished at the same rate as the control (about 35% decline). Both pre- and post-fermentation additions of 200 mg/l grape seed derived tannins were added to Shiraz wines and found no differences early between of the treatments but after 545 days post-fermentation addition was greater than the control thereafter the differences were negligible (~680 days). In this case, although the post-fermentation treatment was different at 545 days the difference was ~25 mg/l even though 200 mg/l was added and there was no observed spike in tannins when the addition took place. In another experiment 200 mg/l of white grape seed tannins were added post-fermentation to Cynthiana and found no significant increase in total phenolics (no actual tannin measure) and found that the wine had small colour differences that, according to the author, may not be important for commercial practises (Main & Morris, 2007).

Thus, while some information exists that suggests there might be an impact of tannin addition on wine composition and wine quality, this has not been well documented and considerable gaps exist in our knowledge of both the composition of the many products in the marketplace, as well as their effectiveness. To address this, we characterised a range of available products and added two of these, one condensed tannin and the other a hydrolysable tannin, to wines made from Merlot and Cabernet Sauvignon grapes grown in the Columbia Valley of Washington, USA. Exogenous tannins were added at two different amounts during barrel ageing, which previously had not been evaluated to assess the impact on wine phenolic content and mouthfeel and to avoid potential losses and impacts from the winemaking process.

2. Materials and methods

2.1. Reagents

Bovine Serum Albumin (BSA, Fraction V, lyophilized powder), sodium dodecyl sulphate (SDS; lauryl sulphate, sodium salt, 95%), triethanolamine (TEA, 98%), ferric chloride hexahydrate (98%), and (+)-catechin hydrate (98%, powder) were purchased from Sigma (St. Louis, MO, USA), as were materials for preparing buffers used in analyses. Reagents were prepared as in Harbertson, Picciotto, and Adams (2003) and stored as described in Heredia, Adams, Fields, Held, and Harbertson (2006).

Martin Vialatte Oenology tannins (Oenotan, Tanigal, Taniraisin, Vitinil AS, Vitinil AJ11, Vitinil B, and Vitinil VR) were donated by