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Comparison of consecutive harvests versus blending treatments to produce lower alcohol wines from Cabernet Sauvignon grapes: Impact on polysaccharide and tannin content and composition

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ABSTRACT

A changing climate has led to winegrapes being harvested with increased sugar levels and at greater risk of berry shrivel. A suggested easy-to-adopt strategy to manage the associated rising wine alcohol levels is the pre-fermentative substitution of juice with either "green harvest wine" or water. Our study investigates the effects of this approach on *Vitis vinifera* L. cv. Cabernet Sauvignon wine quality attributes. Wines were also made from fruit collected at consecutive earlier harvest time points to produce wines comparable in alcohol to the substituted wines. Tannin concentrations and colour did not change significantly in the wines with modified alcohol content even at higher juice substitution rates. Differences in polysaccharide and tannin composition indicated variability in extraction dynamics according to substitution rate and type of blending component. In scenarios where berry shrivel is inevitable, the incorporation of water in particular offers much promise as part of a strategy to manage wine alcohol content.

1. Introduction

Warm and dry weather conditions during grape ripening have been characteristic of a range of viticultural regions in Australia and elsewhere, but the changing climatic conditions have imposed more challenging conditions on the wine industry. The trend of higher daily average temperatures during the vegetative period has led to accelerated phenological development of grapevines, confronting winemakers with increased berry sugar levels at harvest (Schultz & Jones, 2010). Decision-making regarding optimum harvest dates has become difficult as the ripening windows for distinct varieties now frequently overlap. This leads to peaks in harvest activity that may not be manageable in the winery, thereby exposing the unharvested part of the crop to berry shrivel and over-maturity (Suklje et al., 2016).

Furthermore, to account for the heterogeneity inherent in berry ripening, winemakers tend to delay harvest in the search of "flavour ripeness", minimising the contribution of unripe berries. This is of particular importance for the second-most widely grown grape cultivar in Australia, *Vitis vinifera* L. cv. Cabernet Sauvignon, with both "fruity" and "green" attributes shaping the varietal aroma. The risk of berry shrivel is thus increased for the major proportion of the fruit, which can lead to higher wine alcohol concentrations and altered aroma and flavour profiles of the wines (Suklje et al., 2016). Simultaneously, winemakers may seek to achieve a higher level of grape tannin ripeness ("phenolic maturity") by extending grape maturation time, to minimise the impact of bitter seed tannins and maximise the proportion of skin tannins (Bindon, Varela, Kennedy, Holt, & Herderich, 2013; Heymann et al., 2013). However, the potential benefits of extended ripening in this context are not entirely clear, as few studies have investigated the different sensory properties of wines resulting from harvest dates chosen around an optimum ripeness state (Bindon et al., 2013; Lasanta, Caro, Gomez, & Perez, 2014). A 2014 study showed there was no significant differentiation in consumer liking of wines resulting from different harvest time points and containing 13%–15.5% alcohol by volume (ABV) (Bindon et al., 2014a). Indeed, it appears that the sensory quality of some Cabernet Sauvignon wines changes only marginally with different harvest dates after the grapes have passed a certain level of maturity (Heymann et al., 2013). Therefore, in the context of

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Abbreviations: ABV, alcohol by volume; CWM, cell wall material; DAP, diammonium phosphate; GHW, green harvest wine; GPC, gel permeation chromatography; MCP, methyl cellulose precipitable; MM, molecular mass; mol%, molar percentage; MP, mannoprotein; PMS, potassium metabisulfite; PRAG, polysaccharides rich in arabinose and galactose; RG-II, rhamnogalacturonan II; TA, titratable acidity; TSS, total soluble solids

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compressed vintages and with a view to managing wine alcohol concentrations, the perceived benefit of extended ripening needs further examination.

Unmitigated increases of alcohol levels in wines due to the aforementioned reasons are not only problematic in terms of potential impact on product quality (perception of hotness and bitterness (Heymann et al., 2013)). Higher tax penalties that apply for exports above a certain % ABV, as well as the rising trend of consumers demanding wines with moderate alcohol, imply there are limitations in marketability. Hence, intervention by the winemaker is necessary to counterbalance excessive grape maturity with techniques that can decrease wine alcohol concentration. Pre-fermentative and fermentative approaches to lower the final alcohol content in wine are still limited due to associated quality losses (Longo, Blackman, Torley, Rogiers, & Schmidtke, 2017), and physical processes for dealcoholisation via spinning cone columns or reverse osmosis technologies (Longo et al., 2017) are appreciated by large-scale wineries for their low running costs and versatility. Smaller wineries, however, struggle to benefit from such technologies because of the initial costs of the equipment.

Due to the unpredictable nature of compressed vintages, where the occurrence and severity of heatwaves and harvest pressures may vary annually, winemakers are searching for easy-to-adopt, flexible and cost-effective alternatives to deal with overripe and/or shrivelled crops. An approach tested previously involves a sequential harvest regime, where a portion of the crop is harvested very early (at veraison, when berries start to soften and gain colour) and fermented to a low alcohol blending wine (hereafter defined as “green harvest wine”, GHW) that can be incorporated into the wine produced from the overripe or shrivelled remainder (Kontoudakis, Esteruelas, Fort, Canals, & Zamora, 2011), or indeed into any wine that is undesirably high in alcohol. That study showed that the blending approach could be suitable for a partial decrease of alcohol concentration in wines, however different qualitative responses among cultivars (Cabernet Sauvignon, Merlot and Bobal) necessitate further investigation on a variety basis, with different targeted alcohol levels to test the limits for quality wine production. In addition, winemaking legislation in the US and changes to regulations more recently in Australia permit the pre-fermentative incorporation of water into high sugar must under certain conditions to facilitate yeast activity and enable sound fermentation dynamics.

Few studies (Harbertson, Mireles, Harwood, Weller, & Ross, 2009; Kontoudakis et al., 2011) have investigated the impact on wine composition following a manipulation of the pre-fermentative juice matrix via additions of water or GHW, particularly with respect to compositional changes in polyphenols, polysaccharides, volatiles and sensory quality. Water addition (either with an equivalent amount of juice removal [saignée] or simply must dilution) had little effect on polyphenol measures and sensory properties (aroma and flavour), in contrast to a higher ethanol wine that was characterised by having less fresh fruit flavour with a hot/dry mouthfeel (Harbertson et al., 2009). When blending with GHW, there were minimal impacts on polyphenols, a varietally-dependent effect on colour properties (mostly as a function of lower wine pH) and an inability to distinguish between wines from the same harvest stage using sensory assessment, except in the case of one varietal wine that had a greater amount of GHW added and was therefore more acidic (Kontoudakis et al., 2011). Nonetheless, no study investigated these methods in the context of severe berry shrivel and a direct comparison between the different pre-fermentative alcohol adjustment methods has yet to be reported. Thus additional information is required to provide winemakers with tools for adequate decision-making, especially in terms of using water as a means to manage wine alcohol levels.

Given the gaps in knowledge, this work was aimed at investigating the chemical composition resulting from pre-fermentative incorporation of GHW or water into Cabernet Sauvignon must, and evaluating the impact on quality of the resulting wines. To enable a comparison and discussion about potential benefits of each approach, the blended wines were compared to wines of similar targeted alcohol levels made from sequentially-harvested grapes. Berry ripening evolution was monitored and berry ripening heterogeneity was assessed to provide context regarding the vintage conditions and fruit characteristics.

2. Material and methods

2.1. Chemicals

Reagents and reference compounds used for analyses were purchased from Sigma Aldrich (Castle Hill, NSW, Australia) or Alfa Aesar (Ward Hill, MA, USA). Stock solution of standards were prepared volumetrically in redistilled ethanol and stored at −20 °C, and working solutions were stored at 4 °C until required. Analytical grade sodium chloride and HPLC grade solvents were sourced from Chem-Supply (Gillman, SA, Australia) and Merck (Kilsyth, Victoria, Australia), respectively. Water was obtained from a Milli-Q purification system (Millipore, North Ryde, NSW, Australia) for all analyses, and filtered tap water was used for the water blending treatments. Ribose, deoxyglucose and 1-phenyl-3-methyl-5-pyrazolone (PMP) were purchased from Sigma Aldrich. Bentonite (SIHA Active Bentonite G, Eaton Filtration, New Jersey, USA) and activated carbon were purchased from Winequip (Adelaide, SA, Australia). Potassium metabisulfite was sourced from Vebigarden (Padua, Italy).

2.2. Climate data

Daily minimum, maximum and average temperatures, total monthly rainfall, and term averages (Table S1 of the Supporting Information) were sourced from the Bureau of Meteorology (weather station in Noarlunga, SA, at 138.5057°E, 35.1586°S) (Australian Government Bureau of Meteorology, 2017). The Huglin index for the vintage 2014/15 was calculated according to Tonietto and Carbonneau (2004).

2.3. Harvesting and winemaking

Vitis vinifera L. cv. Cabernet Sauvignon grapes were sourced from a commercial vineyard located in McLaren Vale, South Australia (138.521139°E, 35.194167°S). Around 200 kg of grapes were hand-picked on 8 January 2015 (further referred to as H0 or GHW) at approximately 50% veraison and with total soluble solids (TSS) of 8.1 °Brix (potential alcohol of 4.5% ABV) to produce GHW. Subsequent hand harvest of 70–80 kg took place on 3, 9 and 18 February 2015 (further referred to as H1, H2 and H3, respectively) with TSS of 20.5, 23.9 and 27.4 °Brix, respectively. Finally, 350 kg of grapes were hand-picked at commercial ripeness (22 February 2015, designated H4, 30.4 °Brix) and further processed to yield the control wine, a portion of which acted as the base wine for a series of blending treatments. Fig. S1 of the Supporting information outlines the experimental plan.

2.4. Green harvest wine

WIC Winemaking Services (Waite Campus, Urrbrae, SA, Australia) conducted the winemaking. Briefly, grapes were destemmed, crushed and directly pressed. After settling overnight the must was racked and inoculated with EC1118 yeast (Lallemand, Montreal, Canada), and thiamine was added to support fermentation. The winemaking involved applying a fermentation restart protocol (Lallemand, 2011). Once fermentation was complete (tested with a spectrophotometric enzymatic assay (Walker et al., 2014)) the wine was fined with 1 g/L charcoal and 1 g/L bentonite to ensure decolourisation and deodorisation and facilitate settling (Kontoudakis et al., 2011), settled overnight and racked. Potassium metabisulfite (PMS, 10% aqueous solution) was added at 100 mg/L to yield approximately 50 mg/L of total SO_2. The wine (approx. 100 L) was stored in stainless steel kegs at 0 °C until implementation of the blending treatments.