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Co-fermentation of red grapes and white pomace: A natural and economical process to modulate hybrid wine composition

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ABSTRACT

The impact of co-fermenting white grape pomace (WP) and red grape pomace (RP) on the composition of interspecific hybrid wine was studied using the *Vitis* sp. 'Frontenac' and 'Vidal'. The proanthocyanidin and anthocyanin content of the resulting wines were analysed by HPLC-fluorescence and UPLC–MS/MS, respectively. The CIELAB parameters and volatile compounds were analysed using spectrophotometry-UV and GC–MS-SPME, respectively. The WP addition increased the concentration of monomeric and oligomeric flavan-3-ols, and terpenes in the wines. The manipulation of the WP/RP ratio efficiently modulated the anthocyanin profile of the wines, resulting in faded red colour, a desirable achievement in hybrid red wine, which is usually perceived as too dark. An appropriate ratio (30% RP/6% WP) improved the colour stability of the wines without a significant impact on wine colour. Addition of WP proved to be a suitable tool to modulate the colour, the phenolic and volatile composition of interspecific hybrid wine.

1. Introduction

The development and commercialisation of cold-hardy interspecific hybrid grape cultivars have contributed to the vast expansion of northern wine production, notably in Quebec, Canada. The province of Quebec is the third largest wine producer in Canada, and interspecific hybrid cultivars such as Frontenac and Marquette, account for up to 90% of local grape production. Most of the interspecific hybrid grapes are crosses between *Vitis vinifera* and wild North American native species such as *Vitis riparia*, *Vitis labrusca,* and *Vitis rupestris* (Pedneault & Provost, 2016).

The wine market is a fast expanding sector in the province of Quebec. In 2016, wine sales reached CA$ 2.3 billion and accounted for 79.3% of alcohol sales in volume (wine, beer, cider, spirit, others). Red wine alone accounted for 65.8% of alcohol sales. But the clear majority (> 75%) of red wine currently sold in Quebec is imported from Europe, and wine made in Quebec struggle to find its place with less than 3% of the market share (SAQ, 2016).

Red wines produced from hybrid grapes can exhibit atypical organoleptic characteristics when compared to the *Vitis vinifera* wines the consumers are used to. For instance, certain hybrid red wines have been shown to carry higher concentrations of eugenol, *cis*-3-hexenol, 1,8-cineole, nonanal, and *(E,Z)*-2,6-nonadienal that may contribute to undesirable vegetative and earthy aromas (Slegers, Angers, Ouellet, Truchon, & Pedneault, 2015; Sun, Gates, Lavin, Acree, & Sacks, 2011). This, and other factors reviewed by Pedneault and Provost (2016), have led to the assumption that interspecific hybrids produce low-quality wines. In terms of mouthfeel, hybrid wines often have high titratable acidity (Pedneault, Dorais, & Angers, 2013) and low astringency due to a small concentration of polymeric flavan-3-ols (Manns, Coquard Lenerz, & Mansfield, 2013; Springer, Chen, Stahlecker, Cousins, & Sacks, 2016).

With respect to colour, hybrid wines do not undergo the colour evolution from purple towards orange hues typical of *Vitis vinifera* wines and are less likely to form stable colour during ageing (Alcalde-Eon, Escribano-Bailón, Santos-Buelga, & Rivas-Gonzalo, 2006; Li et al., 2016; Manns et al., 2013). Indeed, hybrid cultivars are known to have a high anthocyanin content resulting in deeply coloured red wines. The anthocyanin profile of hybrid red wines is dominated by anthocyanin-3,5-diglucosides (Manns et al., 2013). When compared to the anthocyanin monoglucosides typically found in *Vitis vinifera* wines, anthocyanin di-

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glucosides have been found to be less likely to react with flavan-3-ols to form stable polymeric pigments at wine pH (Burtch, Mansfield, & Manns, 2017; He et al., 2012b; Manns et al., 2013). In contrast, short-term reactions such as self-association and copigmentation between anthocyanin diglucosides and other components such as flavonols and flavan-3-ols are thought to play a significant role in the colour development of hybrid red wines (He et al., 2012a; Manns et al., 2013). Anthocyanins also promote the retention of polymeric proanthocyanins (≥5 flavan-3-ol units) in wine and therefore modulate wine mouthfeel by decreasing the sensory perception of astringency (Casassa & Harbertson, 2014).

In order to improve hybrid wines acceptability among consumers, winemakers must adapt their products to the market trend and constantly innovate to offer high-quality wines. Wine quality is largely related to its chemical composition, especially regarding phenolic and volatile compounds (Ribéreau-Gayon, Dubourdieu, Donèche, & Lonvaud, 2006; Sáenz-Navajas et al., 2015). Some studies have shown a positive correlation between high tier wines and wines showing higher content in total phenolic compounds and tannins (Kassara & Kennedy, 2011; Mercurio, Dambergs, Cozzolino, Herderich, & Smith, 2010). Appropriate winemaking techniques, mainly based on duration and temperature of maceration, contribute to optimising the extraction of varietal aromas and phenolic compounds in wine (Sacchi, Bisson, & Adams, 2005). The use of additives is also a common practice to improve wine quality. For example, the addition of enological tannins and wood chips are typically used to compensate for tannin deficiency and contributes to improving colour stabilisation, wine structure, and aroma (Chen et al., 2016; Kyraleou et al., 2016).

Severe restrictions regarding organic waste management are pushing the industry toward sustainable development to improve cost-effectiveness and meet customers demand for naturally and plant-sourced additives. One of the major by-products of the wine industry is grape pomace, which consists of a mixture of berry skins, seeds, and stalks. The valorisation of this industrial waste has received extensive attention from both the scientific and industry communities over the past few years (García-Lomillo & González-SanJosé, 2017). Recently, non-aromatic vine-shoot extracts used as biostimulants in viticulture successfully improved wine pH and colour intensity and diversified the volatile and phenolic composition of wines (Sánchez-Gómez, Zalacain, Pardo, Alonso, & Salinas, 2017). Addition of enzymatic hydrolysate of grape seeds has also been proposed as a suitable alternative to prevent colour losses during red wine fermentation (Cejudo-Bastante et al., 2016). Use of fresh and dehydrated white grape by-products as wine additives in red winemaking at appropriate levels was also shown to improve the phenolic potential of young red wines, therefore contributing to preserving wine colour during ageing (Gordillo et al., 2014; Pedroza, Carmona, Alonso, Salinas, & Zalacain, 2013).

Using fresh grape pomace as an additive in the wine industry requires fast turn-around because of its perishability, making such management difficult for winemakers. In addition, enormous volumes of grape pomace are produced on a weekly basis, during a very busy period of the year, making it even more complicated to manage. On the other hand, processing grape pomace into ready-to-use concentrates using extraction-concentration technology also results in significant costs. In small-scale winemaking as that occurring in the emerging cold-climate wine industry, using fresh pomace remains the most cost-effective solution, when concomitant harvest dates make it feasible.

This work aimed to study the impact of white pomace c.v. 'Vidal' during the fermentation of red *Vitis* sp. berries c.v. 'Frontenac'. White grape pomace was chosen as a natural additive that could improve the concentrations of tannins and other non-anthocyanin compounds, including volatiles, in hybrid red wines while preventing the extraction of additional anthocyanins as occurs with typical skin maceration. Different proportions of red and white grape pomace were assayed to produce different compositional profiles, and wines were evaluated for phenolic, colour, and volatile compounds during winemaking and wine ageing.

2. Material and methods

2.1. Chemicals

Polyphenol analysis: Acetic acid (HPLC grade), hydrochloric acid (37% solution in water) and acetaldehyde were purchased from Fisher Scientific (Ottawa, ON, Canada). Methanol and acetonitrile (HPLC grade) were purchased from EMD Millipore (Toronto, ON, Canada). (−)-Epicatechin standard, trifluoroacetic acid (HPLC grade) and sodium bisulphite were purchased from Sigma-Aldrich (Oakville, ON, Canada). Cyanidin-3-glucoside, delphinidin-3-glucoside, malvidin-3-glucoside, pelargonidin-3-glucoside and peonidin-3-glucoside standard were purchased from Extrasynthèse (Lyon, France) and Alkemist Labs (Costa Mesa, CA, USA). Purified water was obtained from a MiliQ filtration system.

Volatile compound analysis: Absolute ethanol was purchased from Commercial Alcohols (Brampton, ON, Canada) and sodium chloride (NaCl) from Fisher Scientific (Fair Lawn, NJ, USA). Deuterated standards (d_8-ethyl acetate, d_{13}-hexanol, 3-methyl-1-butyl alcohol-d_4, d_5-2,3,4,5,6-benzyl alcohol, and 2-phenyl-d_5-ethanol) were purchased from C/D/N Isotopes Inc. (Pointe-Claire, QC). *β*-Myrcene was purchased from MP Biomedicals (Santa Ana, CA, USA). Ethyl hexanoate and ethyl propanoate were purchased from Nu-Chek-Prep (Elysian, MN, USA). Other reagents and standards were purchased from Sigma-Aldrich (St. Louis, MO, USA) (Slegers et al., 2015).

2.2. Grape materials

The white *Vitis*. sp. variety c.v. 'Vidal' (Rayon d'Or (S. 4986) X Ugni blanc) and the red *Vitis* sp. variety c.v. 'Frontenac' (Landot (L. 4511) X *Vitis riparia* 89) were used for this study. These cultivars were selected because they are largely grown in Quebec, Canada, and they typically ripen around the same time (mid-October) hence facilitating their use in co-fermentation.

Frontenac grapes (1.5 T; 21.4 °Brix; 14.2 g/L as tartaric acid eq.; pH 3.3) were obtained from a commercial grower located in St-Rémi (QC, Canada; 45° 16′ 0″ N, 73° 37′ 0″ W). Vidal pomace (approx. 350 kg) was obtained from a commercial grower located in Dunham (QC, Canada; 45° 7′ 60″ N, 72° 48′ 0″ W). The Vidal grapes were processed for traditional white winemaking at maturity, as follow: Grapes were partly destemmed, preserving 10% intact clusters, and pressed. The residue was recovered and the remaining stems were removed manually, yielding the white pomace (WP), which majorly contained skins and seeds. In order to prevent spoilage, the WP was stored at 4 °C and treated with 20 mg/kg of sulphur dioxide until further use.

2.3. Winemaking trials

Frontenac grapes were destemmed, crushed, treated with 30 mg/kg of sulphur dioxide and cold-soaked in stainless steel tanks under an inert atmosphere, at 12 °C, overnight. The juice and red grape pomace (RP) were recovered by pressing the grape mash (1.8 bar) and kept separately until winemaking. The white grape pomace was pressed (1.8 bar) to remove the sulphated solution.

Five co-fermentation treatments were prepared using different proportions of WP and RP co-fermented in red Frontenac juice: a) 50% w/w of RP in juice as control; b) 30% w/w of RP and 6% w/w WP in red juice; c) 30% w/w of RP and 12% w/w WP in red juice; d) 30% w/w of RP and 18% w/w of WP in red juice; and e) 23% w/w WP in red juice. Each treatment was carried out in 4 replicates (n = 4). Fermentations were conducted in 100 L stainless steel tanks equipped with floating lids, as follow: Alcoholic fermentation was induced by a commercial dry yeast *Saccharomyces cerevisiae* (Anchor NT50; Scott Laboratories, Pickering, ON, Canada) at 25 g/h L and carried out at 24 °C, until dryness. The cap was punched down twice a day. The progression of alcoholic fermentation was monitored daily by measuring specific