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Enhancement of Chardonnay antioxidant activity and sensory perception through maceration technique

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ABSTRACT

Chardonnay is a versatile white grape variety, lending itself to wines of fuller body, or to light and fruity styles. Phenolic compounds influence the perceived body and flavor of the wines. Chardonnay was chosen to evaluate three maceration techniques on phenolic profiles and sensory attributes; namely carbonic, cryogenic and extended skin contact. Cryogenic maceration and on-skin fermentation resulted in significantly increased phenolic compounds and corresponding increases in Folin-Ciocalteu total phenolic content and DPPH radical scavenging over control wines, while the carbonic maceration changed these values very little. At the same time, the cryogenically treated wines resulted in sensory attributes closely related to the controls. The ability of the cryogenic maceration to increase phenolics, antioxidant activity and maintain sensory characteristics indicates the viability of the technique to produce an antioxidant-enhanced Chardonnay wine.

1. Introduction

White wines, which are typically low in phenolic compounds, as a consequence are also low in antioxidant activity. Higher antioxidant activity can aid in the aging of wines by preventing oxidation from reactive oxygen species. Additionally, phenolic compounds contribute to the stability of the wines as well as the overall mouth-feel. Reports of health benefits associated with phenolic compounds found in wines typically indicate that red wines are the preferred source of these compounds.

Previous research (Gawel, Van Sluyter, Smith, & Waters, 2013; Olejar, Fedrizzi, & Kilmartin, 2015; Singleton, Sieberhagen, De Wet, & Van Wyk, 1975) on white wines showed that an increase in phenolics and antioxidant activity is associated with increases in mouth-feel attributes. Casassa, Beaver, Mireles, and Harbertson (2013) reported in Merlot wines that extended maceration and ethanol concentration accounts for not only increased phenolic content, but also astringency. These studies highlighted the necessity to control the maceration process in such a manner as to maximize the antioxidant activity while minimizing any undesirable sensory attributes.

Chardonnay is used in the making of many styles of wine. This varietal has the ability to work well with a variety of winemaking treatments such as oak barrel aging, malo-lactic fermentation, and ferments in stainless steel. The wines produced range from light and fruity to rich and complex (Herjavec, Jeromel, Da Silva, Orlic, & Redzepovic, 2007; Liberatore, Pati, Nobile, & Notte, 2010). Wine body is associated with its phenolic content and Chardonnay is a varietal that embraces a fuller body, which is why it was chosen for this study to increase phenolics and antioxidant activity.

Maceration of grapes is one method to produce increases in antioxidant activity. However, not all maceration techniques can be applied to all grape varieties. Techniques, which increase phenolics, can also result in bitter and astringent white wines, as well as off colors and flavors. Apart from these undesirable traits, maceration can also create wines not typical of the varietal characteristics. Three maceration techniques were utilized to evaluate their influence on the antioxidant activity and sensory attributes of Chardonnay wines. The methods employed were all chosen based on their contributions to attributes already applied to other varietals.

Extended skin contact resulting from a cold soak is one of the most commonly employed maceration techniques (Gómez-Míguez et al., 2007). Red wines typically have long skin contact from

Abbreviations: C, control; CM, carbonic maceration; CR, cryogenic maceration; ESC, extended skin contact; PC, principle component; PCA, principle component analysis; APCA, ANOVA principle component analysis; DPPH, 2,2′−diphenyl-1−picryhydrazyl; GSH, glutathione; GRP, grape reaction product; VA, volatile acidity; TA, titratable acidity; HPLC, high pressure liquid chromatograpy; Ω, ohm.

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fermentation occurring on the skins. This produces a wine high in antioxidant activity, but they can also be astringent. Another technique typically associated with red wines is carbonic maceration, a method that is known to produce light and fruity wines (Flanzy, 1935). These two red wine methods, on skin ferment and carbonic maceration, were applied to the Chardonnay grape. Following from previous reports with Sauvignon blanc (Baiano et al., 2012; Olejar et al., 2015), cryogenic maceration was the third treatment to be evaluated, as it has been shown to increase phenolics and aromatic characteristics.

2. Materials and methods

2.1. Chemicals

Carbon dioxide gas and dry ice were provided by BOC (Auckland, New Zealand). Phenolic standards, the Folin-Ciocalteu reagent, (±)-6-Hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid (Trolox), and 2,2′–diphenyl-1–picryhydrazyl (DPPH) were obtained from Sigma–Aldrich (St Louis, MO, USA). Methanol, ethanol, acetonitrile, monosodium and disodium phosphate were obtained from Scharlau (Sentmenat, Spain). Orthophosphoric acid was purchased from Ajax Finechem Pty Ltd (Sydney, NSW, Australia). Water (18-Ohm) was produced with a Barnsted Nanopure water system (Thermo Scientific, Waltham, MA, USA).

2.2. Wine samples

Vitis viniferia cv. Chardonnay, clone UCD6, were sourced from the Marlborough Region of New Zealand and were harvested by hand at commercial ripeness during the hours of 0800–0900. The harvested grapes were divided into four groups: control (C), carbonic maceration (CM), cryogenic maceration (CR), and extended skin contact (ESC).

For carbonic maceration, whole grape clusters where placed in stainless steel fermenters and purged with CO_2. Fermenters (Tao, Dykes, & Kilmartin, 2007) were modified as described in Olejar et al. (2015) for CM. After 8 days the CM grapes were removed destemmed and crushed. The other grape treatments were also destemmed and crushed. CR musts were frozen to −20 °C with dry ice. They were then allowed to thaw overnight at winery temperature (15°–20 °C).

Destemmed and crushed grapes were pressed using an 80-L hydraulic basket press (Zambelli Enotech, Camisano, Italy). Juice was obtained and allowed to cold settle at −4 °C for 24 h prior to racking and placing in 11 L glass carboys at 15 °C for fermentation. Yeast strain D47 (Lalvin, Montreal, Canada) and nutrients, Nutriferm Energy and Nutriferm Special (Enartis, Trecate, Italy) were added to the juices. ESC musts did not undergo pressing or cold settling, but instead had yeast and nutrients added directly for fermentation. The ferment cap was punched down morning and evening to ensure proper wetting of the skins for extraction. Upon completion of alcoholic fermentation the ESC wines were pressed.

All wines were transferred to −4 °C and cold settled for 48 h prior to racking off the lees. The wines were then allowed to cold stabilize for an additional 14 days prior to racking and bottling with the addition of 30 mg/L SO_2 in 750 mL glass bottles with aluminum screw cap closures lined with foil.

2.3. Juice and wine analysis

Total soluble solids (TSS) (°Brix), titratable acidity (TA), volatile acidity (VA), and ethanol content (%v/v) were measured with a WineScan (FOSS, Hillerød, Denmark). pH was measured with a Thermo Orion 420 A+ pH meter (ThermoFisher Scientific, Waltham, MA, USA). Conventional analysis was performed on triplicate wine samples and duplicate juice samples.

Wine tristimulus color was obtained by full spectrum scanning in the transmittance mode from 280 nm to 780 nm at 5 nm increments, followed by integration utilizing the method set forth in the *Compendium of International Methods of Wine and Must Analysis* (OIV, 2014). Wine samples were filtered through 0.45 μm syringe filters into 10 mm glass cuvettes and the spectrum recorded. Values for L^*, a^*, and b^* were obtained through integration and the tables provided within the reference literature (OIV, 2014).

2.4. Antioxidant and phenolic profiles

Antioxidant activity of triplicate wine samples was determined by using the DPPH radical scavenging assay described by Villano, Fernandez-Pachon, Moya, Troncoso, and Garcia-Parrilla (2007) using a Trolox calibration curve. To 3.9 mL of a 63.4 μM solution of DPPH, and 0.1 mL of wine or Trolox standard was added. Solutions were mixed and stored for 60 min at room temperature, shielded from the light. Absorbance measurements of the solutions were obtained at 515 nm on a Shimadzu model 1700 UV/Vis spectrophotometer (Kyoto, Japan) using 80% $_{(v/v)}$ methanol as a blank.

Total phenolic content was established using the Folin-Ciocalteu assay as described by Bajčan, Harangozo, Hrabovská, and Bončíková (2013) on triplicate wine samples. Into a 50 mL volumetric flask, 1.0 mL of wine or gallic acid standard and 5.0 mL of 18-Ω water was pipetted. To this solution 0.25 mL of the Folin-Ciocalteu reagent and 3.0 mL of 20% sodium carbonate was added. The flasks were then brought to 50 mL with18-Ω water, mixed well and stored at room temperature, shielded from light for 90 min. Sample and standard absorbances were measured at 765 nm.

Phenolic compounds were determined by HPLC using the method described by Olejar et al. (2015). Triplicate wine samples and standard solutions were filtered through 0.2 μm syringe filter and 20 μL of the filtrate was injected into an Agilent 1100 HPLC with UV/Vis detector (Santa Clara, CA, USA) measuring at 280, 305, 320, and 365 nm and an ESA Coulochem III electrochemical detector (Waltham, MA, USA) measuring at 450 and 750 mV. Chromatographic conditions were a flow rate of 1.0 mL/min over 30 min at 40 °C on a 3.0 × 100 mm, 3 μm, Supelco Ascentis RP-amide column (St. Louis, MO, USA). Separation was performed using a gradient elution of mobile phase A: 30-mmol phosphate buffer at pH 2.6, and mobile phase B: a mix (30:10:60) of 100-mmol phosphate buffer, methanol, and acetonitrile at pH 2.6. The gradient for phase B was 0–10 min 12% $_{(v/v)}$, 10–15 min 30% $_{(v/v)}$, 15–17.5 min 55% $_{(v/v)}$, 17.5–21 55% $_{(v/v)}$, 21–23 min 100% $_{(v/v)}$, and 23–25 min 0% $_{(v/v)}$.

The glutathione (GSH) content in the triplicate wine samples and duplicate juice samples was assessed by HPLC as described in Makhotkina et al. (2014). Utilizing an Agilent 1100 HPLC equipped with an ESA Coulochem III electrochemical detector and a Luna (2) column (250 × 4.6 mm, 5 μm) (Phenomenex, Torrance, CA, USA), samples and standards were filtered with a 0.2 μm syringe filter with 20 μL being injected for analysis. Analyte separation occurred using a gradient program with three mobile phases: mobile phase A, 10 mmol phosphate buffer, pH 5.0; mobile phase B, methanol; mobile phase C, acetonitrile. The gradient program was 0–12 min 5% $_{(v/v)}$ B; 12–15 min 5% $_{(v/v)}$ B, 50% $_{(v/v)}$ C; 15–17 min, 5% $_{(v/v)}$ B, 75% $_{(v/v)}$ C; 17–20 min 5% $_{(v/v)}$ B with a total run time of 40 min at a flow rate of 0.4 mL/min.

2.5. Sensory analysis

The aroma and palate of the wines were assessed by a sensory panel as previously described in Olejar et al. (2015) with the addition of mouth-feel attributes. Evaluation of the twelve