Food Quality and Preference xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Analysis of temporal dominance of sensation data using correspondence analysis on Merlot wine with differing maceration and cap management regimes

Scott C. Frost [a], John W. Blackman [b], Susan E. Ebeler [a], Hildegarde Heymann [a,*]

[a] Department of Viticulture & Enology, University of California, Davis One Shields Avenue, Davis, CA 95616, USA
[b] National Wine and Grape Industry Centre, Charles Sturt University, Locked Bag 588, Wagga Wagga 2678, Australia

ARTICLE INFO

Article history:
Received 4 November 2015
Received in revised form 20 November 2016
Accepted 22 November 2016
Available online xxxx

Keywords:
Temporal dominance of sensation
Correspondence analysis
Descriptive analysis
Post fermentation maceration
Cap management

ABSTRACT

Temporal dominance of sensation (TDS) is a dynamic sensory method that aims to capture the changing sensory profile of a product. TDS returns a frequency table indicating which attribute is selected as most dominant at a given time point. This paper outlines the relationships between TDS, descriptive analysis (DA) and chemical measures taken from a single product set. Merlot wine produced using nine different wine production practices comprised the product set. Principal component analysis (PCA) applied to the DA and chemical data table showed similar treatment discrimination. The DA captured 84.0% of the variability within two components, while the chemical measures captured 91.3%. Correspondence analysis (CA) was applied to the TDS frequency table along with calculating TDS curves. CA accounted for 43.1% of treatment variability within the first two components. The resulting CA factor map provided results consistent with the TDS curves, and allowed global TDS differences to be visually displayed in a single graphic. In addition, bootstrapping followed by calculating 95% confidence ellipses showed treatment discrimination within the CA factor map. Descriptive analysis captured the increasing astringency with longer maceration, while TDS captured the bitter persistence once the astringent sensation decreased.

1. Introduction

Temporal dominance of sensation (TDS) is a dynamic sensory method that aims to capture the changing sensory profile of a product (Pineau et al., 2009). This method is advantageous as it provides a sequence of perceived sensations as a function of time. This differs from traditional descriptive sensory profiling, which evaluates attribute intensity at a single time point. TDS provides additional insight into perception dynamics over a defined period, thus in conjunction with descriptive profiling a comprehensive representation of sensory impacts and differences can be observed.

Methods have been proposed for TDS analysis, including randomized testing on the distance between matrices (Meyners & Pineau, 2010), binning the TDS matrix into two to three time segments, followed by ANOVA (Dinnella, Masi, Naes, & Monteleone, 2013) or correspondence analysis of the binned segments (Meyners, 2016). An approach on temporal check-all-that-apply data (TCATA) used CA to visualize the temporal change amongst the products (Boinbaser, Parente, Castura, & Ares, 2015). "Taste trajectory" has also been proposed for the analysis of TDS data tables (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009).

Wine is a suitable product for TDS evaluation and has been extensively used (Meillon, Urbano, & Schlich, 2009; Sokolowsky & Fischer, 2012). In many situations wine is held in mouth for a time period, allowing various taste sensations to develop and change. It is also common to discuss wine in terms of initial sensation, length, and finish. TDS is a method that can bridge wine consumer terminology and sensory measures. The wines in the presented study are part of an investigation that explored the effect of extended maceration on taste and mouthfeel.

In order to facilitate clarity of the 9 wine treatments, a few specific winemaking techniques should be introduced. During alcoholic fermentation of red wine, the accumulated grape skins at the top of the fermenting liquid is termed the cap. This is problematic, as color, flavor, and aroma compounds are only extracted from grape skins when in contact with the fermenting juice. There are three main ways to keep the cap in contact with the fermenting

* Corresponding author.
E-mail addresses: scfrost@ucdavis.edu (S. Frost), jblackman@csu.edu.au (J.W. Blackman), seebeler@ucdavis.edu (S.E. Ebeler), hheymann@ucdavis.edu (H. Heymann).

http://dx.doi.org/10.1016/j.foodqual.2016.11.011
0950-3293/

wine, pumping over, punching down and by submerging the cap. These methods are applied during active fermentation and are generally termed cap management.

During a pump-over, a specified quantity of the fermenting wine is used to irrigate the cap at specified intervals. In the case of punch downs the cap is manually pushed back into the fermenting wine at specified time intervals. The submerged cap is achieved by including a barrier below the juice surface. The cap is prevented from rising above the surface, and thus contact between the skins and fermentation is continuous.

At the completion of the alcoholic fermentation, termed dryness, the wine is then pressed. This processing step separates the wine from the pomace (grape skins and seeds). However, in some cases the wine is allowed to remain in contact with the pomace after dryness. This practice is called extended maceration (EM). The intent of EM is to influence taste and mouth feel through increased tannin concentration and also modify the polyphenol species distribution (Sacchi, Bisson, & Adams, 2005).

Descriptive analysis, temporal dominance of sensation and measured chemistry will be utilized to evaluate the effect of cap management and extended maceration technique on the chemical and sensory profile of Merlot wine.

2. Materials and methods

2.1. Wine production

Wines were made in the UC Davis Experimental Winery in Fall 2013. Machine harvested *Vitis vinifera* cv. Merlot (4.5 ton), with a total soluble solids measurement of 27.4° Brix, from the UC Davis Oakville Research station was crushed and destemmed, using a Bucher Vaslin Delta E4. The must was then pumped to twenty-seven jacketed stainless steel 150 kg fermentors. In order to help ensure homogeneity, crushed fruit was sequentially added, in 10 cm additions, to each of the 27 fermentors. Post processing, 1 g/L tartaric acid additions were made in order to decrease the pH to 3.6. The must was allowed to cold soak for 24 h. Yeast assimilable nitrogen (YAN) was measured and adjusted to 280 mg/L YAN using a combination of Fermaid K (Lallemand, Montreal, Canada) and Diammonium Phosphate (American Tartaric Products, Windsor, California). Fermentors were inoculated with 200 mg/L of EC1118 yeast (Lallemand, Montreal, Canada) and fermentation began within 72 h of crushing.

The following 9 treatments were performed in triplicate: 1- Pump-over and pressed at dry, zero maceration (Em0); 2- Pump-over and pressed after 1 week of post dry extended maceration (Em1); 3- Pump-over and pressed after 2 weeks of post dry extended maceration (Em2); 4- Pump-over and pressed after 4 weeks of post dry extended maceration (Em4); 5- Pump-over and pressed after 6 weeks of post dry extended maceration (Em6); 6- Pump-over and pressed after 8 weeks of post dry extended maceration (Em8); 7- Submerged cap – pressed at dry (Su0); 8- Submerged cap pressed after 8 weeks post dry maceration (Su8); 9- Punch down (PuD), the ferment was punched down, then pressed at dry. The submerged cap treatments were achieved using purpose designed heavy stainless steel mesh, and punch downs were performed using a stainless steel plunger 3 times daily. The pump-overs were completed by a built-in fermentor pump three times daily for 12 min to achieve one fermentor volume of juice to be pumped on each occasion. Cap temperature and juice temperatures were automatically monitored and adjusted every 15 min, with cap temperatures maintained at 25–28 °C. Final fermentation kinetics were similar for all treatments (data not shown). When the measured Brix had decreased to 14°, malolactic fermentation (MLF) was initiated using 0.01 g/L Lallemand Alpha *Oenococcus oeni* (Lallemand, Montreal, Canada). The wines were considered dry when the residual sugar, the sum of glucose and fructose measurements, was less than 0.1 g/L.

The three "pressed at dry" treatments (Em0, PuD, Su0) were pressed using a hydraulic press 12 days post crushing. The remaining treatments were pressed over the following 8 weeks at the maceration intervals as indicated. During the maceration period, each fermentation tank was pumped over for five minutes per day.

At completion of MLF, wines were racked into 50 L stainless steel containers and 80 ppm of sulfur dioxide in the form of potassium bisulfite (American Tartaric Products, Windsor, California) added to achieve a free sulfur dioxide of 30–40 ppm. Wines were then allowed to further settle and cold stabilize at 0 °C to −2 °C for three weeks prior to bottling. After bottling the wines were stored at 16 °C and 60% relative humidly.

2.2. Descriptive sensory analysis

The 27 wines were evaluated by a trained panel of 12 volunteers (8 males and 4 females, aged 21–72 years) five months after bottling. All panelists had previous winetasting experience, and were selected on the basis of their availability and interest. Consensus terminology and reference standards (Table 1) were developed over seven training sessions held over two weeks. Following training, panelists were required to evaluate the 27 wines in triplicate during 9 tasting sessions. This was completed by tasting 9 wines per session in a randomized block design. Panel performance was evaluated using PanelCheck (Tomic et al., 2010) and was found to be acceptable (data not shown).

Each evaluation session began with the assessment of the 11 aroma standards. Panelists were required to smell each aroma standard labeled with a random 3-digit code and indicate the identity of the standard. After all standards were assessed, feedback was provided by indicating any incorrect responses and the panelists were then instructed to review these aroma standards.

The 9 wines for a single formal evaluation session were randomly divided into a flight of four and a flight of five. The panelists

Table 1
Sensory attributes and reference standards used in descriptive analysis.

Attribute	Reference standard
Aroma	
Red Fruit	20 g raspberry jam + 20 g strawberry jam + 1 mL Crystal Light Liquid Blueberry Raspberry drink mix in 500 mL base wine[a]
Dark Jam	125 mL crème de cassis + 120 g fruit leather + 375 mL base wine[a]
Prune Raisin	80 g prunes + 80 g raisins in 500 mL of base wine[a]
Citrus Floral	2 fresh picked citrus blossoms + ~0.5 in. square of navel orange rind + 25 mL base wine[a]
Bay	4 fresh bay leaves (~4 g) soaked in 500 mL base wine[a]
Vegetative	25 g sweet pea baby food + 1 tbsp. of liquid from canned green beans + 25 mL base wine[a]
Pepper Spice	2.5 g black pepper + 2.5 g white pepper in 500 mL base wine[a]
Earthy	25 g potting soil + 1 unshelled, unsalted, roasted peanut
Aldehydic	40 mL fino sherry + 60 mL base wine[a]
Alcohol	30 mL 151 proof grain alcohol + 70 mL base wine[a]
VA	50 mL base wine[a] + 2 drops acetic acid + 2 drops ethyl acetate
Taste	
Sweet	4.0 g/L sucrose (C&H sugar)
Sour	600 mg/L citric acid
Bitter	800 mg/L caffeine
Hot	10% v/v ethanol
Astringency	Verbal description
Drying	1 g/L green tea extract defined as drying
AstTexture	1 g/L black tea extract defined as coarse

[a] Base wine: Franzia World Classics Burgundy 3 L Bag-in-Box. Am.

Please cite this article in press as: Frost, S. C., et al. Analysis of temporal dominance of sensation data using correspondence analysis on Merlot wine with differing maceration and cap management regimes. *Food Quality and Preference* (2016), http://dx.doi.org/10.1016/j.foodqual.2016.11.011