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Wine finish in red wine: The effect of ethanol and tannin concentration

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ABSTRACT

Wine finish, the tastes and aromas that linger after swallowing wine, is a critical aspect of wine quality. The objective of this study was to use time-intensity (TI) methodology to determine whether the finish parameters of different flavors varied as a function of wine matrix composition. Trained panelists ($n = 10$) executed TI evaluations on three flavor compounds (2-phenylethanol (floral), 3-isobutyl-2-methoxypyrazine (bell pepper), and oak lactone (coconut)), heat, and astringency in wine adjusted to varying ethanol and tannin levels. Multivariate analysis of variance indicated that elevated ethanol increased duration and intensity of the finish for floral and coconut samples ($p < 0.05$). For floral and bell pepper, no significant differences were shown using canonical variates analysis (CVA); however, for coconut, the high ethanol samples were more associated with a higher finish intensity and longer duration of finish. Flavor interactions also affected finish duration, with coconut (oak lactone) finish duration shortened by 10.35 s in the presence of 2-phenylethanol. These results showed that the wine matrix affects red wine finish and can be used by winemakers to understand how different processing techniques that alter the ethanol and tannin content of their wines, may also be affecting the sensory qualities of the wine finish.

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Introduction

The global wine industry accounted for 257.5 billion dollars in 2012, up 3.1% from 2011 (Business Wire, 2012). Wine sales in the United States in 2012 amounted to 34.6 billion dollars (Wine Institute., 2012). The ability to control wine quality is crucial to this success so it behooves winemakers and the wine industry to understand the sensory attributes affecting wine quality. Economic studies indicate that these attributes include the sensory variables of aroma, flavor, mouthfeel, and finish (Benfratello, Piacenza, & Sacchetto, 2009; Cardebat & Figuet, 2004; Combris, Lecocq, & Visser, 1997; Lecocq & Visser, 2006).

Wine finish, defined by Jackson (2002), as the lingering flavor, taste, and mouthfeel one observes after swallowing or expectorating wine is the consumer's last impression of a wine and has long been considered an important aspect of wine quality. One influential wine critic, Michael Broadbent, explicitly stated in his 1979 Pocket Guide to Wine Tasting, "quality can be assessed by the length of time the flavor lingers in the mouth…and by its aftertaste" (Broadbent, 1979). Although encompassing other extensively studied wine sensory attributes such as aroma and flavor, wine finish remains relatively uncharacterized.

In the few studies that have investigated wine finish, a temporal attribute, time-intensity (TI) methodology has been utilized. In TI, trained panelists provide continual ratings of the intensity of a stimulus over time from the onset of that attribute to the point at which it is no longer detectable, generating a curve for each panelist. From this curve, parameters including the time to maximum intensity (T_{max}), the intensity at maximum (I_{max}), the area under the curve (AUC), and the duration (T_{end}) can be extracted. TI curves have been shown to correlate to category intensity scaling while providing additional information about the temporal aspects of the sample (Lundahl, 1992). As a result, TI has become a valuable method for the sensory testing of temporal attributes used in many food and beverage studies including those evaluating Scotch malt whiskey (Piggott, Hunter, & Margomenou, 2000), milk (Miettinen, Hyvönen, & Tuorila, 2003), chewing gum (McGowan & Lee, 2006), ice cream (Frøst, Heymann, Bredie, Dijksterhuis, & Martens, 2005), astringency in red wine (Valentová, Skrovánková, Panovská, & Pokorný, 2002), and flavor finish in white wine (Goodstein, 2011).

In white wine, studies investigating flavor finish found that the T_{end} of finish varies depending on the flavor evaluated and processing choices. Specifically, fruity notes finished 29.9–47.1 s earlier than floral, coconut, and mushroom notes as evaluated by a trained sensory panel using TI (Goodstein, 2011). This same study found

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T_{end} to vary with oaking level. Specifically, consumers perceived a shorter T_{end} of coconut (oak) finish in unoaked Chardonnay as compared to highly oaked Chardonnay. This decrease in coconut T_{end} corresponded to an increase acceptance and willingness to purchase; however, shorter finish does not always result in increased acceptance.

In a red wine study, consumer panel results indicated that finish time differed due to varying wine matrix components and influenced the acceptance of the wine, with a longer finish resulting in increased acceptance (Baker & Ross, 2014). Specifically, increasing ethanol from 9% to 14% increased the T_{end} in red wine for 3-isobutyl-2-methoxypyrazine (bell pepper), 2-phenylethanol (floral), and oak lactone (coconut) with the higher ethanol treatments finishing 7.7, 12.4, and 6.8 s later, respectively, than their low ethanol counterparts as evaluated by consumers. Consumers liked these high ethanol treatments significantly more than their low ethanol counterparts for all three flavors ($p < 0.05$). Tannin concentration significantly lengthened the T_{end} of bell pepper finish (3-isobutyl-2-methoxypyrazine) but did not affect 2-phenylethanol or oak lactone finish. The contribution of wine matrix components to the finish was not surprising as numerous studies have shown tannin and ethanol to affect flavor and aroma perception (Robinson et al., 2009; Secor, 2012; Villamor, Evans, Mattinson, & Ross, 2013).

Based on this previous research showing differences due to tannin and ethanol content, the objective of the present study was to further characterize the matrix effect on wine finish. To meet this objective we used time-intensity (TI) methodology to investigate this effect on the finish of three flavor compounds commonly found in red wines, with intensities known to impact quality (3-isobutyl-2-methoxypyrazine (IBMP), 2-phenylethanol, and oak lactone). Briefly regarding each flavor of interest, 3-isobutyl-2-methoxypyrazine or IBMP (bell pepper) is the most common pyrazine found in red wines and is acceptable at concentrations of 2–20 ng/L yet a defect if above this range (Allen, 1995; Ebeler, 2001; Jackson, 2000; Polásková, Herszage, & Ebeler, 2008). Next, a major phenolic alcohol found in wine, 2-phenylethanol, contributes a floral or rose-like character (Jackson, 2000) and is considered a positive attribute in red wines (Lattey, Bramley, & Francis, 2009). 2-phenylethanol can be detected at 10 mg/L and is commonly found in wines at 46–96 mg/L (Escudero, Campo, Fariña, Cacho, & Ferreira, 2007; Ferreira, Lopez, & Cacho, 2000; Tao, Li, Wang, & Zhang, 2008) Finally, oak lactone (coconut) acceptance has been investigated in wine finish studies (Baker & Ross, 2014; Goodstein, 2011), and varies depending on the type of wine, with increased oakiness decreasing acceptability in Chardonnay wines but increasing acceptability in Syrah.

The present study sought to examine the effect of the wine matrix components, tannin and ethanol, on the finish of those flavors and their interactions with one another. Through this study, we anticipate contributing to the knowledge base regarding flavor-flavor interactions, flavor-matrix interactions, and providing important information for winemakers about how altering the matrix may also affect the finish and subsequent quality of their wines.

Materials and methods

Overview

Wine treatments were prepared from a dealcoholized Syrah adjusted to two ethanol (10% and 16% v/v) and tannin (140< mg/L and 800 mg/L catechin equivalents (CE)) concentrations. To these wine matrix treatments, flavor compounds of interest (2-phenylethanol (floral), 3-isobutyl-2-methoxypyrazine (bell pepper), and oak lactone (coconut)), were added alone and in combination. For each treatment, trained panelists ($n = 10$) executed TI evaluations of the intensity of the three flavor compounds, as well as heat and astringency.

Materials

Food-grade 2-isobutyl-3-methoxypyrazine was obtained from Pyrazine Specialties (Ellenwood, GA). MilliQ water was obtained through purification (Millipore Corporation, Billerica, MA, USA). Food grade flavor compounds 2-phenylethanol (⩾99%) and oak lactone (⩾98%) were obtained from SAFC Sigma Aldrich (St. Louis, MO). Ferric chloride, sodium chloride, potassium hydrogentartrate, triethanolamine, citric acid, 6-propyl-2-thiouracil, sodium dodecyl sulfate, bovine serum albumin, and (+)-catechin were obtained from Sigma Aldrich (St. Louis, MO). Biotan was obtained from Laffort (Bordeaux, France). Ethanol, 200 proof, was obtained from Decon Laboratories Inc. (King of Prussia, PA). Glacial acetic acid and hydrochloric acid, sodium hydroxide and sodium chloride were obtained from J.T. Baker (Phillipsburg, NJ).

Wine analysis

Syrah wine was vinified and donated by Canoe Ridge Winery (Prosser, WA). Prior to donation, Canoe Ridge utilized an Alcohol Reduction/Sweet Spot Trial Reverse Osmosis unit (Maverik North America, Santa Rosa, CA) to dealcoholize the wine from 12.41% to 3.02% ethanol (v/v) and bottled in clear 750 mL screw-cap bottles. This wine was characterized upon receipt (3.02% v/v ethanol, 0.537 g/L titratable acidity (TA), pH 3.78%, 0.25% sugar, <140 mg/L CE) and stored in a dark room at 4 °C until use.

Ethanol content was measured using an ebulliometer (Alla France, France). Titratable acidity was measured using a TitroLine Easy Autotitrator (Schott Instruments, Germany) calibrated with pH 4 and pH 7 standards while the pH was measured using a Fischer Scientific Accumet basic AB15 Plus pH meter. Clinitest® Reagent Tablets (Bayer, Leverkusen, Germany) were used to determine the percent sugar according to the "5-drop method" standard procedure as described by Bayer for the quantitative determination of reducing sugars. Finally, the tannin profile was characterized using a protein precipitation method from Hagerman and Butler (1978) modified by Harbertson, Kennedy, and Adams (2002).

Wine treatments

Following a full factorial design, wine matrix treatments were prepared by adjusting the wines with two levels of ethanol (11% and 16% v/v) and two levels of tannin (0 g/L and 1.5 g/L added catechin equivalents (CE)). These ethanol and tannin concentrations were established based on the typical concentrations found in commercial wines (Landon, Weller, Ross, & Harbertson, 2008; Villamor, Evans, Mattinson, et al., 2013; Villamor, Evans, & Ross, 2013). Prior to tannin adjustment, Biotan was assayed for purity using the protein precipitation assay (Harbertson, Kennedy, & Adams, 2002) and found to be 0.245 g CE per 1 gram Biotan or 24.5% CE. This purity was considered when adding tannin to the wine samples.

Flavor compounds (2-phenylethanol (floral), 3-isobutyl-2-methoxypyrazine (bell pepper), and oak lactone (coconut)), were added to each wine matrix treatment, alone and in combination. To reduce the number evaluations necessary due to the large number of treatments, single and triple compound mixtures were evaluated for each flavor they were spiked with, as well as both astringency and heat while double compound mixtures were only evaluated for the two flavors they were spiked with. The term "flavor block" will be used throughout this paper to refer to all