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# Perception of flavor finish in model white wine: A time-intensity study

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ABSTRACT

This study performed a time intensity trained panel ($n = 10$) evaluation of flavor finish in model white wines. Four flavor compounds representing fruity, floral, coconut, and mushroom flavors were added to a model white wine in single-, two- and four-compounds combinations.

Trained panelists executed time intensity analysis (TI) of these model white wines. TI analysis of single- and two-compound model wines showed that fruity flavor finished earlier than coconut, mushroom and floral flavors ($p < 0.05$). In the four-compound model wine, only fruity flavor finished earlier than floral flavor ($p < 0.05$). For the TI parameter of $I_{max}$ (maximum intensity), similar trends were observed for the single and two-compounds model wines in that mushroom was perceived as significantly more intense than fruity flavor. This difference was not apparent in the four-compound model wine, likely due to the complexity of the model wine. Predicted interactions among the flavor compounds indicated that the perceived intensity of coconut flavor was highly influenced by the presence of other flavor compounds, while the lengths of finish of mushroom and coconut flavors were highly influenced by interactions among flavor compounds. Overall, this study provided an approach to studying wine finish and through results in a model wine, suggested that different flavor compounds are perceived differently in wine finish.

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## 1. Introduction

Wine finish is defined by Jackson as the lingering taste following the swallowing of wine (Jackson, 2000). Wine finish is considered an important parameter in the evaluation of wine quality and has been included in several economic models defining market prices for French (Cardebat & Figuet, 2004; Lecocq & Visser, 2006) and Italian wines (Benfratello, Piacenza, & Sacchetto, 2009). Lengthy finish is most notable in fine red wines but is also observed in Sauvignon Blanc and Chardonnay white wine varieties (Amerine & Roessler, 1983). It is believed that certain flavors are associated with different lengths of finish. Fruity and floral flavors are thought to have a shorter finish while oak, spice, and earthy flavors are thought to have a longer finish (Jackson, 2002). However, this is a relatively unexplored area and commonly accepted theory is based largely upon conventional wisdom rather than scientific data.

Wine finish is influenced by flavor, an important parameter of a wine sensory profile that can dictate wine quality and/or consumer acceptance, thereby making wine flavor a topic of great interest to researchers. Flavor is considered the result of retronasal stimulation (Meilgaard, Civille, & Carr, 2007). This occurs when volatile compounds in the mouth and/or upper digestive tract are able to stimulate receptors in the nasal passage. The stimulation of nasal receptors elicits the transmission of a signal to the brain resulting in the perception of flavor (Jackson, 2002). Volatile compounds are numerous in white wine and other alcoholic beverages. According to a 2001 review by Ebeler, over 1300 compounds have been successfully detected in wine, beer, malt beverages, brandy, and distilled spirits. Major categories of flavor compounds include terpenes, phenols, ethyl esters, acetate esters and lactones (Ebeler, 2001) and numerous compounds are responsible for different perceived flavors. For example, monoterpenes are associated with floral notes (Marais, 1983) whereas oak lactones are associated with coconut notes (Waterhouse & Towey, 1994).

The finish of four compounds, including linalool, ethyl hexanoate, 1-octen-3-ol, and oak lactone, were evaluated in the study. These compounds were selected as they are important flavor compounds in white wine (Ferreira & De Pinho, 2003; Guth, 1996) and also represent major aroma classes according to the Wine Aroma

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Wheel (Noble et al., 1987). Linalool is a volatile terpene (Clarke & Bakker, 2004) associated with green, floral and citrus notes, with a reported taste threshold of 5 ppm (Burdock, 2009). The compound is found in numerous white grape varieties, but present at highest quantities in Gewürztraminer (0.006–175 ppm), Scheurebe (0.007–307 ppm), and Morio-Muscat (0.16–0.28 ppm) wine varietals (Guth, 1997; Schreier, Drawert, & Junker, 1977). Linalool has also been reported in Chardonnay, but at a lower concentration (0.1 ppm) (Aldave et al., 1993), while still maintaining odor activity (Lee & Noble, 2003).

Ethyl hexanoate is an ethyl ester that is associated with fruity (Burdock, 2009) and apple notes (Genovese, Gambuti, Piombino, & Moio, 2007), with a taste threshold of 10 ppm (Burdock, 2009). Ethyl esters are formed as a result of fermentation (Bardi, Crivelli, & Marzona, 1998). Odor activity of ethyl hexanoate has been documented in Gewürztraminer and Scheurebe, which was present at concentrations of 490 ppm and 280 ppm, respectively (Guth, 1997). In Fiano wines, ethyl hexanoate was reported at a concentration of ~3 ppm (Genovese et al., 2007). In Chardonnay wines, ethyl hexanoate was found to have odor activity using gas chromatography–olfactometry (GC/O) analysis, and was described as "fruity" (Lee & Noble, 2003).

The alcohol, 1-octen-3-ol, is associated with mushroom notes and has a taste threshold of 10 ppm (Burdock, 2009). Linked with fungal growth on grapes, this compound has distinct mushroom aroma and flavor (La Guerche, Dauphin, Pons, Blancard, & Darriet, 2006). Sensory testing determined that 1-octen-3-ol had a low sensory odor perception threshold in three different media (water: 2 μg/L, model wine 20 μg/L, and red wine 40 μg/L). Researchers noted these low threshold values are significant as low concentrations could lead to noticeable impact on wine (La Guerche et al., 2006). This compound has been found in musts made from rotten grapes at a concentration of 6–21 μg/L (La Guerche et al., 2006), with concentrations as high as 213 μg/L in sweet Fiano wine (Genovese et al., 2007).

Oak lactone is an important volatile compound present in wines aged in oak barrels, with characteristics of vanilla, wood, and coconut (Burdock, 2009). Also known by the names whiskey lactone, 4-hydroxy-3-methyloctanoic acid lactone, and 2(3H)-furanone, oak lactone exists in four isomers. These forms include naturally occurring (4S, 5S) cis-oak lactone and (4S, 5R) trans-oak lactone, and non-naturally occurring (4R, 5R) cis-oak lactone and (4R, 5S) trans-oak lactone. A sensory analysis of all four oak lactone isomers was performed by Brown, Sefton, Taylor, and Elsey (2006) to determine if sensory differences in aroma detection existed between the four isomers of oak-lactone. The study concluded that cis-oak lactone has a greater impact on wine aroma than the trans-oak lactone in red and white wine. These researchers also reported varying taste thresholds in white wine depending upon the isomers, with a taste threshold of 24 ppm for the cis isomer and 172 ppm for the trans isomer (Brown et al., 2006). Oak lactone has been reported in sweet Fiano wine at a concentration of 165 μg/L (Genovese et al., 2007). In Chardonnay, both the cis and trans isomers were found to be odor active, with a descriptor of "spicy" generated from GC/O analysis (Lee & Noble, 2003).

The objective of the present study was to analyze the sensory finish of linalool, ethyl hexanoate, 1-octen-3-ol, and oak lactone utilizing time-intensity analysis. Time intensity is a method of sensory evaluation that allows the panelist to evaluate the intensity of an attribute over a period of time. The data collected over a time period can then be evaluated based on summary statistics which include $T_{max}$, $I_{max}$, $T_{end}$, and area under the curve (AUC). $T_{max}$ indicates the time it takes to reach maximum intensity, whereas $I_{max}$ indicates the maximum intensity based on a scale of 0–100% low to high intensity. $T_{end}$ indicates the length of time a panelist takes to return to 0% intensity. Area under the curve is an integration which has a value that's interpretation can differ depending upon study objectives (Meilgaard et al., 2007).

Due to the multitude of data points generated by the panelist, there is variation even among trained panelists. Therefore, much discussion and research has been devoted to determining the best method of analysis of TI data. The most basic analysis requires that the summary statistics listed above be compared using analysis of variance (ANOVA) to determine significant differences (MacFie & Liu, 1992). Principle Component Analysis (PCA) is suggested by MacFie and Liu as a potential method for analyzing data, particularly if great differences are seen in the data generated by the panelists. PCA employs the mean values of the panelist evaluations and because of the panelist variation observed in TI studies, a method that considers this variation, canonical variates analysis (CVA), has better application. CVA allows the visualization of differences among samples while considering the heterogeneity of panelist notation (Teillet, Schlich, Urbano, Cordelle, & Guichard, 2010). These CVA axes maximize the distance among products or treatments while minimizing the residual variability.

The time intensity (TI) method has been used to measure flavor changes in chewing gum (Ovejero-Lopez, Bro, & Bredie, 2005), evaluate astringency of alcoholic beverages (Valentová, Skrovánková, Panovská, & Pokorn, 2002), and analyze differences in sweeteners (Bonnans & Noble, 1993). In wine, studies have been performed to analyze bitter and astringent sensations caused by phenols (Robichaud & Noble, 1990), astringency and sweetness perception/interaction (Ishikawa & Noble, 1995) and effectiveness of different palate cleansers (Ross, Hinken, & Weller, 2007). The current study operated under the hypothesis that compounds associated with fruit and floral notes would finish earlier than compounds associated with coconut and mushroom notes as evaluated by the trained panelists.

## 2. Materials and methods

### 2.1. Overview

Trained panelists evaluated the finish of the flavor compounds linalool, ethyl hexanoate, 1-octen-3-ol, and oak lactone by utilizing a time-intensity testing protocol. Flavor compounds were presented to panelists for analysis in model wine. Panelists began by analyzing the finish of a single flavor in model wines containing one flavor compound. Panelists then proceeded to analyze the finish of a single flavor in model wines containing two or all four flavor compounds.

### 2.2. Model wine preparation

Model wine parameters were selected as a result of bench testing and investigation of typical levels of alcohol, fructose, and acidity found in white wine. The model wine contained 9% ethanol (EtOH) and 0.6% fructose, and adjusted to pH 3.3 with tartaric acid. Model wine was prepared with milliQ water, 200 proof ethanol (Decagon, Pullman, WA), D – (-)-fructose (Sigma Aldrich, St. Louis, MO), and DL-tartaric acid (Sigma Aldrich, St. Louis, MO).

The flavor compounds were selected due to reported flavor characteristics and presence in white wine (Guth, 1997). The fruit, floral, coconut, and mushroom compounds were added at the following concentrations: 65.2 mg/L ethyl hexanoate, 43.1 mg/L linalool, 47.6 mg/L oak lactone (mixed cis/trans), and 41.5 mg/L 1-octen-3-ol, respectively (all food-grade, Sigma Aldrich, St. Louis, MO). These specific concentrations were determined through bench testing by starting with the published threshold value of the compounds, and evaluating increasingly higher concentrations. Due to the nature of the study and the variability in time-intensity