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Influence of ethanol content on sweetness and bitterness perception in dry wines

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ABSTRACT

Ethanol is the second major component of wine after water and exhibits important sensory properties. Previous studies suggested that its bittersweet taste varies according to the alcohol content and the matrix. However, the organoleptic impact of ethanol on wine remains largely ambiguous. Various sensory tests were carried out with a trained panel and the results were statistically analyzed. Tastings revealed that variations of ethanol content usually observed in dry wines have no direct effect on sweet taste of wine. The role of ethanol in white wine bitterness was also studied, revealing its ability to impart the perception of bitterness due to sensory interactions with other constituents. Moreover, a threshold effect was observed between 7 and 10% alc. vol.. These results underline the importance of sensory interactions in the perception of taste and illustrate the role of matrix effects.

1. Introduction

Ethanol is a primary metabolite produced by yeasts during alcoholic fermentation of grape sugars present in must. Its content generally varies between 12 and 14% alc. vol. in most dry wines (Ribéreau-Gayon, Glories, Maujean, & Dubourdieu, 2006). The presence of ethanol entails the moderate intake of wine due to its psychophysiology (Allen, McGeary, & Hayes, 2014; Lanier, Hayes, & Duffy, 2005; Nolden & Hayes, 2015) and health (Baum-Baicker, 1985; Cao, Willett, Rimm, Stampfer, & Giovannucci, 2015) effects. However, it also significantly contributes to the physico-chemical properties and to the microbiological stability of the wine. Moreover, ethanol is the most abundant volatile compound in wine and might therefore, depending on its concentration, modify the aromatic perception (Guth & Seis, 2002). For instance, some studies described that the intensity of wine fruitiness decreases with the amount of ethanol (Escudero, Campo, Fariña, Cacho, & Ferreira, 2007; Goldner, Zamora, Di Leo Lira, Gianninoto, & Bandoni, 2009; Le Berre, Atanasova, Langlois, Etiévant, & Thomas-Danguin, 2007). In addition to ethanol impact on wine aromas, the effects of ethanol level on oral sensation have been investigated (DeMiglio, Pickering, & Reynolds, 2002; Nurgel & Pickering, 2005). Studies have shown the minimizing effect of ethanol on red wine astringency (Fontoin, Saucier, Teissedre, & Glories, 2008). This observation has been attributed to the interference of ethanol with hydrophobic interactions between proteins and tannins, leading to a reduction of tannin precipitation and a decreased astringent sensation (Gawel, 1998; McRae, Ziora, Kassara, Cooper, & Smith, 2015). Finally, ethanol is also a taste-active compound. Various authors have described the sweet taste of ethanol in aqueous solution containing low levels of ethanol (0–4% alc. vol.) (Blizard, 2007; Scinska et al., 2000; Wilson, O'Brien, & MacAirt, 1973) as well as the bitter taste and the burning characteristics associated with higher levels of ethanol (10–22% alc. vol.) (Bartoshuk et al., 1993; Blizard, 2007; Mattes & DiMeglio, 2001; Scinska et al., 2000; Thorngate, 1997; Wilson et al., 1973). Neurophysiological and genetic studies have explained the link between sweet taste perception and ethanol consumption by a similar gustatory neural pathway response (Blednov et al., 2008; Lemon, Brasser, & Smith, 2004). Sour and salty attributes have also been cited to describe ethanol taste, but with much lower intensities than bitter or sweet taste (Fischer & Noble, 1994; Mattes & DiMeglio, 2001; Scinska et al., 2000).

Ethanol has been established as bittersweet, and it appears that its taste-properties vary according to its content. This raises the question of its real contribution to wine sweetness and bitterness.

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Concerning its sweet taste, ethanol has been described to enhance wine sweetness directly through its own sweet taste (Jackson, 1994). However, recent studies showed that ethanol does not influence sweet taste of model dry wines and Australian Riesling base wines (Gawel, Van Sluyter, & Waters, 2007; Jones, Gawel, Francis, & Waters, 2008). Thus, the impact of ethanol on red and white dry wine sweet taste was not clearly established. According to several authors, increasing ethanol content through the range of those encountered in wine results in an elevation of its bitter taste. Fischer and Noble described the enhancing role of ethanol between 8 and 14% alc. vol. in a model wine solution containing 100 mg/L of catechin (Fischer & Noble, 1994) while other studies demonstrated a similar enhancing effect by quinine (Martin & Pangborn, 1970), epicatechin and catechin (Noble, 1994; Thorngate, 1992) and grape seed tannin oligomers (Fontoin et al., 2008). A more recent study (Gawel, Van Sluyter, Smith, & Waters, 2013) has investigated the effects of a complex mixture of phenolics on white wine bitterness under various pH and alcohol levels. Its results have also supported a direct effect of ethanol on wine bitterness perception. The results of these studies suggest the influence of ethanol on wine taste. However, the question remains whether ethanol affects wine flavor directly or indirectly in the concentration range encountered in wine.

For this reason, this study was conducted in order to better understand the role of ethanol content on the sweet and bitter taste of wine. Despite the clearly stated bittersweet taste of ethanol, its overall contribution to dry wine taste is still unclear. The first part of this work was aimed at studying the influence of variations of ethanol content in quantities generally encountered in wines (12–14% alc. vol.) on the sweet taste of a red and a white wine. Then, the influence of ethanol content on bitter perception was comparatively studied in two wines of differing levels of bitterness (low and high). This approach sought to determine whether the impact of ethanol on wine bitterness was direct or indirect and to demonstrate the importance of matrix effects on taste perception.

2. Material and methods

2.1. Chemicals

Quinine sulfate and tartaric acid were purchased from Sigma-Aldrich (Saint-Quentin-Fallavier, France). Neohesperidin dihydrochalcone (NHDC) was purchased from Extrasynthese (Genay, France). The water used for solution preparation was pure and demineralized (eau de source de Montagne, Laqueuille, France).

2.2. Wines

2.2.1. Study of ethanol effect on sweetness perception

One white wine (WW) and one red wine (RW) were chosen for their relatively low ethanolic content. The white wine was a Bordeaux 2008 (12% alc. vol.; pH 3.1; 7.2 g/L of titratable acidity; 0.5 g/L of glucose + fructose) and the red wine was a Bordeaux 2008 (12.5% alc. vol.; pH 3.6; 5.6 g/L of titratable acidity; 0.2 g/L of glucose + fructose).

2.2.2. Study of ethanol effect on bitterness perception

During a preliminary sensory analysis, two white wines were selected on the basis of their taste by five experts strongly experienced in wine tasting, The first white wine ("wine A"), chosen for its very low bitterness, was a white Bordeaux 2011 (12.2% alc. vol.; <2 g/L of glucose + fructose; pH 3.1). The second white wine ("wine B"), chosen for its strong bitterness, was a Pessac-Léognan 2011 (12.5% alc. vol.; <2 g/L of glucose + fructose; pH 3.1).

2.3. Sensory analysis

Tastings sessions took place in a specific room equipped with individual booths and air-conditioned at 20 °C (ISO 8589:2007). Normalized glasses were used (ISO 3591:1977). All panelists (15 men and 15 women aged from 25 to 65 years) were wine tasting specialists. They were informed of the nature and risks of the present study and were asked to give their consent to participate in the sensory analyses.

Due to saturation and persistence of the bitter taste as well as palate fatigue of the panel, training and test sessions were spread over one week. Panelists were asked to rinse mouth with water and wait one minute between each sample.

For all evaluations, samples were labeled with random three-digit codes and presented in counterbalanced order to avoid bias.

2.3.1. Panel training

Panelists attended four sessions to train in recognition and discrimination of taste perception.

During the first two sessions, different concentrations of reference standard solutions representative of taste were presented to the panel: NHDC (0–4 mg/L) for sweetness and quinine sulfate (1.5–12 mg/L) for bitterness. Also, different concentrations of quinine sulfate (1.5–12 mg/L) with 3 g/L of tartaric acid were presented to the panel to train them to perceive bitterness independent of acidity.

The last two sessions were used to improve the panel's ability to discriminate sweetness and bitterness. Three series were presented to the panel: quinine sulfate (1.5, 3, 6 and 12 mg/L) with and without 3 g/L tartaric acid and NHDC (0, 1, 2 and 4 mg/L) (Table 1). Panelists were asked to sort the samples by increasing order of bitterness and sweetness for each series.

2.3.2. Sensory experiments on sweetness

To study the effect of ethanol content on wine sweetness, distilled ethanol was added to the white Bordeaux 2008 (12% alc. vol.) to provide ethanol levels of 12.5, 13 and 13.5% alc. vol., and in the same manner, distilled ethanol was added to the red Bordeaux 2008 (12.5% alc. vol.) to provide ethanol levels of 13, 13.5 and 14% alc. vol. as presented in Table 2. The difference between the lower and higher alcohol percentage (1.5% alc. vol.) was based on the ethanol content range generally encountered in wine. The alcoholic strength by volume in wine was measured with a FOSS Winescan (Hillerød, Danmark) and by the O.I.V. official Gibertini method (O.I.V., 2015).

The addition of ethanol leads to a maximal dilution of 1.5%, which is considered as negligible.

The four samples of each wine were presented to the panelists,who were first asked to rate the sweetness intensity on an eight-point scale (0 = "absence" to 7 = "very high"). This test was chosen based on the panel's familiarity with the intensity scale for profile description. In a second phase, panelists were asked to sort the wines by increasing order of sweetness.

2.3.3. Sensory experiments on bitterness

To study the effect of ethanol content on bitterness perception, two white wines were chosen. The first wine had an imperceptible bitterness ("wine A") while the second wine was representative of a bitter wine ("wine B").

Both wines were first dealcoholized by evaporation under vacuum to obtain a white wine concentrate of 5% alc. vol. Then, for each wine, addition of distilled ethanol and pure and demineralized water provided wine samples with ethanol levels of 4, 7, 10 and 12.5% alc. vol. as presented in Table 2 (the final volume was the same for all samples and similar to the initial volume of wine before