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An assessment of the effects of wine volatiles on the perception of taste and astringency in wine

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ABSTRACT

The objective of this work is measuring the effect of different volatile extract compositions on the perception of taste, astringency, global intensity and persistence of wine. Six Spanish wines, two from Chardonnay and four from Tempranillo grapes, all of them showing different chemical and sensory characteristics, were selected. Wines were separated into volatile and non-volatile fractions by solid phase extraction and lyophilisation and further liquid extraction, respectively. Eighteen "reconstituted wines" were prepared, combining different volatile extracts and different non-volatile matrices and adjusting ethanol content to 12% (v/v), and were further described by a specifically trained sensory panel. Taste attributes (sweetness, acidity, bitterness), astringency, aroma intensity, global intensity and persistence were assessed in both, original and "reconstituted" wines by using a numerical category scale. The sensory properties of the original wines were retained by their corresponding "reconstituted samples". The sensory assessment of the "reconstituted wines" showed that the addition of volatile fruity extracts from white wines brought about a decrease in astringency and bitterness and an increase in sweet perception in all cases. While global intensity and persistence of white wine matrices were also increased, they did not change in red wine matrices, which suggests that the volatile fraction plays only a secondary role in these attributes of red wines. Similarly, the effects of replacing the volatile fraction of a red wine by volatile extracts from other red wines were small and inconsistent, which confirms that taste and astringency are primarily driven by non-volatile molecules in these wines.

1. Introduction

The overall flavour experience perceived during consumption of food is elicited by the simultaneous stimulation of several senses. It has been widely accepted that interactions can, and do, occur within stimuli (Noble, 1996) (aroma, taste, appearance, or mouth-feel). The presence of aroma–taste interactions has been largely studied and evidenced by the scientific literature. These interactions may result from physicochemical interactions (structure and binding effects) in the product itself, interactions at the receptor level or cognitive interactions (Small & Prescott, 2005). Since competition at the receptor site is highly unlikely because different receptors are involved among sensory modalities, perceptual interactions are more conceivable. It has been demonstrated that the orbitofrontal cortex is the structure most likely involved in these perceptual interactions. Stevenson, Boakes, and Prescott (1998) studied the associative learning between odour and taste in experiments including conducting period. They were able to demonstrate the implicit nature of this learned synesthesia. In other words, the sweet taste was demonstrated to be processed along with the retronasal perception of the odour to produce a unitary sensation in the participant.

Many studies have shown that odours can suppress, enhance or have no effect on tastes (Caporale, Policastro, & Monteleone, 2004; Labbe, Damevin, Vaccher, Morgenegg, & Martin, 2006). These interactions have been demonstrated to occur in synthetic solutions (Welge-Lüssen, Drago, Wolfensberger, & Hummel, 2005) and in real samples, such as olive oil (Caporale et al., 2004), bitter cocoa and milk beverages (Labbe et al., 2006) or dairy desserts (Lethuaut et al., 2005). Moreover, interactions between aroma and other sensory modalities, such as touch, have recently been described. Kora, Latrille, Souchon, and Martin (2003) carried out a study on texture–flavour interactions in yogurts, revealing that olfactory perception enhanced product-perceived astringency. When the subjects perceived the flavour consisting of notes such as green apple, they may have associated this last perception with the astringency of unripe apple and given a higher score to the

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astringent intensity of the product in question. This observation was attributed to a cognitive association between the two perceptions (astringency and aroma).

Many studies have dealt with sensory taste–aroma interactions of molecules present in wines, e.g. sucrose interacting with vanillin (Welge-Lüssen et al., 2005) or the prune aroma (Prescott, Johnstone, & Francis, 2004), bitterness interactions with coconut aroma (rich in γ-lactones) (Labbe et al., 2006) or cut grass odorant (*cis*-3-hexen-1-ol) (Caporale et al., 2004). Furthermore, studies on the interactions between proteins, polysaccharides or polyphenols and selected aroma substances isolated from red wines have been carried out (Dufour & Bayonove, 1999a; Dufour & Bayonove, 1999b), revealing the existence of complexes driven mainly by hydrophobic forces.

Therefore, even if many studies on taste–aroma interactions have dealt with molecules present in wines, to our knowledge no one has focused on the aroma–taste and aroma–astringency interactions in real wine samples. In this context, the aim of this study is to obtain a preliminary measurement of the effect of the volatile composition of wine on some in-mouth sensory attributes, such as taste, astringency, intensity and persistence. In particular, the work will try to evaluate whether replacing the volatile composition of a given wine by other volatile extracts, e.g. taken from a different wine, has any measurable effect on those in-mouth sensory properties of the reconstituted wine and, in that case, to assess the type, magnitude and wine to wine consistency of such effects.

2. Materials and methods

2.1. Chemicals and reagents

The chemical standards were supplied by Aldrich (Gillingham, UK), Fluka (Buchs, Switzerland), Sigma (St. Louis, Mo), Lancaster (Strasbourg, France), Polyscience (Niles, IL), Chem Science (West Chester, PA), International Express Service (Allauch, France) and Firmenich (Geneva, Switzerland), as indicated in Table 1. Dichloromethane, methanol, and ethanol, LiChrosolv quality, were from Merck (Darmstadt, Germany). Pure water was obtained from a Milli-Q purification system (Millipore, Bedford, MA, USA). Polypropylene cartridges (6 ml), prepacked with LiChrolut EN resins, were also obtained from Merck (Darmstadt, Germany), whereas ammonium sulphate and $NaHCO_3$ were supplied by Panreac (Barcelona, Spain).

2.2. Wines

A set of six commercial Spanish wines, with marked technological, sensory and aromatic compositional differences, was selected. The wines were a 1 year-old monovarietal Chardonnay wine fermented in stainless steel vats (W1), a 1 year-old monovarietal Chardonnay wine fermented in oak barrel (W2), a 1 year-old monovarietal Tempranillo red wine (W3), a high quality 4 year-old (18 months in oak barrel) 90% Tempranillo-10% Cabernet Sauvignon red wine (W4), a 3 year-old (18 months in oak barrel) monovarietal Tempranillo red wine with marked astringency (W5) and a 3 year-old (12 months in oak barrels) monovarietal Tempranillo red wine with marked woody aroma (W6). W1 was selected as the model for white wine, W2 as the model for a protein-rich white wine, W3 as the model for a neutral red, W4 as the model for a highly structured polyphenol-rich red wine, W5 as the model for a very astringent wine, and W6 was exclusively selected because of its typical woody aroma.

Conventional oenological parameters (ethanol concentration, pH, reducing sugars, titratable and volatile acidities) were determined in accordance with official OIV practices (O.I.V., 2005). L-malic and lactic acids were determined by enzymatic methods in accordance with official AOAC analysis methods (AOAC, 2002, chap. 37). Total polyphenol index (TPI) was estimated as absorbance at 280 nm (Ribéreau-Gayon, 1970).

2.3. "Reconstituted wine" preparation

2.3.1. General

The volatile extracts of the six wines, named A1, A2, A3, A4, A5 and A6, respectively, and the non-volatile extracts of the five of them considered more relevant for the study selected as models of very different wine non-volatile matrices, named M1, M2, M3, M4 and M5, were separately obtained as detailed below (Sections 2.3.2 and 2.3.3).

2.3.2. Volatile extracts preparation

SPE cartridges (in 6 ml reservoirs) filled with 2000 mg LiChrolut EN resins were put in the extraction unit (VAC ELUT 20 Station from Varian) and conditioned by passing (slowly) 20 ml of ethanol and 30 ml of a hydroalcoholic solution (12% ethanol (v/v), 5 g l^{-1} of tartaric acid, pH adjusted to 3.0 with 0.1 M NaOH). After this, 600 ml of wine were loaded. The cartridge was then rinsed with 20 ml of the hydroalcoholic solution and volatile compounds were finally eluted with 20 ml of ethanol, using positive pressure to avoid air contact. The extract was spiked with BHA at 10 mg l^{-1}, and was stored in vials with no headspace, sealed and stored at −25 °C prior to sample preparation.

2.3.3. Non-volatile extracts preparation

Fifty millilitres of wine were lyophilised in 250 ml round flasks and, after this, samples were extracted with 3 × 10 ml of dichloromethane in order to eliminate remaining volatile compounds. Afterwards, dichloromethane was completely eliminated by forcing a stream of pure nitrogen (ca. 50 ml min^{-1}) to pass through the sample for 20 min. The total absence of dichloromethane was assessed by headspace solid phase micro extraction (Carboxen/PDMS 75 μm at 30 °C × 10 min) and GC with an electron capture detector (overall system detection limit 1 ng/sample). The extract was then dissolved in mineral water (Evian®, Evian-les Bains, France) and brought up to 10 ml (five times concentrated). After this, samples were placed in vials, with no headspace, in order to avoid sample-oxygen contact and stored at 5 °C prior to sample preparation.

2.3.4. Sample reconstitution

"Reconstituted wines" were prepared by mixing 20 ml of ethanolic volatile extract (corresponds to the volatile extract of 600 ml of wine), 120 ml of non-volatile extract (corresponds to 600 ml of wine) and 52 ml of ethanol, and bringing the mixture to 600 ml with bottled mineral water (final ethanol content is 12% (v/v)). Eighteen samples were prepared by combining different volatile and non-volatile extracts from different wines, as shown in Table 2. Combinations (aroma × matrix) were selected, seeking for those exerting a most likely sensory impact on in-mouth attributes. Efforts were therefore concentrated on the red wine matrices, particularly in the most astringent (M5) in order to evaluate possible changes in astringency. Samples were stored at 5 °C in bottles with no headspace and hermetically closed in order to avoid contact with oxygen prior to sensory evaluation.

2.4. Wine characterisation

2.4.1. General

The characterisation of the six wines used for the study was carried out by both sensory and chemical analyses.