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Volatile composition and aroma profile of Uruguayan Tannat wines

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ABSTRACT

Tannat is a red variety of *Vitis vinifera* that has become the major variety for the production of premium red wines in Uruguay. Due to its small cultivation around the world, research on the viticulture and enology of this variety is still necessary to improve wine quality. In this context, the aim of the present work was to characterize the aroma profile of Uruguayan Tannat wines using chemical and sensory methodologies. The volatile composition of ten Uruguayan Tannat wines, sold in the international market, was studied by gas-chromatography (GC–MS). Sixty two volatile compounds were identified using GC–MS, being alcohols and esters the most abundant compounds. Only few volatile compounds were found at concentrations higher than their odor threshold in all samples. Sensory characterization of wine aroma was characterized by a panel of wine professionals using projective mapping. Red fruits, fruity, dry fruits, and woody were the main descriptors used for describing similarities and differences in the aroma profile of the wines. Projective mapping sorted samples into four main groups. Partial least square regression (PLSR) enabled to explain many of the most important sensory descriptors (woody, earthy, phenolic, sulfur, chemical and microbiological) through volatile composition.

1. Introduction

Aroma is one of the most important quality factors of wine and is one of the key determinants of consumer acceptance (Lockshin & Corsi, 2012; Rapp, 1998; Saénz-Navajas, Ballester, Pêcher, Peyron, & Valentin, 2013). Wine aroma is a complex sensory characteristic that is determined by more than 1300 volatile compounds, including alcohols, esters, acids, aldehydes, isoprenoids, lactones and ketones, with a wide concentration range (Villamor & Ross, 2013). Differences in the aromatic profile of wines are determined by changes in the type, proportion and concentration of these volatile compounds (Atanasova et al., 2005).

Aroma characterization of wine is usually performed by gas chromatography–mass spectroscopy analyses, which enable the identification and quantification of volatile and non-volatile components (Francis & Newton, 2005). The type and concentration of these volatile compounds are responsible for the characteristic aroma of wine. In particular, concentration usually explains variation in aroma between certain types of wine which contain the same volatile compounds (Boido et al., 2003).

The contribution of volatile compounds to wine aroma depends on both their concentration and their perception threshold (Ferreira, Lopez, & Cacho, 2000). However, aroma perception of wine depends on the simultaneous perception of a large number of compounds. In this complex mixtures perceptual interactions between volatile compounds exist (Laffort & Dravnieks, 1982; Villamor & Ross, 2013), which lead to changes in qualitative and quantitative aromatic differences (Atanasova et al., 2005; Thomas-Danguin & Chastrette, 2002). For these reasons, in order to adequately evaluate the aroma profile of wine and understand which compounds are responsible for the characteristics notes are necessary to correlate volatile composition and sensory data (Francis & Newton, 2005; Green, Parr, Breitmeyer, Valentin, & Sherlock, 2011; Noble & Ebeler, 2002; Vilanova, Escudero, Graña, & Cacho, 2013).

Descriptive analysis with highly trained panels has been the most widely used methodology for characterizing the aromatic profile of wine (De La Presa-Owens & Noble, 1995; Heymann & Noble, 1987; Noble, Williams, & Langron, 1984). In this methodology assessors are trained in the identification and quantification of specific notes, and to provide a qualitative and quantitative description of wine aroma (ASTM, 1992). Descriptive analysis allows obtaining detailed, robust, consistent and reproducible results, which are stable in time (Lawless & Heymann, 2010). However, creating and maintaining well-trained, calibrated sensory panels can be economically challenging and time consuming, particularly when dealing with a complex product such as wine (Varela & Ares, 2012). Moreover, due to extensive training highly

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trained assessors can perceive wine aroma differently from consumers, who have a unified and holistic impression of the product.

In this context, several novel methodologies for sensory characterization have been developed in the last decade (Varela & Ares, 2012). These methodologies can be performed with trained, semi-trained or even naïve assessors, providing sensory maps similar to those obtained using classic descriptive analysis (Ares & Varela, 2014). Holistic methodologies are one of the most popular types of novel methodologies for sensory characterization (Varela & Ares, 2012). They rely on the evaluation of global similarities and differences among samples, encouraging the generation of a synthetic representation of the products, which is inhibited when assessors are asked to focus their attention on specific characteristics (Ares & Varela, 2014; Prescott, 1999).

Projective mapping, also known as Napping®, is a holistic methodology for sensory characterization proposed by Risvik, McEwan, Colwill, Rogers, and Lyon (1994). In this methodology consumers are asked to provide a two dimensional projection of a group of samples, according to their own criteria (Varela & Ares, 2012). This methodology has been previously used for sensory characterization of red wine (Hopfer & Heymann, 2013; Perrin & Pagès, 2009; Torri et al., 2013). One of the main advantages of projective mapping for the evaluation of wine aroma is that it enables the evaluation of global differences among samples and the spontaneous identification of the main notes responsible for those differences.

Considering that Uruguay is one of the few places in the world where Tannat is commonly grown, Uruguayan wine-making industry has established a strategy to produce high-quality Tannat wines using state-of-the-art viticultural technology (Carrau, 1997). However, due to its small cultivation around the world, research on the viticulture and enology of this variety is still necessary to better characterize its wine quality potential. Tannat is one of the varieties with the highest contents of anthocyanins and other polyphenolic compounds (Alcalde-Eon, Boido, Carrau, Dellacassa, & Rivas-Gonzalo, 2006; Boido et al., 2011) and has moderate intensity aromas which are usually described as raspberry, plum, quince, and small-berry-like (Varela & Gámbaro, 2006).

In this context, the aim of the present work was to characterize the aroma profile of Uruguayan Tannat wines using physicochemical and sensory methodologies.

2. Materials and methods

2.1. Samples

Ten commercial samples of Uruguayan 100% varietal Tannat wine, sold in the international market, were selected for the study. Samples were obtained directly from the wineries. Samples were selected to represent high quality Uruguayan Tannat wines, belonging to different price segments. Wines were bottled in 750 mL bottles and were conserved under 15 °C until their analysis. A description of the wines is shown in Table 1.

Table 1
Description of the Uruguayan Tannat wine samples considered in the study.

Sample	Export price range (US$)	Vintage	Aged in oak barrel	Alcoholic degree
M1	6–8	2008	Yes	13.0
M2	3–5	2010	No	13.8
M3	6–8	2010	Yes	14.0
M4	9–11	2011	Yes	15.0
M5	9–11	2007	Yes	13.5
M6	6–8	2010	Yes	13.5
M7	9–11	2011	Yes	13.5
M8	9–11	2011	Yes	14.7
M9	3–5	2009	Yes	13.5
M10	3–5	2012	No	12.5

2.2. Volatile composition analysis

2.2.1. Chemical and reagents

Pure standards were purchased from Sigma-Aldrich Corp. (Milwaukee, WI) and Extrasynthese (Genay Cèdex, France). Solvents were of spectrophotometric grade from Merck (USA). ISOLUTE ENV + was purchased from Biotage AB (Uppsala, Sweden). All other chemicals were of analytical grade.

2.2.2. Sample preparation

Volatiles were determined after adsorption and separate elution from an isolute ENV + cartridge packed with 1 g of highly crosslinked styrene-divinyl benzene (SDVB) polymer (40–140 mm, cod. no. 915-0100-C), as previously reported by Boido et al. (2003). The cartridges were sequentially equilibrated with methanol (15 mL) and distilled water (20 mL). A sample of 50 mL of wine, diluted with 50 mL of distilled water and containing 0.1 mL of internal standard (1-heptanol at 230 mg/L in a 50% hydroalcoholic solution), was applied with an appropriate syringe (4–5 mL/min) and the residue was washed with 15 mL of distilled water. The aroma compounds were eluted with 30 mL of dichloromethane. The solution was dried with Na_2SO_4 and concentrated to 1.5 mL on a Vigreux column, stored at 10 °C, and, immediately prior to GC–MS analysis, further concentrated to 150 μL under a gentle nitrogen stream. Sample preparation was performed in duplicate

2.2.3. Gas chromatography–mass spectrometry (GC–MS) analyses

GC/MS analyses were conducted using Shimadzu QP 2010 Ultra mass spectrometry using a DB-WAX 30 (Agilent Technologies J&W, Santa Clara, CA, USA) bonded fused silica capillary column, coated with poly(ethylene glycol) (30 m × 0.25 mm i.d., 0.25 μm film thickness). The GC-oven was programmed from a starting temperature of 40 °C, which was retained 8 min, to 180 °C at 3 °C/min, then ramped to 220 °C at 5 °C/min, 220 °C (20 min); injector temperature, 250 °C; injection was performed in Split mode (1:50); volume injected, 1.0 μL; carrier gas, helium, 76 kPa (42.4 cm/s); interface temperature, 250 °C; energy, 70 eV; acquisition mass range, 35–500 amu.

HRGC-FID and HRGC-MS instrumental procedures using an internal standard (1-heptanol) were applied for quantification, as described by Boido et al. (2003).

The components of the wine aroma were identified by comparison of their linear retention indices (LRI), determined in relation to a homologous series of n-alkanes, with those from pure standards or using published data. Comparison of fragmentation patterns in the mass spectra with those stored on databases (Adams, 2007; McLafferty & Stauffer, 1991; NIST08, version 2.0, National Institute of Standards and Technology, Gaithersburg, MD, USA) was also performed. In cases where pure reference compounds were not used, the identification was indicated as tentative and the quantification was performed using the characteristic fragments (Loscos, Hernandez-Orte, Cacho, & Ferreira, 2007).

2.3. Sensory characterization

Sensory characterization was performed by 30 wine professionals, including sommeliers, winemakers, and oenologists. Participants were recruited from the Uruguayan Sommelier Society and had a minimum of 2 year experience in the wine industry. The tests took place in standard sensory booths (ISO, 2007), under white lighting, controlled temperature (22–24 °C) and airflow conditions. Samples (30 mL) were presented at room temperature (20 °C) in clear 190 mL standard glasses (ISO, 1977), covered with a plastic cover and marked with three digit codes. Wines were presented following a William's Latin square design to minimize order and carry-over effects.

Assessors were asked to smell the samples and to place them on an A3 white sheet (42 cm × 30 cm), according to their similarities