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Effect of five enological practices and of the general phenolic composition on fermentation-related aroma compounds in Mencia young red wines

Ana Añón [a], Jorge F. López [b], Diego Hernando [c], Ignacio Orriols [d], Eugenio Revilla [e,*], Manuel M. Losada [a]

[a] Departamento de Ciencia y Tecnología Aplicadas, Escuela Universitaria de Ingeniería Técnica Agrícola, Universidad Politécnica de Madrid, 28040 Madrid, Spain
[b] Departamento de Matemática Aplicada, Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid, 28040 Madrid, Spain
[c] Estación Enológica de Haro, Bretón de los Herreros 4, 26200 Haro, Spain
[d] Estación de Viticultura y Enología de Galicia, Ponte San Clodio, 32427 Leiro, Spain
[e] Departamento de Química Agrícola, Universidad Autónoma de Madrid, 28049 Madrid, Spain

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A B S T R A C T

The effects of five technological procedures and of the contents of total anthocyanins and condensed tannins on 19 fermentation-related aroma compounds of young red Mencia wines were studied. Multifactor ANOVA revealed that levels of those volatiles changed significantly over the length of storage in bottles and, to a lesser extent, due to other technological factors considered; total anthocyanins and condensed tannins also changed significantly as a result of the five practices assayed. Five aroma compounds possessed an odour activity value >1 in all wines, and another four in some wines. Linear correlation among volatile compounds and general phenolic composition revealed that total anthocyanins were highly related to 14 different aroma compounds. Multifactor ANOVA, considering the content of total anthocyanins as a sixth random factor, revealed that this parameter affected significantly the contents of ethyl lactate, ethyl isovalerate, 1-pentanol and ethyl octanoate. Thus, the aroma of young red Mencia wines may be affected by levels of total anthocyanins.

1. Introduction

Volatile compounds released during alcoholic fermentation are the main aroma components of young red wines (Rapp & Mandery, 1986). These aroma components consist of dozens of alcohols, organic acids, esters, carbonyl compounds, sulfur compounds, nitrogen compounds, lactones and volatile phenols. Several authors have demonstrated that many factors (e.g., grape amino acids composition, sugar content and pH of must, type of yeast, temperature and aeration during the alcoholic fermentation, and length of maceration) have remarkable effects on the concentration of aroma compounds in wines (Callejon et al., 2010; Perestrelo, Fernandes, Alburquerque, Marques, & Camara, 2006). Furthermore, cold prefermentative maceration yields young red wines with higher contents of acetates and other esters than conventional winemaking does (Alvarez, Aleixandre, Garcia, & Lizama, 2005).

It is well known that several post-fermentation practices may change the characteristics of red wines made with similar sets of grapes. Changes in the aroma composition of red wines aged in oak casks are more pronounced if compared with wines stored in stainless steel tanks. First of all, the contact of wine with oak casks gives rise to a higher concentration of aroma compounds extracted from oak wood (Chatonnet, Boidron, & Pons, 1990); on the other hand, some aroma compounds formed during alcoholic fermentation are absorbed by oak wood, lowering their levels in wines (Ramirez et al., 2001).

During the storage of wine in bottles, several chemical changes in volatile composition, like hydrolysis and formation of esters and acetals, take place. This is owing to a series of reactions that depend on the composition of wine (concentration of ethanol, pH), the time the wine is stored in the bottle and the storage temperature (Ramey & Ough, 1980; Rapp & Mandery, 1986). The effect of temperature during the storage of red wines in bottles has been studied by several authors (Puech, Vidal, Pegaz, Riou, & Vuchot, 2006); sensory and chemical changes were less intense when wines were stored at low temperatures. These data suggest that the control of temperature during the storage of wines in bottles may be used to extend the shelf-life of young red wines. On the other hand, it is widely accepted that relatively high temperatures and low pH increase the hydrolysis of acetates and ethyl esters during wine storage (Ramey & Ough, 1980) and, as a consequence, the intensity of fruity aromas decreases.

* Corresponding author. Tel.: +34 914974832.
E-mail address: eugenio.revilla@uam.es (E. Revilla).

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Colloidal macromolecules of wines may interact with aroma compounds, as has been proved for mannoproteins released by yeast (Lubbers, Charpentier, Feuillat, & Voilley, 1994). Interactions between macromolecules and aroma compounds may be repulsive, increasing the volatility of aroma compounds; but may also be attractive, leading to the retention of aroma compounds by colloids. Of course, those interactions depend on the nature of macromolecules and on the type of considered aroma compound (Chalier, Angot, Delteil, Thierry, & Gunata, 2007). The protective effect of anthocyanins extracts and malvidin-3-*O*-glucoside on volatile thiols in model solutions during maturation has been demonstrated (Murat, Tominaga, Saucier, Glories, & Dubourdieu, 2003), and these authors have suggested that the effect may be related to the antioxidant properties of anthocyanins.

Mencia grapes are widely cultivated in north-western Spain. Some studies on the phenolic and aroma composition of red wines made with Mencia grapes have been carried out. They have focused on the characterisation of the aroma profile of Mencia wines (Calleja & Falque, 2005; Noguerol-Pato, Gonzalez-Barreiro, Cancho-Grande, & Simal-Gandara, 2009), on changes of aroma profile of Mencia wines caused by the geographic origin of grapes and by the characteristics of each year (Vilanova et al., 2012), and on modifications of the phenolic composition of those wines during their storage in bottle (Garcia-Falcon, Perez-Lamela, Martinez-Carballo, & Simal-Gandara, 2007) or caused by the use of maceration enzymes and cold prefermentative maceration (Ortega-Heras, Perez-Magariño, & Gonzalez-Sanjose, 2012). Nevertheless, these studies have not considered the effect of other oenological procedures, like winemaking technology, maturation in oak barrels or storage in stainless steel tanks, and the characteristics of storage in bottles on the aroma profile and on the general phenolic composition of Mencia wines. Moreover, the interactions among different technological factors have not been studied, both in Mencia and in other types of wines. For these reasons, a study on the effect of several technological factors on the aroma and general phenolic composition of Mencia wines has been carried out. In addition, the interactions among general phenolic composition and aroma components have been considered.

2. Materials and methods

2.1. Reagents, standards and enological products

All reagents, analytical grade, were supplied by Panreac (Barcelona, Spain). Analytical standards for GC–MS analysis were obtained from Sigma–Aldrich Química (Tres Cantos, Spain). Gelatine and sodium bentonite were supplied by Agrovin (Alcázar de San Juan, Spain). Sulfur dioxide was provided by AirLiquide España (Madrid, Spain).

2.2. Grapes and winemaking

Mencia grapes were harvested during the month of September in a 15-year-old vineyard, located (42.25 N, 6.59 W) in the area of Appellation d'Origine Contrôlé Valdeorras, at about 400 m a.s.l., and close to the Sil river, in an environment characterised by high relative humidity (about 80%) during the month of September. Plants, grafted on 110 Richter and trained on Cordon Royat system, are arranged N–S on a <5% slope, vine spacing being 2.50 m × 1.40 m. Harvest took place by the end of September 2005. Grapes (5000 kg) were hand-harvested, placed in 20-kg plastic boxes, and transported to the winery. Winemaking was carried out in the Jesús Nazareno Cooperative Cellar (El Barco de Valdeorras, Orense, Spain). Grapes were crushed and de-stemmed, and were later treated with sulfur dioxide (50 mg L^{-1}).

Two 2500-L stainless steel tanks were used for winemaking. In one tank, a traditional winemaking was carried out. In the other tank, a prefermentative cryomaceration was carried out, using dry ice to drop the temperature to 4–5 °C; this temperature was maintained for three days, adding dry ice when necessary. In both cases, tanks were inoculated with 40 g/100 L Levuline BRG yeast (Lallemand, Alcázar de San Juan, Spain); temperature was maintained at 26 °C during the alcoholic fermentation, and must was pumped over twice a day. At the end of alcoholic fermentation, wines were transferred to another stainless steel tank, and Uvaferm Alpha lactic bacteria (Lallemand, Alcázar de San Juan, Spain) were inoculated, following the manufacturer's instructions, to ensure an optimal development of malolactic fermentation. Then, wines were transferred to other stainless steel tanks. The level of sulfur dioxide was adjusted to 30 mg L^{-1}, remaining in those tanks until spontaneous sedimentation of lees took place. Thus, two different young red wines were obtained: a control wine made with traditional winemaking (T), and a wine made after cold prefermentative maceration (F).

2.3. Maturation and storage of wines

In February 2006, each type of wine was submitted to two different maturation practices, using two types of containers: 400-L stainless steel tanks (A) and 225-L middle-toasted American oak barrels (R); barrels were purchased from Magreñán (Logroño, Spain). For each wine, two stainless steel tanks and two oak barrels were used; wines were maintained in the maturation containers for two or three months. Thus, eight different wines were obtained after the maturation process. After maturation, wines were treated with gelatine (2 g/100 L) and sodium bentonite (30 g/100 L), filtered through diatomaceous earth, stabilised at −4 °C for 10 days, and finally filtered through a filter press. Then wines were bottled in 750-mL glass bottles, using premium cork stoppers. For each wine, two different sets of bottles were obtained. A set of bottles was maintained in a chamber at 14 °C (set C). The other set remained at room temperature, between 10 and 30 °C (set V). Wines were analysed three and nine months after bottling. In summary, 32 different wines were obtained, combining five different technological factors:

F1: type of winemaking (T or F).
F2: type of container used for maturation (A or R).
F3: length of maturation (2 or 3 months).
F4: temperature of storage in bottles (C or V).
F5: length of storage in bottles (3 or 9 months).

Thus, each wine was identified by a five alpha-numeric code, e.g., wine TA2C3 was obtained by traditional winemaking, matured in a stainless steel tank for two months, and stored in bottle at controlled conditions for three months.

2.4. General analysis of must and wines

Sugar content, pH, total acidity and content of tartaric and malic acids in the must were analysed following OIV methods (OIV, 2010). Alcoholic degree, pH, total acidity, volatile acidity, malic acid, reducing sugars, dry extract, total sulfur dioxide and free sulfur dioxide in wines after three and nine months of storage in bottles were determined by OIV methods (OIV, 2010).

2.5. Analysis of volatile compounds

Volatile compounds were determined by GC–MS in Estación Enológica de Haro (Spain), three months and nine months after bottling, following the procedure described by Prieto et al.