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Sensory changes during bottle storage of Spanish red wines under different initial oxygen doses

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ABSTRACT

Sixteen commercial Spanish red wines selected to cover a wide range of sensory properties were stored at 25 °C for 6 months in air-tight containers under different oxygen doses (0–30 mg L^{-1}) mimicking real and extreme bottling situations. The 16 initial samples (before storage) and the 80 stored samples (16 wines × 5 oxygen doses) were submitted to sensory analysis. Sensory changes related to post-bottling storage and initial oxygen dose were evaluated by means of discriminant and characterisation sensory strategies.

Significant increases in black fruits, dried fruits, woody, lactic and stronger increases in cooked vegetables and spicy notes reveal a general pattern of aroma evolution. Remarkable departures to this general pattern have been observed, which can be related to the initial sensory properties of the wines and to their basic polyphenolic composition. The effect of post-bottling storage in bitterness is wine dependent, while global decreases in both global intensity and persistence evaluated in mouth are observed. Discrete increases in astringency are observed for wines with the lowest initial astringent scores. Important sensory interactions between aroma attributes (herbal and spicy) and bitterness and between roasted and astringency perception are shown. Little impact of the initial oxygen dose in the in-mouth sensory properties is reported. These results are relevant for wine experts in that they help understanding the evolution of wine sensory properties in the bottling stage. This study may help them to develop strategies for managing this winemaking stage with objective criteria.

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1. Introduction

The bottle storage period is critical in the wine value chain, since once the wine is bottled there are no further possibilities to control any sensory deviation. Although the pace of chemical changes during bottling storage slows down in relative terms, there are yet an ageing wide range of chemical reactions taking place, many of them capable of generating different sensory properties – both positive and negative – which could ultimately have a relevant effect on the consumer acceptance of the product (O'Brien, Francis, & Osidacz, 2009). Unfortunately, it is currently not possible to foresee the evolution of the sensory properties of bottled wines set aside for ageing and hence it is also not plausible to inform the consumer about the optimum consumption moment for reaching the desired sensory properties.

During bottle ageing there are yet a wide range of chemical reactions and wine sensory changes in colour, aroma or in-mouth properties. In red wines, increases in the yellow colour (absorbance at 420 nm) and hue have been observed (Chira, Jourdes, & Teissedre, 2012; Chira, Pacella, Jourdes, & Teissedre, 2011). Besides decreases in fresh fruit aromas (He, Zhou, Peck, Soles, & Qian, 2013), astringency (Gómez Gallego, Gómez García-Carpintero, Sánchez-Palomo, González Viñas, & Hermosín-Gutiérrez, 2013; McRae et al., 2012) and an increase in the sour taste (Gómez Gallego et al., 2013) have been reported. The evolution of wine sensory properties during bottling has shown to be dependent on different factors such as the temperature of storage (Hopfer, Buffon, Ebeler, & Heymann, 2013) or the exposition of wine to different oxygen concentrations provided along the ageing period (Caille et al., 2010).

The presence of oxygen during bottle storage is an important factor able to influence the development of wine sensory properties. The oxygen concentration in bottle can be partially adjusted through the use of different closures or containers, although one of the most important sources of oxygen is the bottling process (Lopes et al., 2009). The use of bag-in-box has shown to result in wines with more intense cooked vegetables, earthy or dried fruit aromas and lower in red fruit, grapefruit, cherry, fresh vegetables, floral or black pepper nuances than glass bottles (Hopfer, Ebeler, & Heymann, 2012; Hopfer et al., 2013) given their higher oxygen permeability. Notwithstanding, most of the work aimed to study the evolution of the sensory properties of the wines in the presence of different amounts of oxygen is carried out using different closures capable of generating different oxygen transfer rates (OTR) in white (Godden et al., 2001; Hopfer et al., 2012), rosé (Guaita et al., 2013; Wirth et al., 2012) or red wines (Caille et al., 2010; Gambuti, Rinaldi, Ugliano, & Moio, 2013; Puertolas, Saldana, Condon, Alvarez, & Raso, 2010). In white

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wines, it is observed that closures with higher OTRs are prone to generate oxidised, cooked fruit, toasted, honey and glue-like aroma nuances (Godden et al., 2001; O'Brien et al., 2009), while lower OTRs result in increases in citrus, fresh fruit or reductive aromas such as cabbaged or flint. In rosé and red wines higher OTRs (0.3 vs. 9.5 mg L^{-1} of oxygen) tend to generate wines with higher colour intensity and hue as well as in red fruit or caramel aroma but lower in animal nuances (Caille et al., 2010; Wirth et al., 2012). However, the impact of oxygen on the in-mouth sensory properties seems to be limited. An increase in the total oxygen exposure is able to decrease astringency in a wine with low polyphenolic content, while no effect was observed in a higher polyphenolic wine, demonstrating that the effect of oxygen exposure is dependent on wine composition (Gambuti et al., 2013). This fact attests to the importance of polyphenolic content in the evolution of the sensory properties of real bottled wines, and is supported by studies carried out with model solutions showing that certain compounds are able to control the levels of dissolved oxygen (simply acting as antioxidants) through oxidative phenomena (Chinnici, Sonni, Natali, & Riponi, 2013).

Despite being aware of the importance of both the stage of ageing in the bottle and the initial composition of the wine in the evolution of its sensory properties, so far the studies that have addressed this issue have been conducted with a limited number of samples, often with one (Godden et al., 2001; Guaita et al., 2013; Hopfer et al., 2012, 2013), two (Gambuti et al., 2013; Wirth et al., 2012) or at most four (Caille et al., 2010) wines, with low variability in the initial composition of wine samples, which seriously limits the generalizability of results and the possibility of extracting behavioural patterns. Because of this, in the present work a comprehensive study of the evolution of the sensory properties of a relatively large number of red wines (6 months at 25 °C in air-tight containers spiked with different levels of initial oxygen) with a significant variability in their initial sensory properties and polyphenolic composition has been carried out. It is hypothesised that the evolution of the sensory properties of wines in the bottle is dependent on the initial sensory properties of wines as well as on their polyphenolic composition.

2. Methods and materials

2.1. Commercial wines

Sixteen different Spanish commercial red wines from different wine making areas were selected to cover a wide range of polyphenolic content (TPI). The detailed list of samples, including sample information and basic compositional data obtained following standard operating procedures, is shown in Table 1.

2.2. Storage of wine samples under different oxygen doses

Five different samples of each of the 16 wines were prepared in air-tight 1150-mL amber bottles supplied by Sigma-Aldrich (Aldrich Sure-Seal bottle®) and manipulated in a purification glove box equipped with a vacuum chamber (Jacomex, Dagneux, France) in which oxygen was under 0.002%. For each wine, the content of 7 bottles was mixed in a big beaker and stirred until the oxygen level in the wine dropped to 0.00 mg L^{-1} as measured with a fluorescence oxygen meter OptiOx SG-98 from Mettler Toledo (Barcelona, Spain). After filling the bottles (1035 mL of wine with 115 mL of Argon headspace), they were closed with an internal silicone septum, a crimp cap, other silicone septum and an external screw cap. Through the internal septum, known volumes of oxygen were introduced (with bottles upside down so that the oxygen passed through the wine) with a Hamilton gas-tight syringe (Samplelock™ syringe). Bottles were kept upside down about 15 minutes to assure oxygen contact with the whole wine volume. Oxygen was introduced into the chamber in Tedlar gas sampling bags supplied by Sigma-Aldrich. Introduced oxygen volumes were equivalent to the theoretical concentrations of 0, 1.1, 3.1, 10.6 and 30.4 mg of oxygen per litre of wine. This range covers the normal levels introduced during normal wine bottling operations and extend it to two unrealistic extreme situations (0 and 30.4). All the oxygen was introduced in a single dose. Finally, the resulting eighty 1150-mL bottles were double sealed under vacuum into plastic bags with known oxygen permeability

Table 1
The sixteen studied commercial wines and their original oenological parameters.

Wine code	Origin	Vintage year	Grape variety	TPI[a]	CI[b]	Abs_{420}[c]	Oaking aging[d]	pH	TA[e]	AV[f]	RS[g]	MA[h]	LA[i]	Alcohol (% v/v)
MG_V05	DO Dominio de Valdepusa	2005	Cabernet Sauvignon	83.4	19.3	7.3	12	3.65	4.91	0.56	4.35	0.29	0.77	15.2
AY_C05	DO Cariñena	2005	Merlot, Tempranillo, Cabernet Sauvignon	74.3	10.8	4.7	10	3.52	5.86	0.69	3.39	0.33	1.00	14.3
GC_B10	DO Borja	2010	Garnacha	71.4	14.0	4.8	4	3.43	6.14	0.42	3.61	0.25	0.68	14.7
RM_R10	DOCa Rioja	2010	Graciano	66.4	18.7	6.6	8	3.57	5.80	0.41	2.31	0.19	1.45	14.8
CD_C10	DO Cariñena	2010	Garnacha, Tempranillo, Cabernet Sauvignon	66.4	14.8	5.2	0	3.63	5.30	0.53	2.57	0.24	0.90	13.5
CZ_D08	DO Duero	2008	Tempranillo	62.0	9.6	3.6	18	3.65	5.33	0.57	1.71	0.35	2.47	13.4
BO_B10	DO Borja	2010	Garnacha, Syrah, Tempranillo	61.0	12.5	4.4	0	3.66	5.04	0.47	2.68	0.17	1.07	14.8
CH_R10	DOCa Rioja	2006	Tempranillo, Viura	60.3	13.3	4.9	0	3.88	4.45	0.62	1.77	0.20	3.30	14.1
CT_B07	DO Borja	2007	Garnacha	59.1	9.2	3.6	15	3.47	5.66	0.51	4.34	0.30	0.75	13.9
SC_R10	DOCa Rioja	2010	Tempranillo, Garnacha	57.8	11.0	3.9	0	3.72	4.84	0.48	2.32	0.18	2.52	13.4
SO_C07	DO Cariñena	2007	Garnacha, Tempranillo, Cabernet Sauvignon	54.9	7.2	3.0	18	3.53	5.66	0.75	3.81	0.18	1.21	13.8
AR_A08	DO Arlanza	2008	Tempranillo	53.0	8.8	3.4	12	3.73	5.57	0.63	1.98	0.24	2.79	13.6
MC_R09	DOCa Rioja	2009	Tempranillo, Graciano, Mazuelo	52.3	8.8	3.4	12	3.64	4.92	0.52	2.09	0.21	2.11	13.7
NJ_R09	DOCa Rioja	2009	Tempranillo, Garnacha	49.7	7.8	3.1	18	3.65	5.35	0.66	1.67	0.18	2.14	13.6
RB_R06	DOCa Rioja	2010	Tempranillo, Garnacha	49.4	8.6	3.6	18	3.49	5.37	0.57	2.23	0.23	1.45	14.3
BE_R10	DOCa Rioja	2010	Tempranillo, Garnacha	45.4	8.0	2.9	0	3.61	5.09	0.25	1.52	0.18	1.86	13.9

[a] Total polyphenol index.
[b] Colour intensity.
[c] Absorbance at 420 nm measured in 2-mm cuvettes multiplied by five.
[d] Aging in oak barrels expressed in months.
[e] Total titratable acidity expressed in g L^{-1} of tartatic acid.
[f] Volatile acidity expressed in g L^{-1} of acetic acid.
[g] Reducing sugars expressed in g L^{-1}.
[h] Malic acid expressed in g L^{-1}.
[i] Lactic acid expressed in g L^{-1}.

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