Food Packaging and Shelf Life 8 (2016) 14–23

Contents lists available at ScienceDirect

Food Packaging and Shelf Life

journal homepage: http://www.elsevier.com/locate/fpsl

Influence of packaging and aging on the red wine volatile composition and sensory attributes

N. Moreira[a,b,*], P. Lopes[c], H. Ferreira[d], M. Cabral[c], P. Guedes de Pinho[a,*]

[a] UCIBIO@REQUIMTE/Laboratório de Toxicologia, Departamento de Ciências Biológicas, Faculdade de Farmácia, Universidade do Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal

[b] Universidade Católica Portuguesa, CBQF—Centro de Biotecnologia e Química Fina—Laboratório Associado, Escola Superior de Biotecnologia, Rua Arquiteto Lobão Vital, Apartado 2511, 4202-401 Porto, Portugal

[c] Amorim & Irmãos, S. A., Rua de Meladas 380, 4536-902 Mozelos, Vila da Feira, Portugal

[d] Adega de Borba, Largo Gago Coutinho e Sacadura Cabral, 7150 Borba, Portugal

ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form 21 January 2016
Accepted 26 February 2016
Available online 10 March 2016

Keywords:
Red wine
Cork stopper
Bag-in-box
Volatile composition

ABSTRACT

This work studied the volatile composition and sensory properties of red wines after packaging under different configurations: bag-in-box (BIB) and glass bottles sealed with natural cork stoppers. The experiments were carried out over a period of 12 months and analysis were performed at initial time (just before packaging) and after 3, 6 and 12 months of storage. Volatile compounds composition was determined by two different analytical techniques which combined headspace solid-phase microextraction (HS-SPME) with gas chromatography-ion trap/mass spectrometry (GC-IT/MS). Sensory analysis and other enological parameters, such as free and total SO_2 and color intensity, were also monitored. Results showed that, after one year of storage, BIB wines were characterized by higher levels of several carbonyl compounds when compared to bottled wines. Moreover, bottled wines sealed with cork stoppers retained much more free and total SO_2 than wines in BIB. In addition, the premature wine development under BIB was confirmed by sensory analyses.

1. Introduction

From an organoleptic point of view, the quality of wine depends on its flavor. Wine flavor is composed by a wide variety of compounds with different aromatic properties which presence and concentration depends on a number of factors including grape cultivar, composition of grape must, yeast strain, fermentation conditions, winemaking practices, wine aging and storage conditions, among others. The maintenance or improving of wine quality from the vineyard until bottling, assuring long shelf wine life, are considered to be the main aims in wine production.

The first and foremost function of a food package is to protect the product and preserve its inherent quality (Sajilata, Savitha, Singhai, & Kanetkar, 2007). Package must fulfill the mission of barrier properties to oxygen, carbon dioxide, moisture, light and preserve aroma compounds (Revi, Badeka, Kontakos, & Kontominas, 2014). Moreover, package should be inert with respect to the migration of compounds from the package to the product and/or the sorption of compounds of the product by the packaging (flavor scalping) (Revi et al., 2014; Sajilata et al., 2007).

The micro oxygenation of red wines during aging is commonly accepted, at least initially, to improve their quality by removal unwanted aromas, color stabilization and improvements in mouth feel (Kilmartin, 2010). However, oxidation is one parameter that determines the shelf life, mainly for table wines. Oxidation will depend of wine resistance and the level of exposition to oxygen. If not properly conditioned, wines losses freshness and new organoleptic impressions are developed. Simultaneously, the red color also changes to brown due to degradation and polymerization of phenolic compounds. For these reasons, the choice of the type of package will have a considerable impact on the extent of wine oxidation and therefore, it will affect its sensory properties.

Cork stoppers have been used to seal wine bottles for several centuries, being today the most used wine closure (Mazzoleni, Caldentey, Careri, Mangia, & Colagrande, 1994). Cork is a natural and biodegradable product with physical properties that are unique and particularly adapted to preserve bottled wine (Prat, Besalú, Bañeras, & Anticó, 2011); namely, the ability for compression and rebound, good impermeability to liquid and gases and apparent lack of chemical reactivity (Karbowiak, Mansfield et al.,

* Corresponding authors at: UCIBIO@REQUIMTE/Laboratório de Toxicologia, Departamento de Ciências Biológicas, Faculdade de Farmácia, Universidade do Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal.
E-mail addresses: n.moreiranath.moreira@gmail.com, nmoreira@porto.ucp.pt (N. Moreira), pguedes@ff.up.pt (P. G. de Pinho).

http://dx.doi.org/10.1016/j.fpsl.2016.02.005
2214-2894/

2010). The physicochemical properties and the inner structure of cork stoppers are responsible for its impermeability to oxygen compared to synthetic packaging materials (Lequin et al., 2012). Cork cellular structure is a homogeneous tissue of thin-walled cells orientated in an alveolar, honeycomb type pattern of hexagonal sections with no intercellular spaces (Karbowiak, Gougeon et al., 2010). Cork also present lenticular channels which volume and number varies according to the different types of cork and is related to its quality. The main cork cell wall components are: suberin, the most abundant (33–50%), lignin (13–29%), polysaccharides (6–25%), and extractables (8–24%) (Karbowiak, Mansfield et al., 2010; Silvia et al., 2005). Cork possesses also some 'free' components, not chemically linked to the main structure and thus easily extractable with solvents which can be responsible for the organoleptic properties. The two most important components are waxes and tannins; being tannins easily extracted by water and ethanol. Some of these compounds mainly polyphenols were recently identified in hydroalcoholic solutions stored in bottles (Azevedo et al., 2014).

During the past two decades, the use of glass bottles with cork stoppers for packaging wine has been losing market sales for alternative packing materials such as polymeric materials including polyethyleneterephthalate (PET) bottles, multilayer tetrabrik type containers, metal beverage cans and bag-in-box (BIB) type containers (Revi et al., 2014). In the 90's, the global bottles sales accounted for over 90% in the wine industry but, nowadays, represents less than 60% (http://www.thedrinksreport.com/news/2013/15046-special-report-wine-packaging.html). BIB have been expanding rapidly among some of the largest wine drinking countries of the word; however, very few reports can be found in the literature concerning the real effect of this kind of packaging on the organoleptic characteristics and quality of wines.

BIB packaging improved distribution efficiency, enhanced end-use convenience and increased cost-effectiveness (Fu, Lim, & Mc Nicholas, 2009). In this packaging system, the product is sealed in a bag comprising one or more layers of high-barrier flexible films, which are mechanically supported by an external paperboard carton; a valve fitment is attached to the bag through which the product is filled and dispensed. According to Revi et al. (2014), this type of packaging is widely used for medium quality table wines. Due its large volume capacity; wines packaged in BIB are usually consumed over an extended time after the package is opened, during which its secondary shelf life can be affected by oxygen ingress through the dispensing fitment (Fu et al., 2009; Lee, Kaang, & Park, 2011).

To our knowledge, data on volatile composition and sensory properties of wines packaged under different configurations are still scarcely available in current literature. The present work aims to understand the effect of different packaging on the wine volatile fraction and sensorial wine properties. Experiments were performed using a red wine packed in BIB containers and in glass bottles closed with natural corks. The changes in sensory characteristics and volatile profile of wines were followed during 12 months. Color intensity, free and total SO_2 levels were also monitored.

2. Materials and methods

2.1. Wine and packaging

Red wine used for the trial was from Aragonez, Castelão and Trincadeira grape varieties grown on the Borba Region (Alentejo, Portugal) and produced during 2013 vintage. The grapes were harvested during the month of September and transported to Adega de Borba Cellar's where they were destemmed and crushed. Fermentation was performed in stainless steel tanks under 25 °C during 20 days. During the first 7 days, daily pumping overs were carried out to optimise the extraction of color, aromas and flavors. After malolactic fermentation, wine was filtered and packed in glass bottles sealed with cork stoppers and in BIB containers.

The glass bottles were of Antique green color and 750 cm^3 of capacity with the following specifications: diameter of 18–19 mm at a depth of 3 mm and diameter of 19–21 mm at a depth of 45 mm from the bottle entrance. The closures were natural cork stoppers of average quality with 44 mm length and 24 mm diameter. The cork stoppers were previously washed with a mixture of water and hydrogen peroxide, steamed and dried up 8% of moisture. Finally, corks were coated with a mixture of silicone and paraffin.

The bottling line comprised a filler and a multiple headed corker (Bertolazo, Zimella, Verona, Italy). All bottles were filled to 63 ± 2 mm from the top, and then sealed with a 44 mm of natural, which resulted in a headspace 19 ± 2 mm ($\sim$5.7 dm^3). The natural cork stoppers were compressed to a diameter of 16 mm before insertion under vacuum into bottles. All wine manipulations were performed with high purity nitrogen, and the headspace in the filler bowl; however, empty bottles were not purged with nitrogen to avoid oxygen pick-up. A total of 15 bottles were filled.

The BIB pouches of 5 dm^3 in capacity were composed by a laminated metalized polyester layer with 72 μm of thickness and an inner layer (45 μm) of low-density polyethylene (LDPE). The containers were provided by Conotainer (Madrid, Spain). After filling and bottling, all samples were kept at room temperature. Pouches were filled under vacuum on the winery bottling line filling the pouch headspace with inert gas (nitrogen) and placed inside paperboard cartons so as to provide access to the plastic valve. A total of 15 BIB containers were filled with wine.

After filling step, BIB and bottles which were left upright for 1 h and then stored horizontally in wood pallets under cellar conditions. Five BIB and bottled wine were tested over 3, 6 and 12 months. On day 0, approximately 200 cm^3 of wine was immediately analyzed.

2.2. Chemicals

2-Phenylethyl alcohol ($\geq$99%), 2-phenylethyl acetate ($\geq$97%), ethyl butanoate ($\geq$99.5%), ethyl hexanoate ($\geq$99%), ethyl octanoate ($\geq$99%), ethyl nonanoate ($\geq$97%), ethyl decanoate ($\geq$99%), ethyl dodecanoate ($\geq$99%), diethyl succinate ($\geq$99.5%), β-linalool ($\geq$99%), limonene ($\geq$99%), α-terpinene ($\geq$95%), nerol ($\geq$97%), β-damascenone($\geq$90%), α-ionone ($\geq$90%), ethanal ($\geq$99.5%), propanal ($\geq$97%), butanal ($\geq$99%), pentanal ($\geq$97.5%), hexanal ($\geq$98%), heptanal ($\geq$92%), octanal ($\geq$98%), nonanal ($\geq$95%), decanal ($\geq$95%), 2-propenal ($\geq$99%), 2-methyl-1-butanal ($\geq$90%), 2-methyl-1-propanal ($\geq$98%), 3-methyl-1-butanal ($\geq$97%), benzaldehyde ($\geq$99.5%), phenyl acetaldehyde ($\geq$90%), 2-butanone ($\geq$99%), 2-pentanone ($\geq$99.5%), 3-penten-2-one ($\geq$70%), 3-methyl-2-butanone ($\geq$99%), 2-cyclohexanone ($\geq$99%), furfural ($\geq$99%), 5-methyl-2-furfural ($\geq$99%), diacetyl ($\geq$97%), methylglyoxal (40%), glyoxal, *p*-fluorobenzaldehyde (internal standard $\geq$ 98%), *O*-(2,3,4,5,6-pentafluorobenzyl) hydroxylamine hydrochloride (PFBHA $\geq$ 98%), were purchased from Merck (Darmstadt, Germany), Aldrich (Madrid, Spain) and Fluka (Madrid, Spain). Ethanol ($\geq$99.8%) was also supplied by Sigma-Aldrich (Madrid, Spain). Ultrapure water was obtained from a Milli-Qwater Millipore purification system (Millipore, Bedford, MA, USA). SPME fibers were purchased from Supelco (Madrid, Spain).

2.3. Enological parameters

Just before the filling and bottling of the samples, wines presented the following chemical composition: pH of 3.60, ethanol content of 13%, total acidity of 5.30 g/dm^3 and 32 and 50 mg/dm^3 of