Food Packaging and Shelf Life 13 (2017) 44–48

Contents lists available at ScienceDirect

Food Packaging and Shelf Life

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

A kinetic approach to describe the time evolution of red wine as a function of packaging conditions adopted: Influence of closure and storage position

Francesca Venturi[a,b,*], Chiara Sanmartin[a,b], Isabella Taglieri[a], Ying Xiaoguo[a,c], Mike F. Quartacci[a,b], Cristina Sgherri[a,b], Gianpaolo Andrich[a,b], Angela Zinnai[a,b]

[a] Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto, 80, 56124 Pisa, Italy
[b] Interdepartmental Research Center "Nutraceuticals and Food for Health", University of Pisa, Via del Borghetto, 80, 56124 Pisa, Italy
[c] Zhejiang Provincial Key Laboratory of Health Risk Factors for Seafood, College of Food and Pharmacy, Zhejiang Ocean University, China

ARTICLE INFO

Keywords:
Red wine shelf-life
Storage position
Capsule
Chemical characterization
Sensorial characterization

ABSTRACT

During bottle storage the barrier against the external atmosphere is provided by the closure.

In order to evaluate the influence of capsule and storage position in preserving the quality of the wine, this research project aimed to study the chemical and sensorial evolution of a red wine stored over a period of 12 months in glass bottles closed with natural cork stoppers with or without capsule and maintained in different storage position (horizontal vs vertical).

The different storage conditions adopted deeply affected wine quality suggesting that their rational optimization could allow the maintenance of red wine quality during storage.

In particular, wine degradation rate was higher when the wine was stored in glass bottles closed with a natural cork without the capsule, regardless of the position of storage. On the contrary wine decay was significantly delayed when it was stored in the horizontal position, independently from the closure system used.

1. Introduction

Bottle aging is a necessary stage in the wine-making process because it helps to modify various organoleptic properties to obtain high quality wines (Gao et al., 2015). During red wine storage, spontaneous clearing, colour stabilization and reactions that lead to the formation of more complex compounds have been observed (Del Alamo-Sanza & Nevares Dominguez, 2006; Marquez, Serratosa, & Merida, 2014). As the storage time in bottle increases, reactions of copigmentation and polymerization of anthocyanins take place (Eiro & Heinonen, 2002), causing the formation of more stable compounds responsible for the change from the bluish-red hues of young wines to the orange-red onescharacteristic of aged wines (Atanasova, Fulcrand, Cheyner, & Moutonet, 2002). As oxygen is one of the main factors affecting wine evolution as well as its deterioration (Dombre, Rigou, Wirth, & Chalier, 2015; Ghidossi, Poupot, Thibon, & Mietton-Peuchot, 2012; Kwiatkowski, Skouroumounis, Lattey, & Waters, 2007; Moutounet & Vidal 2006; Silva & Lambri, 2006), changes occurring after fermentation are partly driven by chemical oxidations deriving from wine-making and storage (Wirth et al., 2012).

Nowadays, glass containers are still preferred for bottling wine (Ghidossi et al., 2012) being them readily recyclable and characterized by a high impermeability to gases and vapours, stability over time and transparency (Mentana, Pati, La Notte, & Del Nobile, 2009). During storage the only barrier against the external atmosphere is represented by the closure system, and the evolution of phenolic compounds on the development of wine colour and mouthfeel mainly depends on the transfer of oxygen through the bottle stopper (Gao et al., 2015; Silva, Lambri, & De Faveri, 2003). In this condition, oxygen diffusion into the bottled wine appears strongly dependent on the effective sealing of the closure (Skouroumounis et al., 2005; Venturi, Sanmartin et al., 2016). Indeed, oxygen permeability may greatly change from cork to cork, and this heterogeneity is one of the main factors affecting variation among bottles (Wirth et al., 2010).

Although some authors examined the changes occurring during red wine stabilization in bottle (Del Alamo-Sanza & Nevares Dominguez, 2006; Marquez et al., 2014; Perez-Magarino & Gonzales-San Jose, 2004; Sàenz-Navajas, Avizcuri, Ferreira, & Fernández-Zurbano, 2014; Vincenzi, Marangon, Tolin, & Curioni, 2011), most of the studies carried out so far analyzed only the effect of different types of stoppers on the chemical composition, colour and flavour of bottled wines (Gao et al., 2015 and ref. within). Little is known about the influence of the capsule, combined with a natural cork stopper, on the evolution of the red wine during bottle aging. Moreover, at the best of our knowledge, no study has been focused till now on the effect of storage position (horizontal vs vertical)

* Corresponding author at: Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto 80, 56124 Pisa, Italy.
E-mail address: francesca.venturi@unipi.it (F. Venturi).

http://dx.doi.org/10.1016/j.fpsl.2017.07.001
Received 5 January 2017; Received in revised form 20 June 2017; Accepted 6 July 2017

Table 1
Initial chemical composition of the red wine.

Parameter	Mean value ± c. i.*
Alcohol (%v/v)	11.46 ± 0.06
pH	3.41 ± 0.01
Titratable Acidity (g/L as tartaric acid)	5.32 ± 0.01
Net Volatile Acidity (g/L as acetic acid)	0.40 ± 0.01
Total Phenols (g/L as gallic acid)	3.39 ± 0.05
Proanthocyanidins (g/L as catechins)	1.34 ± 0.03
Total Anthocyanins (g/L as malvin)	0.310 ± 0.002

* c.i. = confidence interval, $p < 0.05$.

on the evolution of red wines maintained in glass bottles closed with natural cork stoppers.

In this research project both chemical and sensorial evolution of a not structured red wine, stored in glass bottles closed with natural cork stoppers with or without capsule, were evaluated over a period of 12 months with the aim to determine the influence of the capsule and the storage position (horizontal vs vertical) in preserving the quality of wine.

2. Materials and methods

2.1. Experimental setup

The red wine was analyzed before the beginning of the experiment and its chemical parameters are reported in Table 1.

The red wine, collected from one single vat, was stored in glass bottles (0.750 L) at the same time in a commercial winery bottling line using a fully automated bottling/filling station. After the washing process, the bottles passed automatically to the filling machine and then to the corking. In order to eliminate the presence of oxygen in the bottles, before capping the air in the headspace was replaced with an inert gas. In particular we used N_2, the chemical inertia of which makes it particularly suitable in fields where the high reactivity of oxygen causes unwanted actions.

All the bottles were closed with the same natural cork stopper. This 100% natural product was extracted from a single cork strip and perfected using the cutting-edge technology. As reported in Fig. 1, the bottles were divided equally in two groups: one group was closed with a natural cork (one-piece cylindrical cork stoppers of natural origin deriving from the bark of the cork-oak tree (*Quercus suber*) by punching) and aluminium capsule, while the other was closed with cork but without the capsule.

Bottles were transported by an air-conditioned truck (T = 20 ± 1 °C) from the bottling/filling facility located at Ruvo di Puglia (BA) to the Food Technology Laboratory of the Department of Agriculture, Food and Environment (DAFE) of the University of Pisa after one day from bottling/packaging. Sampling and analyses were performed at the DAFE. Sampling of wine was carried out after 3 days and 3, 6, 9 and 12 months of storage. Throughout the observation period samples were stored under controlled temperature (T = 20 ± 1 °C). Each group was further divided (Fig. 1) in order to verify the influence of the storage position (vertical vs horizontal) on the time evolution of wine.

2.2. Chemical evolution

All chemical determinations for the characterization of the starting wine were performed at the laboratory of Food Technology of DAFE (University of Pisa) according to the official methods proposed by the International Organization of Vine and Wine (OIV), and described in the Compendium of International Methods of Wine and Must Analysis (OIV, 2014).

2.2.1. Total SO_2 (TSO_2)

Time evolution of total SO_2 concentration (TSO_2) was determined by the Ripper titrimetric method (Zoecklein, Fugelsang, Gump, & Nuri, 1999).

This method is based on the redox reaction in which sulfur dioxide, in the form of the bisulphite ion, reacts with iodine as follows:

$$HSO_3^- + I_3^- + H_2O \rightarrow SO_4^{2-} + 3H^+ + 3I^- \quad (1)$$

Unreacted iodine forms a blue complex with starch indicator to signify the endpoint. The addition of sodium bicarbonate prior to starting the titration creates an inert blanket of carbon dioxide gas which prevents interference caused by oxygen in air. Red wines may require decolorizing with activated carbon prior to performing the titration to ensure that the endpoint color change is observable. When determining total sulfur dioxide, the sample is pretreated with sodium hydroxide solution in order to adjust the pH. This causes chemically

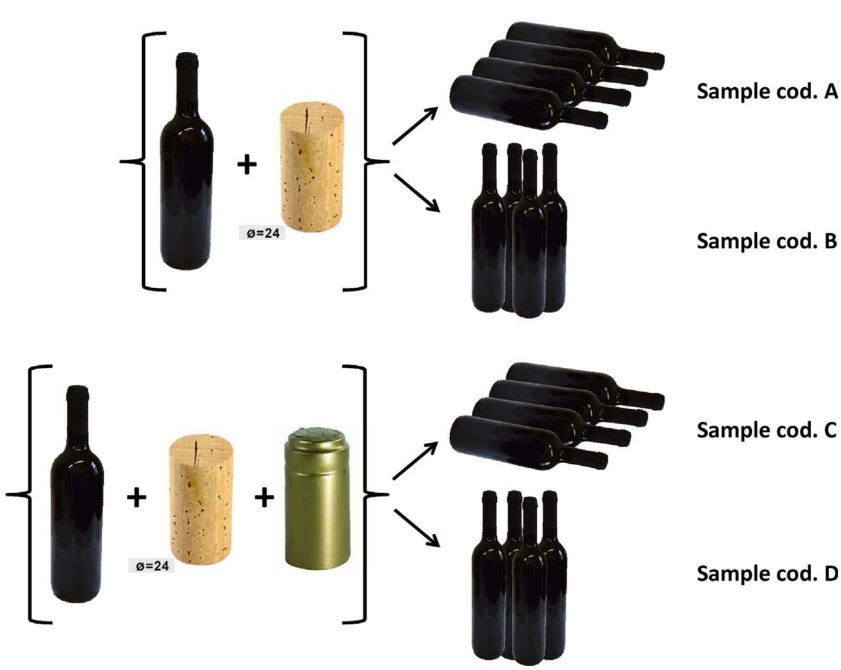

Fig. 1. Experimental protocol adopted.