

Article

Comparison of a Rapid Light-Induced and Forced Test to Study the Oxidative Stability of White Wines

Emilio Celotti ¹, Georgios Lazaridis ¹, Jakob Figelj ¹, Yuri Scutaru ² and Andrea Natolino ^{1,*} 

¹ Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, 33100 Udine, Italy; emilio.celotti@uniud.it (E.C.); lazaridis.georgios@spes.uniud.it (G.L.); figelj.jakob@spes.uniud.it (J.F.)

² Department of Oenology and Chemistry, Technical University of Moldova, MD-2004 Chisinau, Moldova; iurie.scutaru@enl.utm.md

* Correspondence: andrea.natolino@uniud.it; Tel.: +39-0432-558376

Abstract: The oxidation processes of white wines can occur during storage and commercialization due to several factors, and these can negatively affect the color, aroma, and quality of the wine. Wineries should have faster and simpler methods that provide valuable information on oxidation stability of wines and allow fast decision-making procedures, able to trigger suitable technological interventions. Using a portable prototype instrument for light irradiations at different wavelengths and times was considered and evaluated on sensorial, spectrophotometric, and colorimetric parameters of white wines. The sensorial analysis revealed that white and light blue were the most significant, after only 1 h of irradiation. The experimental results showed that hydrogen peroxide could enhance the effect of light treatment, allowing a contemporary evaluation of the oxidation stability of wine against light and chemical stresses. As expected, a good correlation ($R^2 > 0.89$) between optical density at 420 nm and b^* parameter was highlighted. The synergic effect of light and H_2O_2 was also studied on the hydrolyzable and condensed tannins' additions to white wine. The proposed methodology could be used to evaluate the oxidative stability of white wines, but also to evaluate the effect of some oenological adjuvants on wine stability.

Keywords: white wine; wine oxidation; browning; light exposure; tannins



Citation: Celotti, E.; Lazaridis, G.; Figelj, J.; Scutaru, Y.; Natolino, A. Comparison of a Rapid Light-Induced and Forced Test to Study the Oxidative Stability of White Wines. *Molecules* **2022**, *27*, 326. <https://doi.org/10.3390/molecules27010326>

Academic Editors: Fernando M. Nunes, Fernanda Cosme, Luís Filipe Ribeiro and Encarna Gómez-Plaza

Received: 29 October 2021

Accepted: 31 December 2021

Published: 5 January 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Storage and commercialization are crucial steps for both wine producers and consumers, as the wine quality needs to be ensured and maintained. White wines are usually consumed young within a year of production, to maintain their color, and fresh, fruity, and floral aroma. During storage, uncontrolled oxidation reactions can occur and cause several faults: volatile acidity increases [1], color changes from green and light yellow to brown and dark hues [2], flavor decay with many olfactory notes' losses, and off-flavors' formation [3,4].

Wine oxidation is a complex phenomenon since wine contains several organic and inorganic compounds, and it can be divided into enzymatic and non-enzymatic oxidation.

The non-enzymatic process, also called chemical oxidation, has been studied in the last decades and begins with the oxidation of polyphenols containing a catechol or a galloyl group, such as catechin, epicatechin, galocatechin, gallic acid and its esters, and caffeic acid [5]. White wines contain lower polyphenol concentrations (0.2 to 0.5 g/L), mainly hydroxycinnamic acids, but they remain crucial for oxidation-related issues in wine browning and aroma changes. The oxidation of polyphenols can lead to the formation of *o*-quinones with different degrees of polymerization and, due to their instability, further reactions can happen, and brown pigments can be formed [6]. The phenol oxidation induces, contemporary, the oxygen reduction to hydrogen peroxide, which is a potent oxidative compound that can also oxidize ethanol to acetaldehyde in the presence of

transition metals [7]. Besides transition metals (i.e., Fe, Cu), other factors could affect the non-enzymatic oxidation: temperature, pH, and light exposure [8].

Light exposure can cause sensorial changes in wine, with the formation of volatile sulfur compounds and the oxidative browning spoilage. The light-induced off-flavors are mainly due to the riboflavin and are associated with the so-called light-struck taste (LST), characterized by unpleasant cabbage- and onion-like odors. The riboflavin is a highly photosensitive vitamin that induces the photooxidation of methionine generating methanethiol and dimethyl disulfide [9].

Light can induce the photodegradation of tartaric acid and the formation of glyoxal and glyoxylic acid. These two compounds can bin two flavanol units, forming a dimer that undergoes a dehydration and oxidation leading to a formation of yellow pigments and contributing to the oxidative browning of white wines [2,6,10]. These mechanisms of photochemical oxidation are favored by the dissolved oxygen and the transition metal ions, such as iron [9].

Several analytical methods have been proposed to evaluate the oxidative susceptibility or oxidation status of white wines. The cyclic voltammetry is a useful fingerprint technology for quantifying dynamic changes in wines' composition related to their redox state [11], or investigating redox potentials of various wine compounds measuring the anodic peak intensity [12–14]. The oxidative mechanism can be also investigated through the detection of radical species with the so-called Electron Paramagnetic Resonance spectroscopy (EPR) [15,16]. Another approach comprises the metabolomics analysis by UHPLC/QTOF-MS systems that revealed some specific compounds able to discriminate the different oxidative statuses of white wines [17].

All these aforementioned analytical techniques are complex, expensive, and they require high knowledge and highly-skilled technicians. Wine quality control requires the availability of simple and rapid analytical methods, allowing regular and punctual monitoring of the different production steps and a fast decision-making procedure, able to trigger suitable technological interventions, in case of deviations from the normal winemaking conditions.

Due to the complexity of wine oxidation phenomena and the current analytical methods to evaluate the stability and shelf-life of white wines, it is necessary to have new approaches that allow more rapid, complete, and reliable evaluations. The initial aim of the present work is to evaluate, by sensorial analysis, the effect of light exposure at different wavelengths and times, using a portable prototype instrument. Moreover, the evaluation of light, chemical stresses, and their combination was carried out through spectrophotometric and colorimetric indices: optical density at 420 nm, catechins content, L^* , a^* , and b^* parameters. The addition of hydrolyzable and grape tannins at different concentrations (50, 200, and 500 mg/L) were also considered and studied on the oxidation stability of Pinot Gris wine.

2. Results and Discussion

The chemical properties of Pinot Gris and Chardonnay wines are shown in Table 1. All the experimental values are in the common ranges related to the cultivation area and grape variety [18]. The oxidation stability was evaluated by the Polyphenols Oxidative Medium (POM) test, and the results revealed initial technical stability, which allow a better evaluation of chemical and light stresses affecting wine quality during storage and commercialization stages.