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Analytical Methods

Chronocoulometry of wine on multi-walled carbon nanotube modified electrode: Antioxidant capacity assay

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ABSTRACT

Phenolic antioxidants of wine were electrochemically oxidized on multi-walled carbon nanotubes modified glassy carbon electrode (MWNT/GCE) in phosphate buffer solution. Three oxidation peaks were observed at 0.39, 0.61 and 0.83 V for red dry wine and 0.39, 0.80 and 1.18 V for white dry wine, respectively, using differential pulse voltammetry at pH 4.0. The oxidation potentials for individual phenolic antioxidants confirmed the integral nature of the analytical signals for the wines examined. A one-step chronocoulometric method at 0.83 and 1.18 V for red and white wines, respectively, has been developed for the evaluation of wine antioxidant capacity (AOC). The AOC is expressed in gallic acid equivalents per 1 L of wine. The AOC of white wine was significantly less than red wine (386 ± 112 *vs.* 1224 ± 184, $p < 0.0001$), as might be expected. Positive correlations were observed between gallic acid equivalent AOC of wine and total antioxidant capacity, based on coulometric titration with electrogenerated bromine ($r = 0.8957$ at $n = 5$ and $r = 0.8986$ at $n = 4$ for red and white wines, respectively).

1. Introduction

A wide range of beverages, such as fruit juices, tea, coffee, wine and cognac, possess antioxidant properties and, consequently, are associated with positive health benefits when included in the human diet (Rice-Evans & Packer, 1998). Among them, wine is of interest because of the so-called "French paradox", which suggests a decrease in cardiovascular disease mortality related to moderate consumption of wine, particularly red wine (Cooper, Chopra, & Thurnham, 2004; de Lange et al., 2007). Such an effect is associated with phenolic antioxidant content. These include a variety of both flavonoid (flavonol, flavan-3-ol and anthocyanin) and non-flavonoid compounds (phenolic acids, phenolic alcohols, stilbene, hydroxycinnamic acid) (Figueiredo-González, Cancho-Grande, & Simal-Gándara, 2013; Makris, Boskou, & Andrikopoulos, 2007). Phenolic antioxidants demonstrate different biological activities (King, Bomser, & Min, 2006) including cardioprotective (Mladěnka, Zatloukalová, Filipský, & Hrdina, 2010), anti-inflammatory (Widlansky et al., 2005), anti-carcinogenic (Formica & Regelson, 1995), antiviral (Weber, Ruzindana-Umunyana, Imbeault, & Sircar, 2003) and antibacterial (Alvesalo et al., 2006) properties that are largely attributed to their antioxidant potential (Procházková, Boušová, & Wilhelmová, 2011). Wine polyphenols, which originate from the skins and seeds of grapes, are present in greater variety and concentration in red than in white wines (Guilford & Pezzuto, 2011). Phenolic composition of wines depends on the grapes used and the vinification conditions. Growing season, variety, environmental and climatic conditions, plant disease, soil type, geographic locations, and even maturity, influence the concentration of phenolic compounds within the same type of fruit (Cimino, Sulfaro, Trombetta, Saija, & Tomaino, 2007).

Taking into account these factors, investigation of wine antioxidant properties and the evaluation of antioxidant capacity (AOC) are important. AOC characterizes the overall content of antioxidants and its evaluation would remove the necessity for time-consuming and relatively expensive determination of individual component. Moreover, AOC would allow for synergetic effects of different antioxidants. Thus, AOC could be used for characterization of the winemaking process and the properties of the final product to predict the potential health effect.

Phenolic antioxidants are easily oxidized on electrodes. Therefore, electrochemical methods could be considered a promising tool for the evaluation of antioxidant properties. Rapid response, high sensitivity, and low detection limits, in combination with low cost and the potential for miniaturization, are the main advantages of electroanalytical techniques over other analytical methods.

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