Chapter 8

Optimization of a Spectrophotometric Flow Injection: Method for Determination Copper and Manganese in Wines by Design Experiments

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ABSTRACT

This chapter presents the optimization of the hydrodynamic and chemical parameters of the FIA system in the determination of copper and manganese in wine samples by VIS spectrophotometry. This technique has been based on the injection of liquid samples in the non-segmented movement, within a continuous carrier current of a suitable liquid. The injected sample forms a zone that disperses on its way to a detector. The later continuously records the absorbance or other physical parameters, since it continuously passes the sample material through the flow cell, using the factorial designs Plackett-Burman, Box-Behnken, and the factorial design $2^4$. The methods have the advantages of low-cost, easy availability of chemicals, and instrumentation and straightforward application to real samples.

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INTRODUCTION

Wine has been defined as an alcoholic beverage obtained from the alcoholic fermentation of only fresh grape musts (Vitis vinifera), with or without pomace, or the mixture of concentrated grape musts and water. The alcohol content in wine is from 8% to 16% Alc. Vol. The alcohol content may be up to 18% Alc. Vol. for products that are regulated by a denomination of origin. In the case of wines from late harvests, the alcohol content could reach 18% Alc. Vol by natural fermentation. Wines are classified by their content of total reducing sugars. A dry wine has less than 4 g/L; semi-dry: between 4.1 and 12 g/L; semi-sweet: between 12.1 to 50 g/L; and sweet: more than 50 g/L. Mexican wine is wine produced with grapes of 100% Mexican origin, and also is completely fermented and packed in the national territory (NOM-199-SCFI-2017, 2017).

The macromolecules present in wine also have the potential to interact and bind to metals, and may include tannins, polysaccharides, proteins, and combinations of complexes or aggregates of these macromolecules (Kontoudakis, Guo, Scollary, & Clark, 2017). Taking into account the elemental composition, the wine contains macro-elements with concentrations higher than 10 mg/L (Na, K, Mg, Ca), for the case of the micro-elements between 10 μg/L and 10 mg/L (Fe, Cu, Zn, Mn, Pb), and ultra-microelements less than 10 μg/L (Cr, As, Cd, Ni). Data on the mineral content in wines have been studied and reported due to their implications for organoleptic, hygienic and nutritional characteristics, as well as their toxicological implications (Guriérrez, Rubio, Moreno, & González, 2017).

The mineral content of the wine depends on several factors, including the absorption of metals from the soil, contamination by emissions to the atmosphere, type of grape, herbicide treatment, and the process of winemaking. The content of minerals has a significant influence on the quality of a wine, and several studies have done on this subject (Ferreira, et al., 2008).

Most of the abundant mineral elements found in wine come from the grape itself through the absorption of the soils where the grapes are grown, reflecting the elemental profile of the ground. These factors included age, root depth, soil pH, rainfall, temperature and will vary widely from region to region (Orellana, Johansen, & Gazis, 2019). In China, the concentrations of these elements (Cu, Fe and Mn) was regulated on imported wine and the limits fixed are (Copper 1 mg/L, Iron 8 mg/L and Manganese 2 mg/L), these minerals can vary from one area to another and from one variety the wine to another due to the presence of nutrients in the soil. When the grapes were growing, the uptake of these nutrients by the vine itself and the process by which wine was producing. Due to this significant variability, there is no way to guarantee that a particular wine meets import specifications with outperforming analytical tests (Spivey, Thompson, Shelton, & Kavan, 2015).

Schut et al., reported the content of Cu in 72 wines showing an average of 0.18 mg/L with a maximum of 0.55 mg/L. The Organization International de la Vigne et du Vin (OIV) recommended the copper concentration limit in wines is equal to 1.0 mg/L. The Germany national regulations allow the presence of 2.0 mg/L Cu in drinking water and German wines (Schut, Zauner, Hampel, Konig, & Claus, 2011). The OIV recommended a Mn concentration at interval of 0.5 to 5 mg/L (Gomez-Miguel & Sotes, 2014).

During fermentation, Cu is mostly removed through its association and precipitation with yeast cells (Hsia, Plack, & Nagel, 1975). To repress sulfidic-off odors in the wine, the winemaker’s add Cu, as copper (II) sulfate pentahydrate or copper citrate, (Kontoudakis, Schmidtke, Bekker, & Smith, 2019). In USA, Cu sulfate can be added up to 6 mg Cu (II) per litre, although the residual level in wine cannot be over 0.5 mg/L (Code of Federal Regulations 2014) (Clark, Wilkes, & Scollary, 2015).
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