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Estimation of dietary intake and target hazard quotients for metals by consumption of wines from the Canary Islands

Angel J. Gutiérrez [a], Carmen Rubio [a], Isabel M. Moreno [b, *], A. Gustavo González [c], Dailos Gonzalez-Weller [d], Naouel Bencharki [a], Arturo Hardisson [a], Consuelo Revert [e]

[a] Department of Toxicology, School of Medicine, Universidad de La Laguna, Spain
[b] Nutrition, Food Chemistry and Toxicology, Faculty of Pharmacy, University of Sevilla, C/ Profesor García González 2, 41012 Sevilla, Spain
[c] Analytical Chemistry, Faculty of Chemistry, University of Sevilla, C/ Profesor García González nº 1, 41012 Sevilla, Spain
[d] Canarian Public Health Service, Central Laboratory, Santa Cruz de Tenerife, Spain
[e] Department of Physical Medicine and Pharmacology, Universidad de La Laguna, Spain

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ABSTRACT

This paper describes the impact of mineral content on wines and assesses the potential health risk from consuming these wines from Canary Islands. The metal content (B, Ca, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Zn) of red wines belonging to different regions in the Canary Islands was determined by ICP-OES. The studied wine regions were Valle de la Orotava, Tacoronte-Acentejo, Ycoden-Daute-Isora, Abona and Valle de Güimar in Tenerife Island and only one in La Gomera and La Palma Islands. According to the content found, elements could be classified in two categories: the main group including Ca, K, Mg, Na, and the "minor" set consisting of B, Co, Cr, Cu, Fe, Li, Mn, Mo, Ni, Pb and Zn. Once calculated the metal intake through red wines consumption, we can conclude that Canarian drinkers are not exposed to unsafe levels of the metals studied, actually, the safety intake limits (daily) ranges between 0.9% in Zn and 2% in Cu, for normal drinkers. And also it has been demonstrated the good quality of Canarian red wines and there is no reason for health concern through the THQ calculation being the highest values determined in La Gomera wines.

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1. Introduction

Wine is a very complex product, which along with water and alcohol contains a great variety of both inorganic and organic substances. Taking into account elemental composition, wine contains macro-elements [c > 10 mg L^{-1} (Na, K, Mg, Ca)], micro-elements [10 mg L^{-1} > c > 10 μg/L (Fe, Cu, Zn, Mn, Pb)], and ultra microelements [c < 10 μg L^{-1} (Cr, As, Cd, Ni)] (Pytlakowska, 2016). Mineral wine composition is influenced by many factors, including mineral composition of soil, viticultural practices, environmental factors, fermentation process and the procedure of storage condition (Alvarez et al., 2007). Data on the mineral content in wines have been extensively studied and reported due to their implications in organoleptic, hygienic and nutritional characteristics as well as their toxicological implications (Jos et al., 2004). Determination of the concentration of metallic elements in wine allows calculation of the daily intake of such elements from the wine. This intake of metals can be a double-edged sword, not only since it could contain harmful elements, such as Pb, As and Cd, but also, from nutritional point of view, since wine contains essential elements (Ca, Cr, Co, K, Se and Zn) for the human organism, (Ivanova-Petropulos et al., 2015). Moreover, wine is an important source of some elements such as Fe, K, Na, Mg or Al which contribute significantly to the requirements of the human organism when daily consumption of wine is in moderate quantities but may be related with several pathologies when daily intake of these metals is above the maximum permissible levels established due to large amounts of wine consumed (Lara et al., 2005). Thus, Fe which is required for the maintenance of normal body function such as synthesis of metalloproteins, but an excessive intakes of this metal is implicated with pathological events such as the deposition of iron oxides in Parkinson's disease, enhanced oxidative damage, chronic inflammatory diseases, initiator of cancer and premature ageing (Iwegbue, 2014). The ratio of K/Na in wines is of interest in nutritional studies of the effect of diet on hypertension. Mg and Al

* Corresponding author.
E-mail address: imoreno@us.es (I.M. Moreno).

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may be toxic to persons with kidney dysfunction, which prevents adequate elimination of these elements (Álvarez et al., 2012). On the other hand, little or no information is available about the long-term effects of metal ions ingestion. The Environmental Protection Agency (EPA) in the United States developed the target hazard quotients (THQs) for the estimation of potential health risks associated with long-term exposure to chemical pollutants. The THQ is a ratio between the measured concentration and the oral reference dose weighted by the length and frequency of exposure, amount ingested and body weight. If the THQ is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the THQ is greater than 1, then adverse health effects are possible (Iwegbue, 2014; Dalipi et al., 2015).

Among the different analytical techniques mentioned in literature, the application of inductively coupled plasma optical emission spectrometry (ICP OES) showed powerful analytical performance in the determination of trace elements in wine (Moreno et al., 2008; Álvarez et al., 2012; Zioła-Frankowska and Frankowski, 2016).

In this work we carried out a study of the mineral composition in bottled wines from different wine regions of Canary Islands with a view to providing information on the metal intake and THQ values found in the different wines studied. We focused on five wine regions in Tenerife Island: Valle de la Orotava, Tacoronte-Acentejo, Ycoden-Daute-Isora, Abona and Valle de Güimar and the only one in La Gomera and La Palma islands. Particularities of wines from the Canary Islands are that they are elaborated with autochthonous varieties that cannot be found elsewhere in the world, the vines are not contaminated by phylloxera, the climatic conditions with a very moderate mean annual temperature and soils are volcanic (Díaz et al., 2003; Moreno et al., 2007).

2. Material and methods

2.1. Chemicals and reagents

Merck (Darmstadt, Germany) CertiPUR®. ICP-multielement standard solutions of about 1000 mg L^{-1} were used as stock solution for calibration. Other reagents were of analytical grade. Milli-Q treated water was used throughout. The laboratory glassware were kept in a 5% in solution of nitric acid overnight, the washed deionised water, and dried in a dust-free atmosphere in order to prevent metal contamination.

2.2. Instrumentation

Elemental analyses were carried out on a Thermo Jarrell Ash AtomScan 25 inductively coupled plasma atomic emission spectrometer (Genesis Laboratory Systems Inc., CO, USA). Table 1 shows the analytical lines used for each element, as well as the instrumental conditions.

2.3. Sample preparation and analysis

Twenty samples of red wines of different brands with D.O. trademark from the seven Canary Islands DO studied were purchased in liquor retails and markets. All the samples were from 2010 to 2011-vintage. Wine samples were categorized into four classes, two for Tenerife Island DO: wines from the three DO in the North of the island, “Tacoronte-Acentejo”, “El Valle de la Orotava” and “Ycoden-Daute-Isora” with code NT, and wines from the south, Abona and Valle de Güímar DOs with code ST. The other two classes were code G for wines from La Gomera Island and code P for La Palma DO wines. Each sample was identified with a code referring its origin class (NT, ST, G, P) together with the sample number.

The dry ashing method has been considered more adequate to our purposes because with this method neither acid mixture is added to the sample that could produce high blank values in some cases (Moreno et al., 2008).

Once opened, wines samples were digested according to Moreno et al. (2007):

The 25 mL of each sample were placed in porcelain crucibles. To avoid contamination and cross-talking between the samples, single used plastic tools were utilised to transfer the material. Each sample was then dried in an oven at a temperature of 50 °C for at least 12 h. The crucibles with the samples were then introduced in muffle ovens and burned to ash at 450 °C. The temperature in the muffle oven was increased at a rate of approximately 50 °C h^{-1} and maintained at 450 °C during 18–24 h. The white ashes obtained with this procedure were then dissolved in 1.5% nitric acid to a volume of 25 mL.

Table 1
Analytical lines used for each element and the instrumental conditions for the ICP.

Parameter		
RF frequency	27.12 MHz	
Operating Power	1350 W	
Coolant Ar flow	20 L min^{-1}	
Plasma Ar flow	0.6 L min^{-1}	
Carrier Ar flow	0.5 L min^{-1}	
Nebulizer type	Babington V	
Detection wavelengths (nm^{-1})		
B		249.7
Ca		317.9
Co		228.6
Cr		267.7
Cu		327.3
Fe		259.9
K		769.9
Li		670.8
Mg		279.1
Mn		257.6
Mo		202.0
Na		589.6
Ni		231.6
Pb		220.3
Zn		206.2

2.4. Quality controls

Quality controls of the analytical measurements were performed using blank samples and the following reference materials: 1549 SRM Non-Fat Milk Powder, SRM 1515 Apple Leaves and SRM 1573a Tomato Leaves from the National Institute for Standards and Technology (NIST) (Gaithersburg, MD USA) for the mineral elements. The recoveries obtained with the reference materials were upper than 90%. During all of the analytical procedures, each batch of 20 samples was analyzed together with at least a blank and a reference sample. Calibration was performed using the calibration curve method. The validation process was performed according to González et al. (2010).

Instrumental detection and quantification limits in terms of reproducibility, were calculated as three and ten times the standard deviation (SD) resulting from analysis of 15 targets of acid digest (IUPAC, 1995). These values are detailed in Table 2.

2.5. Statistical analysis

The content of each mineral element was considered as chemical descriptor. The statistical package, STATISTICA 7 from StatSoft (2007) was used for the basic statistic and the correlation study. All results were subjected to one-way analysis of variance (ANOVA), and represent means ± SD. Differences in mean values between

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