Determination of copper, manganese and chromium in wine

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Abstract
The aim of the study was to determine the content of copper, manganese and chromium in white and red wines available on Polish market. The results have been compared with similar studies of other researchers as well as with the recommendations regarding dietary intake of analysed elements. Statistical analysis showed that there was a statistically important difference in manganese and copper content between the two groups of wines.

Key words: Wine, copper, manganese, chromium, atomic absorption

Introduction

Wine is a very popular beverage worldwide. In Poland, the production of grape wine in 2015 was 15.3 mln tons [1]. According to the report of the Central Statistical Office [2] consumption of wine and mead in Poland in 2015 was 6.3 L per capita per year (since mead is far less popular one can assume that the major consumption comes from wine). Similarly to other foodstuffs, wine is the subject of wide range of quality tests in order to monitor its nutrient values as well as possible contaminations. All three of the studied elements are essential microelements, which can be, however, a potential threat to human health when provided in excess.

Metals in wine come from both natural and anthropogenic sources. Partly they can be incorporated into grapevine from the soil but can also be introduced to the wine during the production process (stainless steel containers, metal tubing etc.). In addition to that, further amounts of copper and manganese in wine come from pesticides [3]. The chromium concentration in wine usually increases with time which suggests that this element can be introduced from the container material during storage. Apart from health effects, excessive amounts of metals in wine affect its taste and appearance [4] and its concentration can be a significant parameter affecting consumption and conservation of wine. Since metallic ions have important role in oxide-reductive reactions resulting in wine browning, turbidity, cloudiness, and astringency, wine quality depends greatly on its metal composition. Moreover, metals in wine may affect human health. Consumption of wine may contribute to the daily dietary intake of essential metals (i.e., copper, iron, and zinc).

Materials and Methods

Ten wine samples were collected, most of which were purchased in local stores in Tarnów (southern Poland). Basic characteristics of the samples have been described in Table 1.

Analyses were carried out using Agilent 240Z AA atomic absorption spectrometer with graphite-furnace atomization and Zeeman background correction. By careful choice of the temperature program (ashing and atomization temperatures, matrix modifiers) matrix effects were avoided and good analytical signals could be achieved. Each element in a given sample was measured in three replicates.

Results and Discussion

The results together with expanded uncertainties (confidence interval 95%, k=2) are presented in Table 2. Uncertainties were calculated according to the NIST guide for uncertainties expression [5].

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Table 1. Characteristics of the samples

Number	Name	Type	Year of production	Alcohol content [%]	Sweetness	Country of origin
1	Martini Bianco	white	2016	14,4	sweet	Italy
2	Kadarka exclusive		2016	11	semi- sweet	Bulgaria
3	Celebro		2012	11	semi-dry	Spain
4	J.P. Chenet		2015	11	semi- sweet	France
5	Imiglykos Katharos		2013	11	semi- sweet	Greece
6	Duca di Canora (Piemonte Barbera)	red	2009	11,5	semi-dry	Italy
7	Potinho do Covo		2010	13,5	dry	Portugal
8	Kadarka exclusive		2016	11	semi- sweet	Bulgaria
9	Carlo Rossi Kalifornia		2008	11,5	semi- sweet	USA
10	Nemea		2013	13%	dry	Greece

Table 2. Manganese, copper and chromium content in the studied samples

Number	Type	Cu [µg/L]	Mn [µg/L]	Cr [µg/L]
1	white	8.55±1.6	486±18	16.0±0.2
2		23.3±0.2	292±4	4.63±0.16
3		15.8±0.4	760±10	17.1±0.3
4		20.4±0.2	753±25	13.0±0.24
5		18.3±5.2	755±18	30.3±0.7
6	red	870±10	1239±83	17,7±0.1
7		172±6	2030±40	27.5±0.8
8		95.5±7	596±6	21.7±0.5
9		164±2	1502±35	20.7±0.1
10		21.4±14	2313±197	6.68±0.02

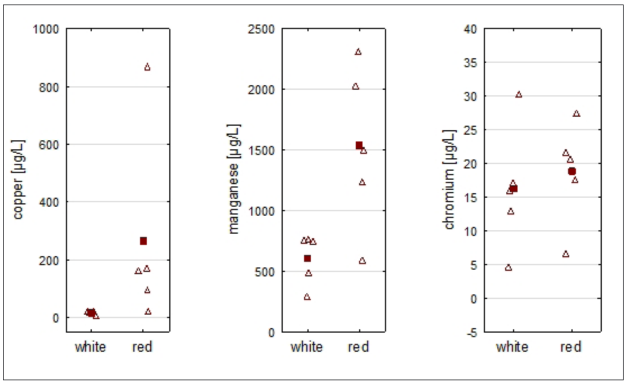

Figure 1. Concentrations of Cu, Mn and Cr in white and red wines (■ – mean; Δ – experimental data).

Results of the analyses were compared with those reported by other researchers and the details of this comparison are presented in Table 3. In general, the values obtained in this study are comparable with the results found in the literature. According to International Organization of Vine and Wine [6], maximum acceptable limit for copper in wine is 1 mg/L (1000 µg/L). Only one of the studied samples (no. 6, Table 1) was relatively close to this value.

In order to find potential correlations among the results, appropriate statistical tests were carried out (Statistica software, Statsoft Inc.). The results pointed out, that the content of manganese and copper differ significantly between red and white wines (with $p<0,02$ for both cases). Both metals are more abundant in the red than the white wines. Experimental data together with mean values are presented on the Fig. 1. One can notice that the results for copper in white wines form very close-fitting group.

Assuming daily consumption of wine equal to 6.3 L per capita per year [2], daily intake of each element was estimated. Comparison with the dietary recommendations [14] showed that none of the examined wine is an important source of studied elements in human diet. This comparison is summarized in Table 4.

Table 3. Comparison of the results with literature data

Reference	Cu [µg/L]	Mn [µg/L]	Cr [µg/L]
Wiese 1997 [7]	White: 170-1700	-	-
Aceto 2002 [8]	10-1000	1000-6000	30-60
Pyrzyńska 2004 [9]	German, red: 2740-3390 Australian, white: 0-1800	German, red: 950-1230 Spanish, red: 400-1200	French, red: 7-90 French, white: 6.6-43.9 Slovenian: 5.2-23.1
Cabrera-Vigue 1997 [10]	-	-	Red: 7.0-90.0 White: 6.6-43.9
Catarino 2006 [11]	Red: 237 White: 49	Red: 879 White: 1036	-
Karadjowa 2002 [12]	Red: 220-460 White: 160-210	-	-
Lara 2005 [13]	Red, white: 0,023-0,028	-	Red: 6.25 (mean) White: not detected
This study	Red: 21.4-870 White: 8.55-23.3	Red: 292-760 White: 596-2313	Red: 6.68-27.5 White: 4.63-30.3

Table 4. Daily intake of each element from studied wines and comparison with dietary recommendations

	Daily intake from wines analysed in this study [µg]	Dietary recommendation [µg/day]
Cu	0.15-15	900 (men, 19-70)
Mn	5-40	2300 (men, all ages)
Cr	0.08-0.52	35 (men, 19-50 years)

Conclusions

This study showed that atomic absorption spectrometry is a suitable technique for the determination of trace elements in wine, which is a relatively complex matrix. This is an encouragement for further studies in this field. The results are comparable with those found in literature. Despite low number of the samples it was possible to find significant difference between red and white wines in regard of copper and manganese content. Wine is a minor source of Cu, Mn and Cr in human diet but still should be a subject of constant monitoring since excessive amounts of these metals can pose a potential health risk for humans.

References

1. Central Statistical Office, *Statistical Yearbook of Industry*, Warsaw, Poland 2016.
2. Central Statistical Office, *Domestic market supplies and consumption of the selected consumer goods per capita in 2016*, Warsaw, Poland 2016.
3. P. Pohl, *TrAC - Trends Anal. Chem.*, 2007, **26**, 941–949.
4. B. Tariba, *Biol. Trace Elem. Res.*, 2011, **144**, 143–156.
5. B. N. Taylor and C. E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, 1994, vol. 1297.
6. International Organization of Vine and Wine, *International code of Oenological practices*, 2016. (http://www.oiv.int/public/medias/2696/code-2016-en.pdf - accesed 10.12.2017)
7. C. Wiese and G. Schwedt, *Fresenius. J. Anal. Chem.*, 1997, **358**, 718–722.
8. M. Aceto, O. Abollino, M. C. Bruzzoniti, E. Mentasti, C. Sarzanini and M. Malandrino, *Food Addit. Contam.*, 2002, **19**, 126–133.
9. K. Pyrzyńska, *Crit. Rev. Anal. Chem.*, 2004, **34**, 69–83.
10. C. Cabrera-Vique, P. L. Teissedre, M. T. Cabanis and J. C. Cabanis, *J. Agric. Food Chem.*, 1997, **45**, 1808–1811.
11. S. Catarino, A. S. Curvelo-Garcia and R. B. de Sousa, *Talanta*, 2006, **70**, 1073–1080.
12. K. I., B. I. and G. S., *Spectrochim. Acta Part B*, 2002, **57**, 581–590.
13. R. Lara, S. Cerutti, J. A. Salonia, R. A. Olsina and L. D. Martinez, *Food Chem. Toxicol.*, 2005, **43**, 293–297.
14. Food and Nutrition Board, *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*, National Academy Press, Washington DC, 2001.