JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal
Published by Faculty of Biotechnology and Food Sciences

BIOGENIC AND RISK ELEMENTS IN GRAPE POMACE OF DIFFERENT CULTIVARS

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https://doi.org/10.55251/jmbfs.11096

ARTICLE INFO

Received 3. 4. 2024
Revised 2. 5. 2024
Accepted 22. 5. 2024
Published 1. 8. 2024

Regular article

OPEN ACCESS

ABSTRACT

The contents of biogenic and risk elements in the pomace of 6 grape cultivars (Blaufränkisch, Cabernet Franc, Cabernet Sauvignon, Devín, Dunaj, and Merlot) were analyzed in this study. Content of K, Ca, P, Mg, and Na was 11 750 – 19 070, 2 400 – 3 908, 1 678 – 2 684, 336 – 760, and 1.43 - 59.3 $mg.kg^{-1}$ DM respectively. Content of Fe, Cu, Mn, Zn, Ni, Cr, and Co was 79.5 – 245, 6.18 – 48.4, 10.3 – 22.6, 4.19 – 17.0, 0.66 – 1.36, 0.058 – 2.33, and 0.42 – 0.63 $mg.kg^{-1}$ DM respectively. Pb and Cd were detected in the grape pomace of Merlot (0.94 and 0.03 $mg.kg^{-1}$ DM, respectively) and Cabernet Sauvignon (0.36 and 0.08 $mg.kg^{-1}$ DM, respectively). The total content of Hg ranged from 0.0055 to 0.0080 $mg.kg^{-1}$ DM. Analysis of variance showed that there are differences in the content of elements among cultivars. Grape pomace of cultivars Blaufränkisch and Cabernet Sauvignon could be characterized by the higher Fe, Mn, Zn, Ni, and Cr content, while grape pomace of cultivar Merlot by higher Mg content. With relatively low content of risk elements, grape pomace can serve as a good source of essential minerals in the human diet.

Keywords: grape pomace, minerals, lead, cadmium, mercury

INTRODUCTION

Winemaking is one of Slovakia's most important traditional industries, with more than 330 000 hl of wine produced and 11.9 L of wine consumed per capita in 2022 **(Ministry of Agriculture and Rural Development of the Slovak Republic, 2023; Statistical Office of the Slovak Republic, 2023)**. The wine industry also produces a considerable amount of valuable unused waste, including grape pomace, which has not been used in the past. Wine and wine by-products are a rich source of antioxidants and health-promoting bioactive molecules such as flavonoids, phenolic acids, stilbenes, proanthocyanins, and other molecules such as natural colors, vitamins, fibers, and minerals **(Chowdhary *et al*., 2022; Ferrer-Gallego and Silva, 2022; Čeryová *et al*., 2021; Jara-Palacios, 2019)**. Due to its content of bioactive substances, grape pomace is a promising raw material for producing nutritional foods, which are of great interest as their consumption can help prevent civilization diseases. Additionally, grape processing by-products are suitable for recovering valuable polyphenolic compounds and reducing environmental waste. The high polyphenol content may lower its pH and increase its resistance to biodegradation **(Kalli *et al*., 2018)**. With a relatively high content of biogenic elements essential for human health, grape pomace can also be an interesting ingredient for fortifying food and increasing the intake of these elements in the human diet (**García-Lomillo and González-SanJosé, 2016**).
The content of risk elements could limit the possible agricultural as well as food uses of grape pomace. In case there are higher levels of certain essential elements in the plants, they could be classified as risk elements, or heavy metals, which could limit their use **(Vollmannová *et al*., 2014)**. These elements can pose long-term risks to human health and harm the environment. Heavy metals are considered priority pollutants due to their potential toxicity if concentrations exceed permitted limits (**Dumitriu Gabur *et al*., 2019).** Conventional agriculture is a major contributor to heavy metal contamination in the food chain, posing a risk to environmental health. By-products and wastes may also contain harmful elements and compounds, such as heavy metals and pesticide residues, which can negatively impact human health. Therefore, it is important to prevent contamination of food products that incorporate by-products. **(Dumitriu Gabur *et al*., 2021).** Contamination of both the wine and the grape pomace can occur at different stages of the vine-growing process. This is most often caused by applying fertilizers, pesticides, herbicides, and fungicides during crop cultivation **(Pérez Cid *et al*., 2019).** According to **Herrero-Hernández *et al*. (2012)**, the presence of risk elements in the grape pomace can be attributed to treating vines with fertilizers and plant protection products. The accumulation of risk elements in grapes is influenced by various factors such as variety, degree of maturity, geography, and the use of agrochemicals. Additionally, climatic factors such as temperature, humidity, and wind can also have an impact **(Fiket *et al*., 2011).**
Although recently, there has been an increased interest in the study of bioactive compounds from grape pomace, studies on the content of biogenic, but especially risk elements, are scarce. Therefore, this study aimed to determine the content of these elements in grape pomace from different grape cultivars and to evaluate the safety of this material as a potential raw material for food production.

MATERIAL AND METHODS

Plant material

Grape pomace of Blaufränkisch (BL), Cabernet Franc (CF), Cabernet Sauvignon (CS), Devín (DE), Dunaj (DU), and Merlot (M) were provided by the Tajna winery. All samples were taken from the same site, in the municipality of Tajná, located in the Nitra wine region of Slovakia. The collected samples were dried at 50 °C for four days using a drying oven Memmert SF 110 (Memmert GmbH, Schwabach, Germany) and then thoroughly homogenized for 60 seconds at 25 000 rpm using batch mill IKA A10 (IKA-Werke GmbH & Co. KG, Staufen, Germany).

Determination of the macroelement contents

Contents of macroelements were determined according to **Musilová *et al*. (2023).** 1 g of the sample was mineralized in 10 ml of concentrated HNO_3 and 5 ml of concentrated HClO using the mineralization device MARS X-press (CEM Corp., Matthews, NC, USA). The mineralized sample was filtered through quantitative filter paper Filtrak 390 (Munktell, GmbH, Bärenstein, Germany). To determine K, Ca, P, and Mg content, 2 ml of filtered sample was diluted with distilled water to the volume of 50 ml and measured against a blank solution using atomic absorption spectrophotometer VARIAN AASpectra DUO 240FS (Varian, Ltd., Mulgrave, VIC, AUS). To determine P content, 1 ml of filtered sample was diluted with 8 ml of solution ($C_6H_8O_6$, H_2SO_4, $(NH_4)_2MoO_4$, and $C_4H_4KO_7Sb,0 \times 5H_2O$) and deionized water to the volume of 50 ml and measured against blank solution using a UV/Visible Scanning Spectrophotometer Shimadzu UV- 1800 (Shimadzu, Kyoto, Japan). Analyses were performed in 4 replicates.

Determination of the microelement and risk element contents

Contents of microelements were determined according to **Čeryová *et al*. (2023).** 1 g of sample was mineralized in 5 ml of concentrated HNO_3 and 5 ml of redistilled water using mineralization device MARS X-press (CEM Corp., Matthews, NC, USA). The mineralized sample was filtered using filtrating paper Filtra 390 (Munktell, GmbH, Bärenstein, Germany), and diluted with distilled water to the volume of 50 ml. The contents of Fe, Cu, Zn, Mn, Co, Cr, and Ni were determined against a blank solution using an atomic absorption spectrometer Varian 240FS (Varian Inc., Mulgrave, VIC, Australia). The contents of Pb and Cd were determined against a blank solution using an atomic absorption spectrometer Varian 240Z (Varian Inc., Mulgrave, VIC, Australia). The content of mercury was determined according to **Lidiková *et al*. (2021)** by cold-vapor atomic absorption spectroscopy method using selective Hg analyzer AMA254 (Al-tec, Prague, Czech Republic).

Statistical analysis

Statistical analyses were performed using the program XLSTAT **(Lumivero, 2024)**. Shapiro-Wilk test was used to assess the normality of the distribution. Based on the normality tests, analysis of variance (ANOVA with Tukey's multiple pairwise comparison) and non-parametric analysis of variance (Kruskal-Wallis test with Dunn's multiple pairwise comparison with Bonferroni correction) were used to compare the contents of analyzed elements in individual cultivars. Pearson correlation was used to determine the relationships between the analyzed elements.

RESULTS AND DISCUSSION

Content of macroelements in grape pomace

The most abundant macroelement in grape pomace of all analyzed cultivars was K, followed by Ca, P, Mg, and Na. The total content of K ranged from 11 750 (Dunaj) to 19 070 mg.kg-1 (Merlot). Total content of Ca ranged from 2 400 (Devín) to 3 908 mg.kg-1 (Merlot). The total content of P ranged from 1 678 (Devín) to 2 684 mg.kg-1 (Dunaj). Total content of Mg ranged from 336 (Cabernet Sauvignon) to 760 mg.kg-1 (Cabernet Franc). The total content of Na ranged from 1.43 (Blaufränkisch) to 59.3 mg.kg-1 (Devín). Statistical analysis of results showed that there are differences in the content of macronutrients among cultivars. While Devín has the lowest content of Ca and P, it has the highest content of Na. On the other hand, the cultivar Dunaj has the lowest K content but the highest Mg content. Cultivar Merlot had the highest content of K and Ca.

Table 1 Content of macroelements in analyzed samples (mg.kg^{-1} DM)

Cultivar	K	Ca	P	Mg	Na
BL	12 698^{ab}	3 257^{bc}	1 823^{ab}	355^{ab}	1.43^{a}
sd	1 358	323	195	30.9	0.15
CF	16 019^{ab}	3 803^{bc}	1 921^{ab}	760^{c}	9.24^{abc}
sd	1 399	359	208	82.6	0.95
CS	12 675^{ab}	3 017^{ab}	1 996^{ab}	336^{a}	5.09^{ab}
sd	1 156	256	221	29.4	0.54
DE	13 399^{ab}	2 400^{a}	1 678^{a}	572^{abc}	59.3^{c}
sd	1 305	185	152	55.5	0.55
DU	11 750^{a}	3 359^{bc}	2 684^{b}	754^{bc}	13.1^{bc}
sd	1 425	339	258	79.4	1.52
M	19 070^{b}	3 908^{c}	2 627^{ab}	579^{abc}	9.53^{abc}
sd	2 181	422	269	61.2	1.11

Legend: BL – Blaufränkisch, DE - Devín, CF- Cabernet Franc, DU - Dunaj, M - Merlot, CS- Cabernet Sauvignon, sd- standard deviation (n=4)

Šimko *et al*. (2019) reported similar content of K (12 892 – 15 055 mg.kg^{-1}), but higher levels of Ca (4 457 – 5 517 mg.kg^{-1}), P (3 180 – 3 210 mg.kg^{-1}), Mg (1 200 – 1 205 mg.kg^{-1}), and Na (260 – 462 mg.kg^{-1}) in grape pomace of Pinot Blanc from different localities in Slovakia. **Tangolar *et al*. (2018)** reported similar content of Ca (2350 – 3460 mg.kg^{-1}), P (1230 – 1910 mg.kg^{-1}), Mg (610 – 850 mg.kg^{-1}), Na (20 – 70 mg.kg^{-1}), and a wider range of the K (6780 – 17 600 mg.kg^{-1}) in grape pomace of 6 different cultivars. In grape pomace of Cabernet Sauvignon, they reported higher content of K, Mg, and Na (1 110, 530, 50 mg.kg^{-1} respectively), and lower content of Ca and P (1 110 and 1 190 mg.kg^{-1} respectively). **Chikwhana *et al*. (2018)** reported similar content of Ca (2 390 – 3 730 mg.kg^{-1}), similar and higher content of K (15 000 – 24 200 mg.kg^{-1}), P (2 170 – 3 420 mg.kg^{-1}), and Na (33.2 – 117 mg.kg^{-1}), and higher content of Mg (950 – 1 370 mg.kg^{-1}) in grape pomace of three cultivars from South Africa. **Ziarati *et al*. (2017)** reported similar content of Mg (321.5 mg.kg^{-1}) and Na (1.36 mg.kg^{-1}), but lower content of K (1348.6 mg.kg^{-1}), Ca (845.6 mg.kg^{-1}), and P (112.0 mg.kg^{-1}) in grape pomace of 5 different cultivars. **Sagdic *et al.* (2014)** reported similar average content of Ca (2 400 mg.kg^{-1}), but higher average content of P (3 800 mg.kg^{-1}), and Mg (1000 mg.kg^{-1}) in grape pomace of 5 Turkish grape cultivars. **Hanušovský *et al*. (2019)** reported higher levels of macronutrients (23 825 – 58 550 mg K.kg^{-1}, 2226 – 5367 mg Ca.kg^{-1}, 2260 – 3798 mg P.kg^{-1}, 687 – 1173 mg Mg.kg^{-1} in, and 341 – 1556 mg Na.kg^{-1}) in grape pomace of different cultivars from Slovakia and Austria, and **Corbin *et al*. (2015**) reported a higher content of macronutrients (27 333 mg K.kg^{-1}, 3867 mg Ca.kg^{-1}, 2 733 mg P.kg^{-1}, 987 mg Mg.kg^{-1}, and 58 mg Na.kg^{-1}) in grape pomace of Cabernet Sauvignon. **Bennemann *et al*. (2016)** determined K, Ca, P, and Mg in grape pomace of 9 different cultivars. They reported similar and higher content of Mg (587 – 1 055 mg.Kg^{-1}; 622 mg.kg^{-1} in CS, 587 mg.kg^{-1} in M, and 1014 mg.kg^{-1} in CF), lower content of K (59.6 – 258 mg.kg^{-1}; 138 mg.kg^{-1} in GP of Cabernet Sauvignon,108 mg.kg^{-1} in Merlot, and 186.6 mg.kg^{-1}in Cabernet Franc), and P (330 – 498 mg.kg^{-1}; 396 mg.kg^{-1} in CS, 400 mg.kg^{-1} in M, 451 mg.kg^{-1} in CF), and wider range of Ca 1580 – 4295 mg.kg^{-1} (2842 mg.kg^{-1} in Cabernet Sauvignon, 1580 mg.kg^{-1} in Merlot, and 2962 mg.kg^{-1} in Cabernet Franc).

Table 2 Content of microelements and risk elements in analyzed samples (mg.kg^{-1} DM)

Cultivar	Fe	Cu	Mn	Zn	Ni	Cr	Co	Pb	Cd	Hg
BL	224^{bc}	33.2^{abc}	22.6^{b}	16.1^{bc}	1.05^{bc}	1.83^{ab}	0.44^{a}	<LOD^{a}	<LOD^{a}	0.0058^{a}
sd	13.1	1.9	2.47	0.82	0.10	0.20	0.02			0.0006
CF	79.5^{a}	7.76^{ab}	13.1^{ab}	4.19^{a}	0.88^{ab}	0.05^{ab}	0.63^{b}	<LOD^{a}	<LOD^{a}	0.0075^{b}
sd	3.55	0.45	1.03	0.22	0.09	0.01	0.04			0.0009
CS	245^{c}	31.6^{bc}	22.3^{b}	17.0^{c}	1.36^{c}	2.33^{b}	0.54^{ab}	0.36^{ab}	0.084^{b}	0.0068^{ab}
sd	11.8	2.06	1.25	0.80	0.15	0.03	0.03	0.02	0.005	0.0008
DE	133^{abc}	6.18^{a}	10.3^{a}	4.29^{ab}	0.66^{a}	0.05^{a}	0.42^{a}	<LOD^{a}	<LOD^{a}	0.0080^{b}
sd	6.58	0.34	0.56	0.22	0.07	0.007	0.02			0.0010
DU	81.6^{ab}	11.9^{abc}	12.0^{ab}	5.34^{abc}	0.77^{a}	0.05^{a}	0.63^{b}	<LOD^{a}	<LOD^{a}	0.0055^{a}
sd	3.85	0.58	0.64	0.28	0.07	0.01	0.03			0.0005
M	115^{abc}	48.4^{c}	11.9^{ab}	7.12^{abc}	0.82^{ab}	0.11^{ab}	0.52^{ab}	0.94^{b}	0.031^{ab}	0.0067^{ab}
sd	5.69	0.29	0.60	0.35	0.09	0.01	0.03	0.06	0.004	0.0005
ML								1.00*	0.10*	

Legend: BL - Blaufränkisch, DE - Devín, CF- Cabernet Franc, DU - Dunaj, M - Merlot, CS - Cabernet Sauvignon, sd- standard deviation (n=4), ML- maximum level
*Maximum level of Pb in other foodstuffs set by Ordinance No. 18558/2006-SL Coll., Maximum level of Cd in grape seed set by COMMISSION REGULATION (EU) 2023/915

Content of microelements and risk elements in grape pomace

The most abundant microelement in all analyzed samples was Fe. The total content of Fe ranged from 79.5 (Cabernet Franc) to 245 mg.kg^{-1} (Blaufränkisch). The total content of Cu ranged from 6.18 (Devín) to 48.4 mg.kg^{-1} (Merlot). The total content of Mn ranged from 10.3 (Devín) to 22.6 mg.kg^{-1} (Blaufränkisch). The total content of Zn ranged from 4.19 (Cabernet Franc) to 17.0 (Cabernet Sauvignon). The total content of Ni ranged from 0.66 (Devín) to 1.36 mg.kg^{-1} (Cabernet Sauvignon). The total content of Cr ranged from 0.05 (Cabernet Franc, Devín, Dunaj) to 2.33 (Cabernet Sauvignon). The total content of Co ranged from 0.42 (Devín) to 0.63 mg.kg^{-1}(Cabernet Franc). Pb and Cd were detected in the grape pomace of Merlot (0.94 mg.kg^{-1}, 0.03 mg.kg^{-1} respectively) and Cabernet Sauvignon (0.36 mg.kg^{-1}, 0.08 mg.kg^{-1} respectively). The total content of Hg ranged from 0.0055 (Dunaj) to 0.0080 mg.kg^{-1} (Devín). Statistical analysis of results showed that there are differences in the content of micronutrients among cultivars. Cultivars Blaufränkisch and Cabernet Sauvignon had the highest Fe, Mn, Zn, Ni, and Cr content, while cultivar Merlot had the highest content of Cu. On the other hand, grape pomace of cultivars Devín and Cabernet Frand had the highest content of Hg. **Šimko *et al*. (2019)** reported similar content of Fe (66.2 – 99.1 mg.kg^{-1}), Cu (11.7 – 15.4 mg.kg^{-1}), Mn (11.0 – 14.0 mg.kg^{-1}), and Zn (14.3 – 32.0 mg.kg^{-1}) in grape pomace of Pinot Blanc from different localities in Slovakia. **Chikwanha *et al*. (2018)** reported similar levels of Fe (78.9 – 147 mg.kg^{-1}), Cu (6.75 – 13.4 mg.kg^{-1}), Mn (14.2 – 18.5 mg.kg^{-1}), and Zn (6.9 – 19.2 mg.kg^{-1}) in grape pomace of three cultivars from South Africa. **Kolláthová *et al*. (2019)** reported similar levels of Fe (42.4 – 153 mg.kg^{-1}), Mn (7.11 – 17.8 mg.kg^{-1}), Cu (16.7 – 60.5 mg.kg^{-1}), and higher levels of Zn (18.9 – 41.3 mg.kg^{-1}) in grape pomace of three cultivars from Austria and Slovakia. **Corbin *et al*. (2015)** reported similar levels of Zn (15.0 mg.kg^{-1}), but lower levels of Fe (85.0 mg.kg^{-1}) in grape pomace from Cabernet Sauvignon. **Ziarati *et al*. (2017)** reported similar levels of Cu (48.7 mg .kg^{-1}), Mn (31.0 mg.kg^{-1}), Co (0.91 mg.kg^{-1}), and Cr (0,44 mg.kg^{-1}), but higher levels of Fe (460.2 mg.kg^{-1}), Zn (427.3 mg.kg^{-1}) in grape pomace of 5 different cultivars. **Tangolar *et al*. (2018)** reported lower content of Fe (13.9 – 19.6 mg.kg^{-1}), and similar content of Cu (5.2 – 18.4 mg.kg^{-1}), Mn (3.6 – 18.4 mg.kg^{-1}), and Zn (2.6 – 4.7 mg.kg^{-1}) in grape pomace of 6 different cultivars. In grape pomace of Cabernet Sauvignon, they reported lower content of Fe (18.9 mg.kg^{-1}), Cu (18.4 mg.kg^{-1}), Mn (10.9 mg.kg^{-1}), and Zn (4.7 mg.kg^{-1}). **Pereira *et al*. (2020)** reported similar content of Fe (86.6 – 215 mg.kg^{-1}), and a wider range of content of Zn (1.60 – 28.3 mg.kg^{-1}), similar and higher content of Cu (6.17 – 87.7 mg.kg^{-1}), Mn (19.1 – 84.1 mg.kg^{-1}), and higher content of Ni (3.75 mg.kg^{-1}), Cr (2.50 mg.kg^{-1}), Pb (5.00 mg.kg^{-1}) in grape pomace from eight cultivars. In Merlot, they reported similar content of Fe (119 mg.kg^{-1}), and higher content of Mn, Zn, Ni, Cr, and Pb (84.1, 13.8, 3.75, 2.50, and 5.00 mg.kg^{-1} respectively), but lower content of Cu and Hg (30.1 and 0.004 mg.kg-1 respectively). In Cabernet Sauvignon, they reported similar content of Mn and Cr (19.1 and 2.50 mg.kg^{-1} respectively) and higher content of Ni and Pb (3.75 and 5.00 mg.kg^{-1} respectively), but lower content of Fe, Cu, Zn, and Hg (161, 16.0, 11.6, and 0.004 mg.kg^{-1} respectively). **Sagdic *et al*. (2014)** reported similar average content of Fe (220 mg.kg-1), but higher content of Pb (9.25 – 32.0 mg.kg^{-1}) in grape pomace of 5 Turkish grape cultivars. The content of Zn, Cu, Cr, Co, and Cd were less than 5 mg.kg^{-1}.

In addition to genetic factors, variations in soil composition, climate, vineyard management practices, and other environmental factors can all contribute to differences in the content of minerals in grapes. Different soil types contain varying levels of minerals, which are absorbed by the grapevine roots and subsequently incorporated into the grapes **(Likar *et al*., 2015).** Environmental factors, such as air and water pollution, can introduce contaminants that may impact soil health and subsequently affect the composition of grapes **(Jimenéz-Ballesta *et al*.,2022).** Processing techniques, such as winemaking methods and storage conditions, can also affect the mineral content of grapes **(Shimizu *et al*., 2020).**

While there are no set limits regarding contaminants in grape pomace, European legislation sets the maximum levels of Cd in grape seeds at 0.10 mg.kg^{-1}, and Slovak legislation sets the maximum level of Pb in other foodstuffs at 1.00 mg.kg^{-1}. These levels were not exceeded. Considering that grape pomace would be used as an ingredient in relatively low concentrations, it would not pose a risk for consumers. However, it is important to monitor risk elements in materials and try to minimize the intake of these elements.

Table 3 Relationships between monitored parameters

Variables	K	Ca	P	Mg	Na	Fe	Cu	Mn	Zn	Ni	Cr	Co	Pb	Cd	Hg
K	**1**														
Ca	0.650	**1**													
P	0.293	0.586	**1**												
Mg	0.243	0.363	0.412	**1**											
Na	-0.109	-0.722	-0.370	0.198	**1**										
Fe	-0.378	-0.385	-0.448	**-0.980**	-0.254	**1**									
Cu	0.458	0.414	0.356	-0.567	-0.545	0.457	**1**								
Mn	-0.393	-0.074	-0.332	**-0.831**	-0.595	**0.900**	0.428	**1**							
Zn	-0.342	-0.130	-0.243	**-0.914**	-0.532	**0.951**	0.564	**0.971**	**1**						
Ni	-0.241	0.027	-0.197	-0.726	-0.623	0.811	0.435	**0.900**	**0.889**	**1**					
Cr	-0.424	-0.225	-0.351	**-0.898**	-0.463	**0.960**	0.428	**0.973**	**0.983**	**0.922**	**1**				
Co	0.087	0.618	0.552	0.636	-0.480	-0.525	-0.223	-0.203	-0.308	0.049	-0.277	**1**			
Pb	0.750	0.463	0.529	-0.172	-0.251	0.037	**0.816**	-0.075	0.093	0.124	-0.015	-0.017	**1**		
Cd	0.041	-0.034	0.077	-0.575	-0.314	0.596	0.514	0.497	0.603	0.782	0.631	0.054	0.529	**1**	
Hg	0.333	-0.315	-0.569	0.133	0.650	-0.168	-0.378	-0.392	-0.403	-0.230	-0.296	-0.230	-0.015	0.021	**1**

Legend: Values in bold are significant ($p < 0.05$)

Pearson correlation showed that the content of Ni positively correlated with the content of Mn and Zn, and the content of Cu positively correlated with the content of Pb. The contents of Fe, Mn, Zn, and Cr positively correlated with each other, on the other hand, the content of these elements correlated negatively with the content of Mg. **Pereira *et al*. (2020)** reported a positive correlation between the content of Cu and Fe, and between the content of Cu and Zn in grape pomace.

CONCLUSION

Our results suggest that the content of biogenic and risk elements in pomace grapes is variable depending on genetic factors. Grape pomace of cultivars Blaufränkisch and Cabernet Sauvignon could be characterized by the higher Fe, Mn, Zn, Ni, and Cr content, while grape pomace of cultivar Merlot by higher Mg content. With the increasing interest in the use of by-products of grape processing in food production, it is necessary to carry out further studies that can indicate the influence of cultivar, but also of locality and processing method, on the content of essential biogenic elements and, in particular, of hazardous risk elements. Grape pomace can serve as a good source of minerals, mainly K, in the human diet, with a relatively low content of risk elements. Including grape pomace in industrial food production could be a step toward the future of human nutrition and health.

Acknowledgments: This research was supported by the Slovak Research and Development Agency under grant No. APVV-22-0255

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