ASSESSMENT OF BIOACTIVE COMPOUNDS IN RED WINES AVAILABLE FOR PURCHASE IN LATVIA

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Moderate consumption of wine is associated with positive health effects. Red wine contains more polyphenolic compounds than white wine, so it is considered healthier. The aim of the study was to determine the concentration of bioactive compounds of red grape and berry wines available for purchase in Latvia. A selection of 15 red grape and berry wines purchased in Latvian supermarkets were analysed. The total phenol concentration was determined using the Folin-Ciocalteu spectrophotometric method with minor modifications. Total flavonoid concentration was determined using the colorimetric flavonoid determination method. Antiradical activity was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) reagent and ABTS (2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonate) radical cation determination method. The results show that the analysed red wine samples can be divided into five clusters according to the concentration of total phenols, flavonoids, and antiradical activity. Cluster 1 separately divided Latvian black chokeberry wine, with high total phenol concentration (TPC) and total flavonoid concentration (TFC), high antiradical activity via the DPPH method, and relatively low antiradical activity via ABTS method. Cluster 4 combined red wines with medium TPC, high TFC and high antiradical activity via both DPPH and ABTS methods, and included grape wines from different countries of origin. Cluster 5 combined red wines with high TPC, medium TFC, and medium antiradical activity via both DPPH and ABTS methods.

Keywords: black currant wine, phenolic compounds, antiradical activity.

INTRODUCTION

Wine is one of the most widely used alcoholic beverages in the world, especially in European countries and America. In recent years, wine, especially the red wine, is becoming more and more popular because of its sensory properties (taste, aroma) and chemical composition. Wine consumption in a moderate amount can positively influence human health — reduce coronary heart and atherosclerotic diseases risk (Corder *et al.*, 2015). Although excessive alcohol consumption can cause serious health problems, it has been concluded that moderate wine consumption can have the opposite effect by improving health (Bonello *et al.*, 2016). The recommended dose of wine for a healthy adult is 0.4 ml per kilogram of body weight, which is on average one (150 ml) to two (300 ml) glasses of wine per day (Bodnieks *et al.*, 2015). The positive health effects of wine are based on the action of polyphenolic compounds in wine, which are formed during red wine fermentation when grape juice is

fermented together with grape skins, grape seeds, and other grape fragments. It has been concluded that red wines contain at least ten times more polyphenolic compounds than white wines, so they are considered healthier. The total polyphenol concentration in red wines ranges from 2000 to 6000 mg·l⁻¹, depending on the variety. These polyphenolic compounds mainly provide the sensory properties (colour, bitter, and astringent taste, and aroma) of red wines but also inhibit the formation of free radicals in the human body and thus reduce the risk of diseases caused by oxidative stress (Bonello *et al.*, 2016; Garavaglia *et al.*, 2016; Chamizo-Gonzalez *et al.*, 2020).

Traditionally wine is made from white or red wine grapes, but nowadays it is made from non-traditional raw materials as well, such as berries and fruit. Berry and fruit wines are produced in many countries around the world: France, the United States, the United Kingdom, South Korea, and Latvia (Čakar *et al.*, 2016, Giri *et al.*, 2018). The main phenolic

compounds in chokeberries and black currants are anthocyanins, which give the berries their dark colour. Chokeberries contain cyanidin 3-galactoside, cyanidin 3-arabinoside, cyanidin 3-glycoside, and cyanidin 3-xyloside, as well as flavonols (quercetin 3-glycoside, quercetin 3-galactoside, quercetin 3-rutinoside, quercetin 3-robinobiose and quercetin 3-vicianoside, kaemferol) and phenolic acids, in particular chlorogenic acid (Sidor and Gramza-Michalowska, 2019). The main phenolic compounds in black currants are delphinidin 3-glycoside, delphinidin 3-rutinoside, cyanidin 3-rutinoside and cyanidin 3-glycoside (Cortez and Gonzalez de Mejia, 2019). Black currant and chokeberry berries are well recognised for their rich chemical composition, but so far the chemical composition and biological activity of black currant and chokeberry wines have been little studied in comparison with foreign grape wines.

Therefore, the aim of the current study was to determine the concentration of bioactive compounds of red grape and berry wines available for purchase in Latvia.

MATERIALS AND METHODS

Wine samples used in the study. Fifteen red grape and berry wines available for purchase in Latvian supermarkets were analysed in the study (Table 1). The study included local berry (black chokeberry and black currant) red wines as well as foreign red wines from well-known wine producing countries — Spain, France, Italy, Argentina, and Australia. All red wines analysed in the study were chosen according to the principles of accessibility and convenience. The main inclusion criteria were wine colour (only red wines were included in the study) and wine price (5.00 to 15.00 EUR per 0.75 l bottle), which are the main wine selection criteria for Latvian consumers (Legzdina and Straumite, 2020).

Determination of total phenol concentration. Total phenol concentration (TPC) of red wine samples was determined using the Folin-Ciocalteu spectrophotometric method (Lamuela-Raventos *et al.*, 1999) with minor modifications. Wine samples were diluted 1 : 50 with distilled water. 0.5 ml of diluted wine solution was mixed with 2.5 ml of Folin-Ciocalteu reagent, which was diluted 1 : 10 with distilled water. After 5 minutes, 2 ml of 7.5% Na₂CO₃ was added and mixed. Samples were kept at room temperature (22 ± 1 °C) for 30 min. Absorbance was determined at wavelength λ = 765 nm using a UV-VIS JENWAY 6300 spectrophotometer (Baroworld Scientific Ltd, United Kingdom). Total phenol concentration of the analysed wine samples was expressed as milligrams of gallic acid equivalent per 100 ml⁻¹ of wine (GAE mg · 100 ml⁻¹) using the gallic acid calibration curve. Measurements were done in triplicate for each wine sample.

Determination of total flavonoid concentration. Total flavonoid concentration (TFC) of analysed red wine samples was determined using the colorimetric flavonoid determination method (Chun *et al.*, 2003). Wine samples were diluted 1 : 50 with distilled water. 0.5 ml of diluted wine solution was mixed with 2 ml of distilled water and 0.15 ml 5% NaNO₂. After 5 minutes, 0.15 ml 10% anhydrous AlCl₃ was added to the mixture. After another 5 minutes, 1 ml of 1M NaOH was added, mixed and kept in the dark at room temperature (22 ± 1 °C) for 15 min. Absorbance was measured at wavelength λ = 415 nm using a UV-VIS JENWAY 6300 spectrophotometer (Baroworld Scientific Ltd, United Kingdom). Total flavonoid concentration of the analysed wine samples was expressed as milligrams of catechin equivalent per 100 ml⁻¹ of wine (CE mg per 100 ml⁻¹) using the catechin calibration curve. Measurements were done in triplicate for each wine sample.

Table 1. Characteristics of wine samples used in the study

Wine ID code	Wine producer	Raw material	Country of production	Alcohol content, %	Year of production	Type of packaging
AuCaS	Jacobs Creek	Cabernet Sauvignon Shiraz	Australia	13.9	2018	Glass bottle
FrMik	Lavel Blanc	Blend of wines from European Community countries	France	11.0	n.g.	Glass bottle
FrCar	J.P. Chenet	Carignan Shiraz Merlot Grenache	France	12.0	n.g.	Glass bottle
ItNdA	Barone Montalto	Nero d'Avola	Italy	13.5	n.g.	Glass bottle
ItPri	Casa Charlize	Primitivo	Italy	13.5	n.g.	Glass bottle
LvUp1	Dadzis	Black currant	Latvia	12.0	2019	Glass bottle
LvUp2	Durbes Veltes	Black currant	Latvia	12.0	2018	Glass bottle
LvUp3	Abava Winery	Black currant	Latvia	10.0	n.g.	Glass bottle
LvUp4	Aizpute Winery	Black currant	Latvia	12.0	2018	Glass bottle
LvAro	Zilver	Black chokeberry	Latvia	12.0	n.g.	Glass bottle
SpCaS1	Don Simon	Cabernet Sauvignon	Spain	12.0	n.g.	Tetra Pak
SpMer	Don Simon	Merlot	Spain	12.0	n.g.	Tetra Pak
SpCaS2	El Matador Tinto Tetra	Cabernet Sauvignon	Spain	11.0	n.g.	Tetra Pak
ArCaS	La Chamiza	Cabernet Sauvignon	Argentina	13.0	2008	Glass bottle
SpTem	Valdepalacios	Tempranillo Grenache	Spain	13.0	2006	Glass bottle

*n.g. information is not given by the wine producers

Determination of DPPH radical scavenging activity.

Antiradical activity of the analysed wine samples was determined using 2,2-diphenyl-1-picrylhydrazyl-(DPPH) reagent (Haley *et al.*, 2003). 0.5 ml of wine solution was mixed with 3.5 ml of DPPH methanol solution (0.004 g DPPH to 100 ml methanol) and kept in the dark at room temperature (22 ± 1 °C) for 30 min. Absorbance was measured at wavelength $\lambda = 517$ nm using a UV-VIS JENWAY 6300 spectrophotometer (Baroworld Scientific Ltd, United Kingdom). Antiradical activity of the analysed wine samples was expressed as milimoles of Trolox equivalent of 100 ml^{-1} of wine (TE mM 100 ml^{-1}) using the Trolox calibration curve. For each wine sample, three parallel dilutions with 1 : 50 distilled water were prepared and for each dilution three parallel measurements were repeated.

Determination of ABTS radical scavenging activity.

Antiradical activity of the analysed wine samples was determined using the method for the determination of 2,2-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) radical cation (Pannala *et al.*, 1999). Phosphate buffered saline (PBS) was obtained by dissolving 8.18 g NaCl, 0.27 g KH_2PO_4 , 1.42 g Na_2HPO_4 and 0.15 g KCl in 1 l of distilled water. For wine analysis, the ABTS solution was diluted with PBS to obtain the absorbance of 0.800 ± 0.030 at wavelength $\lambda = 734$ nm. For further analysis, 5 ml ABTS solution was mixed with the diluted wine solution. Absorbance was measured at wavelength $\lambda = 734$ nm using a UV-VIS JENWAY 6300 spectrophotometer (Baroworld Scientific Ltd, United Kingdom). Antiradical activity of the analysed wine samples was expressed as milimoles of Trolox equivalent of 100 ml^{-1} wine (TE mM 100 ml^{-1}) using the Trolox calibration curve. For each wine samples, three parallel dilutions with 1 : 50 distilled water were prepared and for each dilution, three parallel measurements were repeated.

Statistical analysis. Data mathematical processing was performed using statistical methods — arithmetic mean, standard deviation, and two-way analysis of variance (ANOVA) followed by Tukey's test using the software Microsoft Excel 2010. The analysis of hierarchical clusters, which can be used to classify data sets into subgroups or clusters, was performed using IBM SPSS Statistics version 17.0. For the interpretation of the results, it was assumed that $p = 0.05$ with 95% confidence.

RESULTS

Total phenol concentration (TPC) in the analysed wine samples is shown in Figure 1. TPC concentration ranged from 109.08 ± 10.17 GAE $\text{mg} \cdot 100 \text{ ml}^{-1}$ for sample FrMik (Lavel Blanc, France) to 348.66 ± 5.13 GAE $\text{mg} \cdot 100 \text{ ml}^{-1}$ for sample LvAro (Zilver, Latvia).

Total flavonoid concentration (TFC) in the analysed wine samples is shown in Figure 2. Total flavonoid concentration ranges from 95.42 ± 8.22 CE $\text{mg} \cdot 100 \text{ ml}^{-1}$ for sample LvUp4 (Aizpute Winery, Latvia) to 277.28 ± 18.61 CE

Fig. 1. Total phenol concentration in the analysed red wines samples.

AuCaS, Jacobs Creek; FrMik, Lavel Blanc; FrCar, J. P. Chenet; ItNdA, Barone Montalto; ItPri, Casa Charlize; LvUp1, Dadzis; LvUp2, Durbes Veltes; LvUp3, Abava Winery, LvUp4, Aizpute Winery; LvAro, Zilver; SpCaS1, Don Simon; SpMer, Don Simon; SpCaS2, El Matador Tinto Tetra; ArCaS, La Chamiza; SpTem, Valdepalacios

The same letters indicate that there not a significant difference between the values ($p > 0.05$).

Fig. 2. Total flavonoid concentration in the analysed red wines samples.

AuCaS, Jacobs Creek; FrMik, Lavel Blanc; FrCar, J. P. Chenet; ItNdA, Barone Montalto; ItPri, Casa Charlize; LvUp1, Dadzis; LvUp2, Durbes Veltes; LvUp3, Abava Winery, LvUp4, Aizpute Winery; LvAro, Zilver; SpCaS1, Don Simon; SpMer, Don Simon; SpCaS2, El Matador Tinto Tetra; ArCaS, La Chamiza; SpTem, Valdepalacios.

The same letters indicate that there not a significant difference between the values ($p > 0.05$).

$\text{mg} \cdot 100 \text{ ml}^{-1}$, 270.05 ± 11.91 CE $\text{mg} \cdot 100 \text{ ml}^{-1}$ for samples AuCaS (Jacobs Creek, Australia) and LvAro (Zilver, Latvia), $p > 0.05$.

Antiradical activity of the analysed wine samples was measured via DPPH and ABTS methods. The obtained antiradical activity data of the analysed wine samples is summarised in Table 2. Using the DPPH method, antiradical activity ranged from 9.61 ± 0.05 TE mM 100 ml^{-1} for sample LvUp4 (Aizpute Winery, Latvia) to 21.27 ± 0.63 TE mM 100 ml^{-1} and 20.79 ± 0.31 TE 100 ml^{-1} for samples LvAro (Zilver, Latvia) and ItPri (Casa Charlize, Italy). Us-

Table 2. Antiradical activity of analysed red wines samples

Wine code	Antiradical activity	
	DPPH TE mM·100 ml ⁻¹	ABTS TE mM·100 ml ⁻¹
AuCaS	19.29 ± 0.25 c	33.95 ± 1.81 b
FrMik	20.33 ± 0.24 b	29.66 ± 1.22 c
FrCar	19.63 ± 0.06 bc	39.35 ± 1.06 a
ItNdA	18.77 ± 0.11 d	34.18 ± 1.93 b
ItPri	20.79 ± 0.31 ab	42.96 ± 1.09 a
LvUp1	11.21 ± 0.25 g	28.98 ± 1.54 c
LvUp2	16.83 ± 0.28 e	30.06 ± 1.47 bc
LvUp3	13.51 ± 0.11 f	32.76 ± 2.67 b
LvUp4	9.61 ± 0.05 h	25.69 ± 0.96 d
LvAro	21.27 ± 0.63 a	12.15 ± 0.83 e
SpCaS1	16.99 ± 0.49 e	6.79 ± 0.93 f
SpMer	19.22 ± 0.30 c	7.61 ± 1.54 f
SpCaS2	14.36 ± 0.34 f	12.15 ± 1.08 e
ArCaS	18.04 ± 0.35 d	8.02 ± 0.69 f
SpTem	19.08 ± 0.24 c	10.74 ± 0.86 e

AuCaS, Jacobs Creek; FrMik, Lavel Blanc; FrCar, J. P. Chenet; ItNdA, Barone Montalto; ItPri, Casa Charlize; LvUp1, Dadzis; LvUp2, Durbes Veltes; LvUp3, Abava Winery; LvUp4, Aizpute Winery; LvAro, Zilver; SpCaS1, Don Simon; SpMer, Don Simon; SpCaS2, El Matador Tinto Tetra; ArCaS, La Chamiza; SpTem, Valdepalacios

The highest and lowest antiradical activity values via both DPPH and ABTS methods are highlighted in bold. The same letters indicate that there not a significant difference between the values ($p > 0.05$).

ing the ABTS method, samples ItPri (Casa Charlize, Italy) and FrCar (J.P. Chenet France) showed the highest antiradical activity — 42.96 ± 1.09 TE mM·100 ml⁻¹, 39.35 ± 1.06 TE mM·100 ml⁻¹, while samples SpCaS1 (Don Simon, Spain), SpMer (Don Simon, Spain) and ArCaS (La Chamiza, Argentina) show the lowest antiradical activity, i.e., 6.79 ± 1.93 TE mM·100 ml⁻¹, 7.61 ± 1.54 TE mM·100 ml⁻¹ and 8.02 ± 0.69 TE mM·100 ml⁻¹, $p > 0.05$.

Cluster analysis (see Figure 3) divided the red wine samples into five clusters according to the concentration of total phenols, flavonoids, and antiradical activity.

Cluster 1 included red wine with high TPC (348.66 ± 5.13 GAE mg·100 ml⁻¹) and TFC (270.05 ± 11.91 CE mg·100 ml⁻¹), high antiradical activity via DPPH method (21.27 ± 0.63 TE mM·100 ml⁻¹), and relatively low antiradical activity via ABTS method (12.15 ± 0.83 TE mM·100 ml⁻¹) — sample LvAro.

Cluster 2 contained red wines with low TPC (109.08 ± 10.17 GAE mg·100 ml⁻¹), average TFC (177.13 ± 15.25 CE mg·100 ml⁻¹) and average antiradical activity via both DPPH (20.33 ± 0.24 TE mM·100 ml⁻¹), and ABTS (29.66 ± 1.22 TE mM·100 ml⁻¹) methods — sample FrMik.

Cluster 3 combined red wines with low TPC ranging from 132.43 ± 7.51 to 182.53 ± 2.70 GAE mg·100 ml⁻¹, low TFC ranging from 95.42 ± 8.22 to 134.03 ± 14.01 CE mg·100 ml⁻¹, low antiradical activity via DPPH method ranging from 9.61 ± 0.05 to 16.83 ± 0.28 TE mM·100 ml⁻¹ and me-

Fig. 3. Analysis of clusters of TPC, TFC and antiradical activity.

AuCaS, Jacobs Creek; FrMik, Lavel Blanc; FrCar, J. P. Chenet; ItNdA, Barone Montalto; ItPri, Casa Charlize; LvUp1, Dadzis; LvUp2, Durbes Veltes; LvUp3, Abava Winery; LvUp4, Aizpute Winery; LvAro, Zilver; SpCaS1, Don Simon; SpMer, Don Simon; SpCaS2, El Matador Tinto Tetra; ArCaS, La Chamiza; SpTem, Valdepalacios.

dium antiradical activity via ABTS method ranging from 12.15 ± 1.08 to 30.06 ± 1.47 TE mM·100 ml⁻¹ (samples LvUp1, LvUp2, LvUp4, and SpCaS2).

Cluster 4 included red wines with medium TPC ranging from 194.00 ± 9.77 to 219.38 ± 10.71 GAE mg·100 ml⁻¹, high TFC ranging from 208.52 ± 16.44 to 277.28 ± 18.61 CE mg·100 ml⁻¹ and high antiradical activity via DPPH method ranging from 18.77 ± 0.11 to 20.79 ± 0.31 TE mM·100 ml⁻¹ and ABTS method ranging from 33.95 ± 1.81 to 42.96 ± 1.09 TE mM·100 ml⁻¹ (samples AuCaS, FrCar, ItNdA, ItPri).

Cluster 5 contained red wines with high TPC (200.96 ± 10.11 – 274.66 ± 4.77 GAE mg·100 ml⁻¹), medium TFC (143.99 ± 13.87 – 195.57 ± 19.35 CE mg·100 ml⁻¹), and medium antiradical activity via both DPPH (13.51 ± 0.11 – 19.22 ± 0.30 TE mM·100 ml⁻¹) and ABTS (6.79 ± 0.93 – 32.76 ± 2.67 TE mM·100 ml⁻¹) methods (samples ArCaS, SpTem, SpMer, SpCaS1, and LvUp3).

DISCUSSION

The highest TPC among analysed red wine samples was found in the Latvian chokeberry wine sample LvAro (Zilver, Latvia) — 348.66 ± 5.13 GAE mg·100 ml⁻¹ (Fig. 3). This level is higher than determined in the studies of other authors. Čakar *et al.* (2016) concluded that, depending on production technology used, total phenol concentration in chokeberry wines can range from 233.09 ± 1.25 GAE mg·100 ml⁻¹ to 241.46 ± 0.98 GAE mg·100 ml⁻¹, whereas Czarniecki *et al.* (2011) concluded that TPC in chokeberry wine is 319.89 ± 21.69 GAE mg·100 ml⁻¹. These studies also concluded that chokeberry wine contains the highest concentrations of most phenolic compounds among ana-

lysed berry (raspberry, white and red grape, blackberry, blueberry, chokeberry, sour cherry) and fruit (apple) wines, which are in line with the results of this study. The lowest concentration of TPC (109.08 ± 10.17 GAE mg·100 ml⁻¹) was found in the sample FrMik (Lavel Blanc, France) prepared from wines from unknown raw material from European Community countries. Latvian berry (blackcurrant and black chokeberry) wines are produced in private wineries in Durbe (Dadzis and Durbes veltes — black currant wines), Aizpute (Aizpute winery black currant wine), Sigulda region (Zilver — black chokeberry wine) and Tukums region (Abava winery — black currant wine). The Latvian berry wines are made from berry juice, sugar, and water. In order to ensure the expressiveness of the taste of berry wines, only ripe and high-quality raw materials are used in the production. No dyes, preservatives, flavourings or other fruit and berry additives are added to the wines during the production process. Wines contain sulphites naturally occurring during fermentation. To produce black currant wines, Latvian winemakers choose blackcurrant varieties 'Titania' and 'Zagadka', because they are productive, suitable for processing with a pronounced sweet and sour taste, and are resistant to various plant diseases. The chokeberry wine analysed in the study was made from black chokeberry (*Aronia melanocarpa*). The obtained results showed that the wines from black currant compared with red grape wines do not have a high concentration of biologically active compounds. Relatively low TPC (132.43 ± 7.51 GAE mg·100 ml⁻¹) was also found in the black currant wine sample LvUp4 (Aizpute winery, Latvia). Previous studies found that phenolic compound concentration in black currant wine was 201.36 GAE mg·100 ml⁻¹ (Curko *et al.*, 2016) and 145.75–150.90 GAE mg·100 ml⁻¹ (Ekholm *et al.*, 2013; Punbusayakul, 2018). This means that the obtained results for the sample LvUp4 are 1.1 to 1.5 times lower than in the studies mentioned above. The other analysed black currant wine samples showed higher total phenol concentration. The observed differences in total phenols can be explained by possible differences in berry variety, year of harvest, climate conditions, environmental factors, degree of ripeness of berries at harvest, oenological practises used and storage conditions (Chankvetadze *et al.*, 2018).

The highest total flavonoid concentration was found for samples AuCaS (Jacobs Creek, Australia) and LvAro (Zilver, Latvia) — 277.28 ± 18.61 CE mg·100 ml⁻¹ and 270.05 ± 11.91 CE mg·100 ml⁻¹, respectively (Fig. 2), $p > 0.05$. Sample AuCaS was made from Cabernet Sauvignon and Shiraz grapes with a high concentration of flavonoids. Flavonoid compound concentration of Cabernet Sauvignon wine may range between 85.99 ± 5.55 CE mg·100 ml⁻¹ to 229.03 ± 15.72 CE mg·100 ml⁻¹ (Jiang and Zhang, 2012) and for Shiraz grape wines — 94.12 ± 8.76 – 114.02 ± 3.50 CE mg·100 ml⁻¹ (Escudero-Gilete *et al.*, 2016). The concentration of total flavonoids in the AuCaS sample obtained in the study is higher than in the studies of the mentioned authors, which is likely because AuCaS is a mixed wine. Sample LvAro was obtained from chokeberries, which contain total flavonoids at concentration 219.30 ± 8.60 CE mg·100

ml⁻¹ to 438.40 ± 51.70 CE mg·100 ml⁻¹, depending on the variety (Jurčević *et al.*, 2015). This agrees with the observed concentration in LvAro wine (270.05 ± 11.91 CE mg·100 ml⁻¹). The lowest concentration of total flavonoids was found for sample LvUp4 (Aizpute Winery, Latvia) — 95.42 ± 8.22 CE mg·100 ml⁻¹. A similar total flavonoid concentration (88.90 ± 1.63 to 97.51 ± 1.29 CE mg·100 ml⁻¹) in blackcurrant wine was observed by Kostic *et al.* (2011), while Ayvaz *et al.* (2015) found that black currant wine may contain up to 142.52 CE mg·100 ml⁻¹. The other black currant wines studied (LvUp1, LvUp2, LvUp3, $p < 0.05$) contained a higher concentration of total flavonoids than sample LvUp4, which agrees with the results of Ayvaz *et al.* (2015). The observed differences in total flavonoid concentration can also be explained by possible differences in berry variety, year of harvest, climate conditions, environmental factors, degree of ripeness of berries at harvest, oenological practises used, and storage conditions (Chankvetadze *et al.*, 2018).

The highest antiradical activity via DPPH method was found for samples LvAro (Zilver, Latvia) and ItPri (Casa Charlize, Italy) — 21.27 ± 0.63 TE mM·100 ml⁻¹ and 20.79 ± 0.31 TE mM·100 ml⁻¹, respectively (Table 2). The obtained results are in agreement with previous studies on chokecherry wine and other products: from 12.09 ± 0.93 to 40.19 ± 2.13 TE mM·100 ml⁻¹ (Jurčević *et al.*, 2015; Jakobek *et al.*, 2007). The lowest antiradical activity via DPPH method was found for the sample LvUp4 (Aizpute Winery, Latvia) — 9.61 ± 0.05 TE mM·100 ml⁻¹, while the other black currant wines had even higher antiradical activity ranging from 11.21 ± 0.25 to 16.83 ± 0.28 TE mM·100 ml⁻¹, which is significantly higher than that of the black currant wine analysed in another study (Punbusayakul, 2018) — 6.91 ± 0.46 TE mM·100 ml⁻¹. The differences between the results can be explained by differences in climatic conditions, oenological practices, or blackcurrant varieties (Chankvetadze *et al.*, 2018).

In contrast, the highest antiradical activity via ABTS method was found for samples ItPri (Casa Charlize, Italy) and FrCar (J. P. Chenet, France) — 42.96 ± 1.09 TE mM·100 ml⁻¹ and 39.35 ± 1.06 TE mM·100 ml⁻¹, respectively. The obtained results agree with previous studies (Faccia *et al.*, 2016; Carluccio *et al.*, 2019) studies on Primitivo wine using the same method: up to 64.60 ± 1.10 TE mM·100 ml⁻¹ depending on the oenological practises used. The lowest antiradical activity via ABTS method was found for samples SpCaS1 (Don Simon, Spain), SpMer (Don Simon, Spain) and ArCaS (La Chamiza, Argentina) — 6.79 ± 1.93 TE mM·100 ml⁻¹, 7.61 ± 1.54 TE mM·100 ml⁻¹ and 8.02 ± 0.69 TE mM·100 ml⁻¹, respectively. De Beer *et al.* (2003) and Carranza-Concha *et al.* (2017) also concluded that Cabernet and Merlot wines have low antiradical activity (via ABTS method) — 10.90 to 13.18 mM TE·100 ml⁻¹. The low antiradical activity of ArCaS can be explained by wine aging, which contributed to the reduction of polyphenolic compounds in wine, as it was produced in 2008.

CONCLUSIONS

The results indicated that the analysed red grape and berry wines available for purchase in Latvia differ in the composition of bioactive compounds. The cluster analyses showed that black chokeberry wine (LvAro) was separated from the rest, and it has high TPC, TFC, and DPPH activity. Red grape wines from different origins as Australia (AuCaS), France (FrCar), and Italy (ItNdA, ItPri) were also separated in a cluster characteristic with high TFC and antioxidant activity.

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BIOLOĢISKI AKTĪVO VIELU ANALĪZE LATVIJĀ NOPĒRKAMOS SARKANVĪNOS

Vīns ir viens no pasaulē biežāk lietotajiem alkoholiskajiem dzērieniem. Kaut arī pārmērīga alkoholisko dzērienu lietošana var izraisīt nopietnas veselības problēmas, ir secināts, ka vīna mērena lietošana var veselību uzlabot. Vīna pozitīvā ietekme uz veselību tiek pamatota ar tā sastāvā esošo antioksidantu — polifenolu savienojumu — darbību. Sarkanvīns satur vairāk polifenolu savienojumu nekā baltvīns, tāpēc to uzskata par veselīgāku. Pētījuma mērķis bija analizēt Latvijā nopērkamo sarkanvīnu kopējo fenolu, kopējo flavonoīdu saturu un antiradikālo aktivitāti. Pētījumā analizēti 15 Latvijas lielveikalos iegādājami vīnogu un ogu sarkanvīni. Kopējais fenolu saturs noteikts, izmantojot *Folin-Ciocalteu* spektrofotometrisko metodi ar nelielām izmaiņām. Kopējais flavonoīdu saturs noteikts, izmantojot kolorimetrisko flavonoīdu noteikšanas metodi. Antiradikālā aktivitāte noteikta, izmantojot DPPH reaģentu un ABTS radikāļu katjonu noteikšanas metodi. Iegūtie rezultāti rāda, ka visus analizētos sarkanvīnu paraugus pēc kopējo fenolu un kopējo flavonoīdu satura un antiradikālās aktivitātes var iedalīt piecos klasteros. 1. klasteri atsevišķi izdalīts paraugs LvAro, tas ir, Latvijas aroniju vīns, ar augstu kopējo fenolu un kopējo flavonoīdu saturu un antiradikālo aktivitāti, noteiktu ar DPPH metodi, bet salīdzinoši zemu antiradikālo aktivitāti, nosakot ar ABTS metodi. 4. klasteris apvieno dažādu valstu vīnogu vīnus ar vidēju kopējo fenolu saturu, augstu kopējo flavonoīdu saturu un augstu antiradikālo aktivitāti, noteiktu gan ar DPPH, gan ABTS metodi (paraugi AuCaS, FrCar, ItndA, ItPri). 5. klasteris apvieno sarkanvīnus ar augstu kopējo fenolu un vidēju kopējo flavonoīdu saturu, vidēju antiradikālo aktivitāti, noteiktu gan ar DPPH, gan ABTS metodi (paraugi ArCaS, SpTem, SpMer, SpCaS1, LvUp3).