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Radmila PAJOVIĆ-ŠĆEPANOVIĆ, Sanja SAVKOVIĆ, Danijela RAIČEVIĆ, Tatjana POPOVIĆ [1]

CHARACTERISTICS OF THE MONTENEGRIN ROSE WINE

SUMMARY

Rose wine production and its consumption in Montenegro have become more intense in recent years. This paper presents results of rose wine quality analyses in vintages 2014, 2015 and 2016 with the aim to perform characterization of these wines in Montenegro. Chemical and polyphenolic composition of wine were analysed, as well as the influence of vintage on wine quality. The composition of grape varieties used for producing wines was examined, as well.

When it comes to composition by grape variety, the analysis showed that most producers use international varieties for production of rose wines: Cabernet Sauvignon (the most frequent), Grenache, Marselan and Cabernet Franc. One producer uses exclusively the indigenous variety Vranac, and one uses a coupage of Vranac and Grenache for production of rose wines.

Chemical analyses of rose wines in the reference three-year period have shown that most parameters varied significantly, apart from density and volatile acids that were stable. The average parameters of the chemical composition of rose wine are as follows: alcohol 13.1vol%, total extracts 22.9 g/l, total acidity, 6.3 g/l, pH 3.28, the volatile acidity of 0.5g/l, and total SO2 of 109.4 mg/l. The chemical composition of the tested wines was significantly affected by the vintage. Namely, in 2014, wines had lower alcohol content, a higher total acid content and a lower pH value, while in 2015 and in 2016, alcohol content was higher, the total acid content was lower and consistent for these two vintages, while pH value was higher.

The results obtained from the investigation of the polyphenol composition showed that the total phenol content, the phenol index and the anthocyanin content varies statistically significantly among the examined wines and the average values amounted to 267 mg/l, 12.9 and 37.6 mg/l respectively.

Keywords: chemical composition, phenols composition, vintage

INTRODUCTION

The rose wine production has a growing trend and accounted for 10% of world wine production in 2011. The increase in rose wine consumption is recorded on the global wine market, especially in the United States and in France

[1]Radmila Pajović-Šćepanović (corresponding author: radapa@t-com.me), Danijela Raičević, Tatjana Popović, Sanja Savković University of Montengro, Biotechnical faculty, Podgorica, MONTENEGRO.

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(Blot and Couderc, 2013). In the last decade, Montenegro experienced an increase in the number of producers and the number of wine types produced. According to the available data, in 2012, the total production of rose wines amounted to 3.3% of the total production of wine (Pajović et al. 2016). However, over the last few years, there has been a significant increase in the production of rose wines and in their consumption in Montenegro.

The composition of rose wine (chemical, polyphenolic and aromatic composition) depends on rose wines production technology, as well as on the composition of the grape variety used for wine production. Among the most important wine grape varieties, the most suitable for production of quality wine is an international variety – Cabernet Sauvignon. It is suitable for the production of rose wine as monovarietal grape with typical pink colour, good acidity and lingering note of rose. However, each country should find its own style in production of rose wines that should be mostly based on coupage of some autochthonous varieties, or on their mix with some international varieties.

In the past, production of rose wines was based on only one type of rose and that was "Montenegrin quality wine Rose". Its characteristics were described by Pejovic (1987). He stated that this wine belonged to the light, fresh wines (lower alcohol content); it had balanced and harmonious taste and its colour tone was somewhat more intense - adjusted to the taste of that time consumers. Production of this rose was mosltly based on indigenous Montenegrin varieties. Recent researches of rose wines in Montenegro, however, indicate that rose wine have a higher content of alcohol and total acids, and more intense aromatic properties with noted differences in style among producers (Pajović et al. 2016).

Since the production and consumption of rose wines in Montenegro is becoming more intense, with this study we wanted to investigate the quality of a number of rose wines in vintages 2014, 2015 and 2016. In this study, the chemical composition of wine, the impact of the harvest on wine quality and polyphenolic composition of Montenegrin rose wines were analysed, while the special attention is given to composition of grape varieties used for producing rose wines, with the aim to perform characterization of rose wine produced in Montenegro.

MATERIAL AND METHOD

This paper analyses eight rose wines from seven different wine producers during the three vintages - 2014, 2015 and 2016. Seven dry and one semi-sweet rose wine were examined. Table 1 presents data on wine labels, wine names, names of wineries/producers, composition of grape varieties used for producing wines, locality/ sub-region /region from which the grapes come from.

Material

Table 1 shows that the majority of producers use international varieties such as: Cabernet Sauvignon (the most frequent), Grenache, Marselan, Cabernet Franc and Sangiovesse. Only one producer uses solely the indigenous grape

variety of Vranac, while "13.jul - Plantaže" predominantly use the coupage of Vranac and Grenache.

As regards the origin of the raw materials, Table 1 shows that the grapes used for wine production come from Montenegrin region of Skadar Lake, mostly from Sub-region Podgorica (3, 4, 6); Sub-region Piperi (1 and 2); Sub-region Katunski (7); Sub-region Crmnica (8) and only one producer comes from Montenegrin Costal region and that is from the Sub-region of Boka Kotorska (5).

Table 1: Data about analysed Rose wines

Nb	Wine	Winery/ Producer	Grape varieties used for producing wines	Locality/ Subregion/ Region
1.	Arhonto Rose	Krgović	Cabernet Sauvignon, Sangiovesse	Rogami, Podgorica Sub-region Piperi, Montenegrin region of Skadar Lake
2.	Zenta-Rose	Vučinić	Cabernet Sauvignon	Rogami, Podgorica Sub-region Piperi, Montenegrin region of Skadar Lake
3.	Crnogorski rose	13. jul Plantaže	Vranac, Grenache	Ćemovsko polje, Podgorica Sub-region Podgorica, Montenegrin region of Skadar Lake
4.	Moje vino roze	13. jul Plantaže	Vranac, Grenache	Ćemovsko polje, Podgorica Sub-region Podgorica, Montenegrin region of Skadar Lake
5.	Savina Rose	Castel Savina	Grenache	Meljine, Herceg Novi, Sub-region Boka kotorska, Montenegrin Costal region
6.	Monte-Grande rose	Monte Grande	Cabernet Sauvignon	Zeta, Podgorica Sub-region Podgorica, Montenegrin region of Skadar Lake
7.	Harmonia	Ravil	Vranac	Zagarač, Danilovgrad, Sub-region Katunski, Montenegrin region of Skadar Lake
8.	Buk rose	Winery Buk	Marselan, Cabernet Sauvignon, Cabernet. franc	Crmnica, Bar, Subregion Crmnica, Montenegrin region of Skadar Lake

Method of work

Analyses were carried out in oenological laboratories of Biotechnical Faculty. Wines were the representative samples.

Physicochemical analyses

The following parameters of physicochemical composition of wine were tested: density, alcohol, extract, total acids, pH, volatile acids and residual sugar

in wine. The analyses were performed in accordance with compendium of international methods of wine and must analyses (OIV, 2011).

Spectrophotometrical analyses

The analyses of the flavonoids were done by spectrophotometric methods (Di Stefano at al. 1989) carried out under optimized conditions for red wine analysis (Rigo at al. 2000) with the use of spectrophotometer Varian Cary 100 Bio UV-Visible (Bio Tech, Maryland, United States). Total Phenols were assessed by the method of Folin-Ciocalteu. Concentrations were determined by means of a calibration curve as (+)-catechin in mg/kg of grape or mg/L of wine.

Total anthocyanins were determined on the basis of maximal absorbance in the visible range (536-542 nm). They were quantified in mg kg-1 FW by assuming an average absorbance of the mixture of anthocyanins extracted from grape Cabernet Sauvignon (average MW =500 Da, ε = 18800 M-1 cm-1 in 70:30:1 ethanol:water:HCl solution).

Index of 280 is method for determination of total phenols based on direct reading of absorbance μ=280nm after diluting wine samples with water 1:10 (Ribereau-Gayon et al. 1982).

Data analysis

In order to establish the significance of differences between examined wines and their interaction for each studied parameter, a two factorial analysis of variance (ANOVA) was applied. For those parameters and factors where significant differences were detected, additionally an LSD test was applied to the significance level of $p<0.05$. Analysis of the experimental data was performed using the statistical package IBM SPSS Statistics 20.

RESULTS AND DISCUSSION

Chemical composition of red wines

Table 2 shows the chemical composition of the tested wines (1-8), per vintage (2014, 2015 and 2016), as well as the three-year average values of the analysed parameters.

Table 2 shows that density of rose wines, in a three-year period, had similar values without significant statistical difference, ranging in the expected frame of 0.9900 to 0.9920 for dry wines, while the density of semi-sweet wine was 0.9970. The average content of alcohol in a three-year period significantly varied, and in the majority of wines (six out of eight) amounted to about 13 vol%, that is from 13.1 vol% (wine 5) to 13.9 vol% (wine 1). The extract content in rose wines also varied from 19.2 g/l (wine7) to 24.3g/l (wine 2) for dry wines.

The parameters which define the acidity condition of wine - total acid content and pH value significantly varied among the tested wines, observed as a three-year average.

Table 2: Chemical composition of Montenegrin rose wines (1-8) in three vintage and averages values of parameters (mean values ±SD)

		Density	Alc. vol%	Total extracts g/l	Total acidity g/l	pH	Volatile acidity g/l	Total SO_2 mg/l	Residual sugar g/l
1	2014	0.9900	13.6	19.8	6.0	3.33	0.6	169.7	1.9
	2015	0.9900	14.2	24.2	6.0	3.26	0.6	120.0	2.4
	2016	0.9900	13.9	20.9	5.0	3.42	0.6	140.9	2.6
	mean	**0.9900^{AC}**	**13.9±0.3^{A}**	**21.6±2.3^{A}**	**5.6±0.6^{A}**	**3.36±0.08^{A}**	**0.6±0.1^{AB}**	**143.5±27.1^{A}**	**2.3±0.6^{A}**
2	2014	0.9945	12.6	36.1	7.1	3.25	0.7	97.3	3.5
	2015	0.9920	14.0	26.3	6.2	3.28	0.7	126.7	1.7
	2016	0.9900	13.5	19.6	6.8	2.42	0.7	103.4	1.6
	mean	**0.9920^{B}**	**13.4±0.7^{BC}**	**24.3±3.7^{A}**	**6.7±0.5^{B}**	**3.31±0.13^{AB}**	**0.7±0.1^{B}**	**109.1±14.7^{B}**	**2.2±0.9^{A}**
3	2014	0.9920	12.5	21.6	6.8	3.01	0.4	106.8	2.8
	2015	0.9890	12.9	15.4	6.1	3.30	0.4	85.7	2.1
	2016	0.9924	12.5	22.9	5.9	3.16	0.3	55.7	2.1
	mean	**0.9910^{AB}**	**12.6±0.3^{D}**	**20.0±3.5^{A}**	**6.3±0.5^{C}**	**3.16±0.18^{CD}**	**0.4±0.1^{C}**	**82.7±23.5^{C}**	**2.3±0.5^{A}**
4	2014	0.9970	11.0	30.2	6.7	3.30	0.5	193.8	10.0
	2015	0.9970	11.6	29.4	5.6	3.67	0.8	181.0	19.1
	2016	0.9960	11.8	39.3	4.5	3.68	0.4	82.2	15.0
	mean	**0.9970^{C}**	**11.5±0.4^{E}**	**33.0±5.5^{D}**	**5.6±1.0^{A}**	**3.55±0.22^{E}**	**0.5±0.3^{AB}**	**152.4±54.1^{A}**	**14.6±4.3^{B}**
5	2014	0.9915	12.3	19.8	7.1	3.07	0.6	118.8	2.6
	2015	0.9900	13.5	19.6	6.8	3.09	0.5	85.3	2.8
	2016	0.9915	13.5	23.5	6.6	3.06	0.4	87.9	2.6
	mean	**0.9910^{AB}**	**13.1±0.6^{B}**	**21.0±2.1^{AC}**	**6.8±0.3^{B}**	**3.07±0.05^{D}**	**0.5±0.1^{AC}**	**97.3±16.3^{D}**	**2.6±0.4^{AC}**
6	2014	0.9920	12.9	22.9	6.6	3.26	0.8	103.1	2.9
	2015	0.9910	13.7	22.9	6.2	3.35	0.7	86.6	2.6
	2016	0.9910	13.7	22.7	6.4	3.07	0.5	109.9	2.0
	mean	**0.9910^{AB}**	**13.4±0.5^{C}**	**22.8±5.6^{AB}**	**6.4±0.3^{C}**	**3.22±0.15^{B}**	**0.7±0.2^{B}**	**99.9±12.8^{BD}**	**2.5±0.5^{AC}**
7	2014	0.9910	12.9	20.1	7.0	3.30	0.6	103.4	3.5
	2015	0.9900	13.4	19.3	6.6	3.41	0.5	104.7	3.4
	2016	0.9910	13.7	18.3	6.6	3.47	0.6	98.3	3.0
	mean	**0.9910^{AB}**	**13.3±0.5^{BC}**	**19.2±1.1^{CB}**	**6.7±0.2^{B}**	**3.39±0.10^{A}**	**0.5±0.1^{B}**	**102±4.1^{BD}**	**3.2±0.5^{C}**
8	2014	0.9900	12.6	20.1	6.3	3.13	0.6	86.6	2.6
	2015	0.9900	14.1	21.4	5.7	3.23	0.5	86.6	2.7
	2016	0.9910	13.40	21.90	6.15	3.19	0.4	91.8	2.3
	mean	**0.9900^{A}**	**13.4±0.7^{BC}**	**21.3±1.3^{AC}**	**6.1±0.4^{C}**	**3.18±0.08^{C}**	**0.5±0.1^{AC}**	**88.3±5.8^{C}**	**2.5±0.3^{AC}**

Different capital subscript letters indicate significantly different means ($p < 0.05$) for average values of three years examined wines

The values ranged from 5.6 g/l and 3.55 (wine 4) to 6.8 g/l and 3.07 (wine 5). The volatile acids were low and uniform among the analysed wines. The three-year average value ranged from 0.4 g/l (wine 4) to 0.7 g/l (wine 6). The residual content of sugar differs statistically significantly and for most wines it was about 2 g/l for a three-year period, except for a semi-sweet wine 4, where the

values were expectedly higher. The greatest variation among the studied parameters of chemical composition was recorded in the total contents of the total SO_2 in wines. Namely, it ranged from 82.7 mg/l (wine 3) to 143.5 mg/l (wine 1) for dry wines, while a slightly higher value was recorded in a semi-sweet wine - 152.4 g/l.

Regarding the vintage, differences were found between the tested wines and they will be presented in the next chapter.

The influence of vintage on the chemical composition of the examined rose wines

The vintage examined in our study differ in weather conditions, which was reflected in the chemical composition of must, and therefore of wine. Popović et al., (2017) concluded that 2014 was unfavourable for grapes ripening due to heavy rainfall during the growing season which affected the chemical composition of must - acid content was significantly higher, while the sugar content was lower. On the other hand, the vintage 2015 and vintage 2016 had much favourable conditions for grapes maturing - higher mean annual and mean vegetation temperatures resulting in better chemical composition of must and wine.

Table 3 shows the average chemical composition of the examined wines in three tested vintage years: 2014, 2015 and 2016.

Table 3: Influence of vintage on the chemical composition of Montenegrin Rose wines (mean values ±SD)

	Density	**Alcohol vol%**	**Total extracts g/l**	**Total acidity g/l**	**pH**	**Volatile acidity g/l**	**Total SO_2 mg/l**	**Residual sugar g/l**
2014	0.9921^{A}	12.6 ± 0.7^{A}	22.7±4.7	6.9 ± 0.4^{A}	3.20 ± 0.13^{A}	0.6 ± 0.1^{A}	122.4 ± 37.7^{A}	3.7 ± 2.5^{AC}
2015	0.9911^{B}	13.4 ± 0.8^{B}	22.3±5.4	6.1 ± 0.5^{B}	3.32 ± 0.18^{B}	0.6 ± 0.1^{A}	109.6 ± 32.8^{B}	4.6 ± 5.6^{B}
2016	0.9916^{AB}	13.2 ± 0.7^{C}	23.6±6.4	6.0 ± 0.8^{B}	3.30 ± 0.24^{B}	0.5 ± 0.2^{B}	96.3 ± 24.6^{C}	3.9 ± 4.3^{C}

Different capital subscript letters indicate significantly different means ($p < 0.05$) for average values of examined wines among vintages

Table 3 shows that the density was lowest in 2015 and significantly different from the values found in the vintages 2015 and 2016. Alcohol content was significantly different in different vintages.The lowest alcohol content was recorded in 2014 and amounted to 12.6 vol%, while in the vintages 2015 and 2016, it was 13.4 vol% and 13.2 vol% respectively. The content of total extract had uniform values and did not differ in different vintages. The total acid content was highest in 2014 - 6.9 g/l and it was statistically significantly different from the values found in the vintages 2015 and 2016, where the content was lower and it was 6.1 g/l and 6.0 g/l. The pH value of the wine was also statistically significantly different in 2014. As expected, the value amounted to 3.20 and it was lower than the values recorded in other two vintages where there was no difference (3.30 and 3.32). Volatile acid was lowest in the wines produced in 2016 and it was 0.5 g/l, which is statistically significantly different from the values found in the vintages 2014 and 2015 reaching the value of 0.6 g/l. The

contents of total SO_2 were significantly different in different vintages. The highest value was recorded in 2014 - 122.4 mg/l; slightly lower value was found in 2015.- 109.6 mg/l, while the lowest value was recorded in 2016 and it amounted to 96.3 mg/l.

The foregoing data on the average chemical composition of wine are significantly distinct from the data provided by Pejović, (1987) - 11.5% by volume of alcohol, the total acid 5.3 g/l, who analysed the five-year average of rose wines in Montenegro. The reason for this is mainly a change in a style of the rose wines production. Pajović et al., (2016) report the following findings: average alcohol content of 13.3 vol%, total acid content of 6.0 g/l and a pH value of 3.20 for three vines observing them as a five-year and seven-year average. Our results, especially for the vintages 2015 and 2016, are completely compatible with these values, confirming the fact that in recent years a change of style in the production of rose wines is moving towards higher alcohol content and higher acid content.

Polyphenolic composition of the examined rose wines

The paper also examined the content of phenolic compounds in rose wines and the content of total polyphenols and anthocyanins in vintage 2016. The results are shown in table 4.

Table 4: Content of phenols in Montnegrian rose wines

	Total phenols (mg/l)	**Index 280**	**Total anthocyanins (mg/l)**
1	265.1 ±8.2 ^{A}	10.2±0.1 ^{A}	39.4±5.8 ^{A}
2	313.1±50.9 ^{C}	10.5±0.1 ^{AB}	40.6±4.3 ^{A}
3	209.4±18.0 ^{B}	8.9±0.6 ^{C}	22.3±2.1 ^{B}
4	356.6±13.7 ^{D}	33.2±1.1 ^{E}	24.1±3.1 ^{B}
5	200.5±17.2 ^{B}	8.8±0.2 ^{C}	40.1±0.3 ^{AD}
6	213.1±9.3 ^{B}	8.6±0.1 ^{C}	38.4±0.5 ^{A}
7	289.6±8.2 ^{AC}	11.0±0.3 ^{B}	50.5±1.6 ^{C}
8	291.2±8.6 ^{AC}	12.0±0.2 ^{D}	45.3±0.4 ^{D}
mean	**267.3±53.4**	**12.9±7.9**	**37.6±9.6**

Different capital subscript letters indicate significantly different means ($p < 0.05$)

The total content of polyphenols statistically quite varied among the examined wines and ranged from 200.5 mg/l (5 wine) to 356.6 mg/l (wine 4), while the average value amounted to 267.3 mg/l. The values obtained in our study are significantly lower than the value of 1304 mg/l reported by Minussi et al. (2003) for the rose wine made by coupage. These values are also lower than the one cited by Paixero et al. (2007) for a rose wine Tinta Negra Mole - 665 mg/l, but they are compatible with values specified by Zhu et al. (2012) for rose wine of north American *V. labrusca* Catawba, which amounted to 368.83 mg/l. As expected, the values of total phenols in the examined rose wines are lower than the values in red wines from Montenegrin region which ranged from 890 to 1600 mg/l in the vintage 2011 and 2012 (Pajović et al. 2014).

Phenol index values were low, ranging from 8.6 to 33.2, which was in proportion to total phenol content in each tested wine, determined by Folin-Ciocalteu method.

The content of anthocyanin in the examined Montenegrin wines ranged from 22.3 mg/l (wine 3) to 50.5 mg/l (7 wine), while the average value was 37.6 mg/l. The observed values are in accordance with the values of 36.1-53.2 mg/l reported by Suriano et al.2015 for the young rose wine Bambino Nero.

CONCLUSION

This paper presents an analysis of the following rose wines: "Arhonto Rose", "Zenta Rose", "Crnogorski rose", "Moje vino rose", "Savina Rose", "Monte-Grande Rose", "Harmonia" and "Buk Rose". All tested wines are dry, except one which is semi-sweet. The grape for production of these wines comes from Montenegrin region of Skadar Lake, mainly from Subregion Podgorica -3; Subregion Piperi - 2; Subregion Katunski -1; Subregion Crmnica -1, while one producer comes from Montenegrin Costal region and it is Subregion Boka Kotorska.

The results showed that the majority of producers use international varieties for production of rose wines: Cabernet Sauvignon (the most frequent), Grenache, Marselan, Cabernet. Cabernet Sauvignon (the most frequent), Grenache, Marselan, Cabernet Franc. One producer uses exclusively the indigenous variety Vranac, and only one uses a coupage of Vranac and Grenache for production of rose wines.

Chemical analysis of rose wine on a three-year average showed the following parameters: density of wine was balanced; the alcohol content significantly varied among wines, but averaged 13.1 vol%. The total acid content and pH values also significantly varied and they were on average 6.3 g/l and 3.28 respectively; extract content also varied and averaged 22.9 g/l; volatile acids were equal to the average value of 0.5 g/l; SO2 varied significantly, and it was 109.4 g/l, on average.

The chemical composition of the examined wines was influenced significantly by the vintage. Namely, in 2014, wines had a lower alcohol content, higher total acid content and lower pH value, while in 2015 and in 2016, alcohol content was higher, the total acid content was lower and consistent for these two vintages, while, proportionally to these values, pH value was higher.

The results of the investigation of the polyphenol composition showed that the total phenol content, the phenol index and the anthocyanins content varies statistically significantly among the tested wines and the average values are 267 mg/l, 12.9 and 37.6 mg/l respectively.

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