THE INFLUENCE OF VARIETY AND VINTAGE ON THE CHEMICAL COMPOSITION AND SENSORY PROPERTIES OF RED WINES IN PODGORICA SUBREGION (MONTENEGRO)

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Abstract

This paper presents the results of investigation of the influence of variety and vintage on the chemical composition and sensory properties of Vranac, Kratosija and Cabernet Sauvignon wines in Podgorica subregion (Montenegro) in vintages 2012 and 2013. The varietal wines were produced from the grapes grown at four different localities, according to a uniform manner (traditional method) in the winery of the Biotechnical Faculty, located at the experimental farm in Podgorica, at the vineyard location of Ljeskopolje. The analysis of basic chemical parameters of wines and sensorial testing of wines were carried out. The research findings show that variety and vintage (climatic conditions) significantly affected the chemical composition of wine. The higher content of alcohol and extract was measured in 2012 vintage, while the total acid content in wine was higher in 2013, as a result of frequent rainfall during the growing season, especially in August and September. The highest content of alcohol, extracts and total acids was found in Kratosija wine, then in Cabernet Sauvignon, while the lowest content was found in Vranac wine in both vintages. According to sensory properties and average testing score for the two years of research, all wines fall into the category of superior wines.

Keywords*:* red wine, Vranac, Kratosija, Cabernet Sauvignon, locality.

Introduction

Chemical composition and organoleptic or sensory properties of wine determine its quality. The chemical composition of wine, as well as the chemical composition of grapes and must is very complex and rich. The quantity of individual ingredients and the ingredients ratio affect significantly the quality of the future wine. The main quality indicators of the must and future wine quality are the concentration of sugar and total acidity in grapes. (Pajovic et al. 2013, Raicevic et al. 2015). The sensory properties of wine are important wine quality indicators. Using the sense of sight, the sense of smell (olfactory evaluation) and the sense of taste (gustatory evaluation), we assess wine clarity and color, as well as its smell and taste, i.e. we determine wine sensory profile. (Raicevic et al. 2012, Pajovic et al. 2013). There are several factors, including grape variety, that influence wine chemical composition and sensory profile. Vranac is the leading variety of grape in Montenegro (Ulicevic, 1966, Pejovic, 1987, Bozinovic, 2005, Popovic et al. 2013). In Montenegro, red wines are produced predominantly, and Vranac accounts for nearly 80% of these wines, followed by Kratosija and Cabernet Sauvignon. Vranac is the dominant grape among red grapes, whereas Kratosija is decreasing and Cabernet Sauvignon is increasing (Pajovic et al. 2014). Vranac variety is characterized by a high good phenolic content, as previous published for Vranac grape and wines grown and produced in Montenegro and R. Macedonia, (Pajovic et al. 2014, Raicevic et al. 2014, Ivanova-Petropulos et al. 2015). Vranac variety is characterized by a high alcohol and extract content and a low total acids content, while Kratosija wine has a high content of all these parameters (Pajovic et al. 2016). Climatic conditions and soil are also important factors that affect the yield and quality of grapes, and therefore the chemical and polyphenol composition of wine (Ribereau- Gayon, 1982, Lee et al.2009, Chira et al. 2011, Roullier-Gall et al. 2014, Popovic et al. 2016). The average atmospheric temperature decrease means low sugar level and increased total acids content in grapes, and later in wine. (Fregoni, 1973, Ranković - Vasić et al. 2011).

This study examined the effects of variety, harvest and climate as crucial *terroir* elements on chemical composition and the sensory properties of Vranac, Cabernet Sauvignon and Kratosija wines (in the period 2012-2013) produced from grapes grown at four representative localities in the Podgorica subregion.

Materials and methods

Meteorological data processing

The monthly mean minimum and maximum temperature (° C), the average monthly rainfall (L/ m²), the average monthly relative humidity (%) and number of rainy days (rainfalls ≥ 01 mm) in the vegetative stage (from 1 April until harvest time) were analysed.Hydro-meteorological data are taken over from the Hydro-meteorological Institute of Montenegro while monitoring, recording and collection of these data have been carried out by hydro- meteorological stations (MONSTAT 2013 and 2014).

Samples and winemaking process

The tested wines were produced from the grape varieties Vranac (n = 3), Kratosija (n = 3), and Cabernet Sauvignon (n = 3). The harvest was done at the time of technological maturity (21–23 Brix), between 5 and 20 September in 2012 and 2013. Grape was (20 kg) sampled in vinayaerd from 4 localites (Sipcanik (L1), Rogami (L2), Ljeskopolje (L3), Kokoti (L4). The localities belong to Podgorica subregion and lie in the range from 25 and 50 m above sea level. Vineyard characteristics are presented in Table 1.

Table 1. The characteristics of the vineyards from which grapes were sampled

Locality	Rootstock	Planting year	Plant density	Training system	Row
Vranac					
L1	Kober 5BB	1978	4 274 (2.6 x 0.9 m)	Double Guyot	north –
L2	Teleki SO4	2006	6 211 (2.3 x 0.7m)	Single Guyot	north - south
L3	Kober 5BB	2005	4 000 (2.5 x 1.0 m)	Double Guyot	north - south
	Kratosija				
L1	1103 Paulsen	2006	5 495 (2.6 x 0.7 m)	Single Guyot	north - south
L2	Teleki SO4	2006	6 211 (2.3 x 0.7m)	Single Guyot	north - south
L3	Kober 5BB	2005	4 000 (2.5 x 1.0 m)	Double Guyot	north - south
	Cabernet Sauvignon				
L1	1103 Paulsen	2006	5 495 (2.6 x 0.7 m)	Single Guyot	north - south
L2	Teleki SO4	2006	6 211 (2.3 x 0.7m)	Single Guyot	north - south
L4	Kober 5BB	2008	5 714 (2.5 x 0.7 m)	Single Guyot	north - south

The same vinification conditions were provided for the all tested varieties. The vinification was conducted by applying the classical technique (spontaneous fermentation). After destemming and crushing the grapes, the pomace was put in plastic fermentation tanks. The potassium metabisulfite was added to pomace (5g of SO2 to 100 kg of grapes). The cap was punched down manually. The fermentation lasted an average of seven days at a temperature between 25 and 28°C. After fermentation, the wine decantation into the vessels for wine aging was performed. After the spontaneous malolactic fermentation, the wine was decanted again and necessary amount of SO2 was added. The wines are produced in three repetitions of each variety and each locality. The analysis of wine was performed four months after fermentation.

Proximate chemical composition of wines

The following parameters: alcohol, total acidity, volatile acidity, total and free SO2, dry extract and pH, were analyzed according to the official methods of analysis of wines (OIV. 2011)

Sensorial analysis

The wines from the 20012 and 2013 harvest season were subjected to sensory evaluation by the method of 100-point O.I.V. / U.I.O.E. method: max. 15 points for clarity, max. 30 points for bouquet, max. 44 points for flavor and max. 11 points for harmony (OIV, 2009). The OIV point scoring method comprises the following wine categories: table wine without geographical indication score 60 to 64.99; table wines with controlled geographical indication score 65 to 74.99; quality wines with controlled geographical origin score 75 to 84.99; superior wine scoring more than 85. Organoleptic evaluation was carried by a tasting committee consisting of 6 members.

Statistical analysis

Data was processed by ANOVA (p indicated) and, when significant, the means were separated using Tukey's honest significant difference (HSD) test ($p < 0.05$). Statistical analysis was performed using the StatSoft, Inc. (2003) Statistica.

Results and discussion

Meteorological data during the research period

The average vegetation temperature in the Podgorica district in the basin of Lake Skadar was 24.3 °C and 23.4°C, whereas the precipitation in the same vegetation period (from 1 April until harvest time) was 102.6 L/m^2 and 112.5 L/m^2, relative humidity was 51.2 and 53.3 % and number of rainy days was 7.5 and 9.3 in 2012 and 2013, respectively (MONSTAT 2013, 2014). Meteorological data for Podgorica sub region during the growing season (April-September) are given in Table 2.

Table 2. Meteorological data for Podgorica, during the growing season (April-September)

	AVERAGE MONTHLY AIR VAZDUHA (º C), TEMPERATURE (º C)						
	April	May	June	July	August	September	average
2012	14,5	19,9	27,3	30,4	29,7	23,9	24.3
2013	17,1	20,1	24,5	28,5	28,8	21.3	23.4
	MONTHLY TEMPERATURE (absolute max.) (º C)						
2012	31,1	33,5	38,3	40,7	44	36.1.	37.3
2013	32,6	34,1	38,4	39,4	41,3	31.9	36.3
	MONTHLY TEMPERATURE(absolute min) (º C)						
2012	0,4	10,7	14,9	19,6	17,7	10.9	13.4
2013	8,6	10	11,3	16,9	18,5	11.1	12.4
	MONTHLY PRECIPITATIONS (L / m²)						
2012	351,2	132	33,7	11,3	0,5	86.6	102.6
2013	101.2	211.2	51	10,3	123,1	178,4	112.5
	AVERAGE MONTHLY RELATIVE AIR HUMIDITY (%)						
2012	70	59	48	41	36	53	51.2
2013	60	62	54	40	44	60	53.3
	NUMBER OF RAINY DAYS (rainfalls ≥ 0,1 mm)						
2012	21	12	2	2	2	6	7.5
2013	10	15	9	6	7	9	9.3

If we compare the years of research, it may be concluded that during the growing season (from 1 April until the harvest time), the year 2012 was warmer than 2013. At the same time, the mean annual minimum and maximum temperature as well as the mean temperature during the 2012 growing season was higher. The average precipitation during the 2013 growing season was 9.9 L/m^2 higher than in 2012, while in August and September it was even 214.4 L/m^2 higher than in the previous year. The average monthly humidity was 2.1% higher. There were more rainy days during the 2013 growing season than during 2012, and even twice more during August and September.

The impact of the vintage year on chemical composition of wine
The analyzed parameters of chemical composition of Vranac, Kratosija and Cabernet Sauvignon are shown in Table 3.

By observing the vintage years, the higher alcohol, total extract and reducing sugar content as well as the higher pH value, a decrease in total acid contents is recorded in 2012, when compared to the year 2013. The lower content was observed in all cultivars from all localities and that was the result of higher average air temperature and low precipitation in the growing season of the research year, which is consistent with previous studies conducted by Fregoni, 1973, Ranković - Vasić *et al.* 2011, Popovic et al.2016. The vintage year has a statistically significant influence on all parameters in wine, except on reducing sugar.

The impact of grape variety on chemical composition of wine
Based on tabular overview of chemical composition of the investigated wines, it can be seen that Kratosija wine has the highest average alcohol content in 2012 and 2013 respectively, but also on average for both years of research (13.7% vol) and the highest total extract content (30.6 g / L). It is followed by Cabernet Sauvignon (13.2 vol% and 29.9 g / L), while the lowest content of alcohol (13% vol) and total extract (29.7 g / L) was found in Vranac wine. The obtained alcohol and extract values confirmed the values recorded by Pajović et al. 2016, who analysed the wines of small private producers. In the research period from 2007 to 2013, the average value of the alcohol and extract in wines were as follows: in Vranac wine (14.0 vol% and 28.0 g/l), in Kratosija (14.6 vol% and 32.2 g/l), while in Cabernet Sauvignon (13.9 vol% and 27.5 g/l). In the research period from 2008 to 2010, Raičević et al. 2012 obtained the average value of the alcohol in Vranac (14.2 vol%), and the value of extract (30.5g / l). However, the values obtained in this study are different, i.e. higher than the values obtained by Pejović, 1987. The values of alcohol (12.5vol%) and extract (23.87g/l) in Vranac wine and values of alcohol in Kratosija (11.50 to 13:00 vol%) (Pejovic,1988) and in Cabernet Sauvignon (10.9 vol%) (Pejovic et al.1996). The average amount of total acids in wines varies from 5.1 gr/l in Vranac and 5.8 g/L in Cabernet Sauvignon to 6.9 g/L in Kratosija. The values of total acids are within the limits stated by Pajović et al (2016) and range from 5.2 g/l in Vranac and Cabernet Sauvignon to 6.2 g/l in Kratošija. Similar values of total acids in Vranac were obtained by Pejović, 1987 (5.1 g/l) and Raičević et al. 2012 (6.2 g/l). In regard to the amount of reducing sugar, all wines belong to the category of dry wines (up to 4 g/l). The volatile acidity showed an overall average value of 0.46 to 0.65 g/L with no influence on the quality of wines that was protected from further oxidation and microbial contamination by the free SO2 present in a sufficient level in the wines (24.2 to 26.9 mg/L). The average total acidity content and pH values were significantly different ($p \leq 0.001$) in wines from all the 3 grape varieties. Based on the determined parameters of the chemical composition of the investigated wines, it may be concluded that all wines are typical for the investigated grape varieties and for the Podgorica region climate, and they are all characterized by a high alcohol and extract content (Ivanova et al. 2012, Raicevic et al. 2012, Kosmerl et al. 2013, Pajovic et al. 2013).

Table 3. Chemical characteristics in four-month-old wines from Vranac, Kratosija and Cabernet Sauvignon from the 2012 and 2013 vintages

	2012							2013						
Locality	Alcohol (%vol)	Total extract (g/l)	Reducing sugar (g/l)	Titratable Acidity (g/l)	Volatile acidity (g/l)	Free SO_2 (mg/l)	pH	Alcohol (% vol)	Total extract (g/l)	Reducing sugar (g/l)	Titratable Acidity (g/l)	Volatile acidity (g/l)	Free SO_2 (mg/l)	pH
Vranac														
L1	13.5	31	2.3	4.8	0.5	25.3	3.49	12.9	29	2.03	5.2	0.61	26.2	3.37
L2	13	29.9	3	5.1	0.55	25.6	3.45	12.1	27.7	2.1	5.6	0.65	26.7	3.33
L3	13.7	32	2.5	4.6	0.56	25	3.5	12.8	28.6	2.3	5.4	0.6	25.8	3.36
Mean	**13.4**±0.29^{A}	**30.97**±1.14^{A}	**2.6**±0.23^{A}	**4.8**±0.21^{A}	**0.54**±0.03^{A}	**25.3**±0.93^{A}	**3.48**±0.03^{A}	**12.6**±0.4^{B}	**28.4**±0.62^{B}	**2.14**±0.07^{B}	**5.4**±0.17^{B}	**0.62**±0.04^{B}	**26.2**±0.40^{B}	**3.35**±0.02^{B}
Kratosija														
L1	13.3	29.6	3.2	7.1	0.53	25.1	3.23	12.8	28.6	2.2	7.5	0.62	25.8	3.25
L2	14.5	32.8	3.15	6.7	0.46	25	3.31	13	29.5	2.25	7	0.59	24.9	3.29
L3	14.8	33.9	3.4	6.3	0.49	24.3	3.35	13.5	30.9	2.34	6.8	0.55	25.8	3.29
Mean	**14.2**±0.31^{A}	**32.1**±1.15^{A}	**3.25**±0.31^{A}	**6.7**±0.33^{A}	**0.49**±0.02^{A}	**24.8**±0.91^{A}	**3.30**±0.021^{A}	**13.1**±0.31^{B}	**29.7**±0.67^{B}	**2.26**±0.09^{B}	**7.1**±0.25^{B}	**0.59**±0.03^{B}	**25.5**±0.35^{B}	**3.28**±0.013^{B}
Cabernet Sauvignon														
L1	13.5	31.6	2.32	5.4	0.53	24.5	3.44	12.7	28.7	2.21	6.1	0.63	26.7	3.31
L2	13.4	29.7	2.17	6	0.47	25	3.37	12.4	27.5	2.25	6.3	0.57	26.9	3.32
L4	13.9	32	2.42	5.2	0.49	24.2	3.45	13	29.8	2.4	5.9	0.61	25.9	3.32
Mean	**13.6**±0.30^{A}	**31.1**±1.10^{A}	**2.30**±0.21	**5.5**±0.30^{A}	**0.50**±0.03^{A}	**24.6**±0.90^{A}	**3.42**±0.02^{A}	**12.7**±0.4^{B}	**28.7**±0.62^{B}	**2.29**±0.09^{B}	**6.1**±0.25^{B}	**0.60**±0.04^{B}	**26.5**±0.41^{B}	**3.32**±0.02^{B}

ANOVA was used to compare data (n.s. not significant, a,b, $p \leq 0.05$, A,B $P \leq 0.001$). Different lower-case letters indicate significant differences of means between varieties using Tukey's HSD test ($p \leq 0.05$).

Table 4. The average chemical composition of Vranac, Cabernet Sauvignon and Kratosija wine for the year 2012/2013

The average for 2012/2013	Alcohol (% vol)	Total extract (g/l)	Reducing sugar (g/l)	Titratable Acidity (g/l)	Volatile acidity (g/l)	Free SO_2 (mg/l)	pH
Vranac	13.0 ±0.29^{A}	29.7±1.11^{A}	2.37±0.31^{A}	5.1±0.27^{A}	0.58±0.04	25.8±0.44	3.42 ±0.05^{A}
Kratosija	13.65±0.44$^{A\ B}$	30.9± 1.46^{B}	2.76±0.43^{B}	6.9±0.43^{B}	0.54±0.03	25.2±0.28	3.29 ±0.04^{B}
Cabernet Sauvignon	13.15±0.34^{A}	29.9± 1.62^{A}	2.30±0.36^{A}	5.8±0.31^{C}	0.55±0.03	25.5±0.52	3.37±0.03^{C}

ANOVA was used to compare data (n.s. not significant, a,b,c $p \leq 0.05$, A,B,C $P \leq 0.001$). Different lower-case letters indicate significant differences of means between varieties using Tukey's HSD test ($p \leq 0.05$).

Considering the results obtained, it may be concluded that, statistically, the grape variety has the most significant influence ($p \leq 0.001$) on total acid content and pH value, while it has no statistically significant effect on volatile acids and free SO2 content. The average content of alcohol, extract and reducing sugar is significantly higher in Kratosija wine than in the other two varieties, while there is no statistically significant difference between these parameters values in Vranac and Cabernet Sauvignon. The results obtained in this research confirm the high impact of the grape variety on the investigated parameters, as was ascertained by previous research (Pajović et al. 2014, Ivanova-Petropulos et al. 2015, Raičević et al. 2015) on these varieties in Montenegrin and Macedonian region.

Sensory evaluation of wines

The average tasting score of wine for the two years of research is given in Table 5.

Table 5. The sensory properties of Vranac, Kratosija and Cabernet Sauvignon wine

	APPEARANCE (max 15)	BOUQUET (max 30)	FLAVOUR (max 44)	Harmony/ Overall evaluation (max 11)	TOTAL (max 100)
Vranac					
2012	12.6	25.7	37.8	8.8	84.9
2013	13	26	38.2	9.4	86.6
Mean	12.8	25.9	38	9.1	85.8 ±0.89^{A}
Kratosija					
2012	12.5	25.4	37.6	8.7	84.2
2013	12.8	25.8	38	9.3	85.9
Mean	12.7	25.6	37.8	9	85.1 ±0.74$^{A\ B}$
Cabernet Sauvignon					
2012	12.7	25.9	37.8	8.9	85.25
2013	13.1	26.1	38.3	9.4	86.8
Mean	12.9	26	38.0	9.2	86.0 ±0.99^{A}

ANOVA was used to compare data (n.s. not significant, a,b,c $p \leq 0.05$, A,B,C $P \leq 0.001$). Different lower-case letters indicate significant differences of means between varieties using Tukey's HSD test ($p \leq 0.05$).

When it comes to appearance of the tested wines, there was no statistically significant difference between the average testing scores during the two years of research. The results ranged from 12.7 to 12.9. However, if we look at each year respectively, Cabernet Sauvignon produced in 2013 got the highest average score (13.1). Bouquet and flavour got the similar testing scores. The average scores for both years of research range from 25.6 to 26 for bouquet and from 37 to 38 for flavour. Cabernet Sauvignon produced in 2013 was the best ranked wine with the score (26.1 and 38.3). The average sensory score for harmony, for the two researched years, range from 9 to 9.2, with the highest score (9.4) achieved by Vranac and Cabernet Sauvignon in 2013. Cabernet Sauvignon got highest average sensory score (86 points). It is followed by Vranac wine (85.8), while Kratosija wine got the lowest

average score (85.1 points). Based on the evaluation of sensory properties, the influence of the vintage is obvious. The wines produced 2013 got a better average score (86.4) in relation to the wines produced in 2012 (84.7). The best ranked wine was Cabernet Sauvignon in 2013 (86.8). According to sensory properties and average testing score for the two years of research, all wines fall into the category of superior wines. Previous research on Vranac wine conducted by Pajović et al.2013 also proved that the vintage year significantly affected the quality of wine and most of the Vranac wines were categorized as superior wines, with the total sensory scores ranged from 85.1 to 88.7.

Conclusions

This paper presents the results of the investigated wines - Vranac, Kratosija and Cabernet Sauvignon. The study results of chemical composition and sensory evaluation of wine sampled from four localities in Podgorica subregion were analyzed.Based on the results obtained during the course of two years, it can be concluded that:

- There are favorable environmental conditions for wine grapes growing and winemaking in Podgorica subregion.
- The influence of the vintage year, i.e. the influence of climatic conditions has statistically significant effect on the total acid content and pH value, but it has no statistically significant effect on volatile acids and free SO2. The average content of alcohol, extract and reducing sugar is significantly higher in Kratosija wine than in the other two varieties, while there is no statistically significant difference between these parameters values in Vranac and Cabernet Sauvignon.
- The higher alcohol and total extract content was recorded in investigated wines in 2012 which can be associated with a higher mean annual air temperature and mean air temperature in the growing season. The total acid content in the year 2012 was lower than in 2013 because of the higher rainfall in August and September 2013.
- The highest average content of alcohol, extract, reducing sugars and total acidity was found in Kratosija wine, then in Cabernet Sauvignon, while the lowest content was registered in Vranac wine. Kratosija wine has a lower pH value compared to Vranac and Cabernet Sauvignon.
- The grape variety has a high statistical influence on all investigated parameters, except on the content of volatile acids and free SO2.
- All investigated wines belong to the category of superior wines. Sensory evaluation has shown that Cabernet Sauvignon and Vranac wine were the highest ranked (no significant difference), while the Kratosija was the lowest ranked wine.

While differences were observed, similar trends were apparent that could be further examined and validated in other wine varietals.

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