THE INFLUENCE OF CLIMATIC CONDITIONS ON OENOLOGICAL PARAMETERS OF SOME WINE CULTIVARS FROM DIFFERENT ROMANIAN VINEYARD

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ABSTRACT

A study concerning the influence of climatic conditions on the oenological parameters of wine cultivars was carried out using six wine cultivars under the climatic conditions of 2019. Wine samples were taken from Ștefănești-Argeș, Babadag and Drăgășani viticultural centres. Determination of the oenological parameters has been made for the following wine cultivars: Riesling Italian, Fetească Regală, Sauvignon Blanc, Fetească Neagră, Merlot and Pinot Noir. The chemical parameters were determined using a Mindray BS 200 oenological analyser and the statistical analysis of the results was carried out using the Duncan test. A correlation was made between the parameters of the six wine cultivars from the three viticultural centres, focusing on the correlations between the total polyphenols of wines and their antioxidant activity.

Keywords: climate change, wine cultivar, chemical composition, polyphenols, antioxidant activity

INTRODUCTION

The global warming has caused many disturbances in the viticultural ecosystems, the vine cultivars being forced to modify their annual cycle of vegetation, with consequences, most often negative, for the quality and quantity of grape production and also for the resulting wines (Tănase, 2019). Already, negative effects of climate change in some vineyards on the globe, such as: earlier ripening of grapes, loss of acidity through respiration and a greater accumulation of sugar, were reported. Also, if the harvest takes place earlier than usual (August or September, instead of October in the northern hemisphere) and the vine is not irrigated, dehydrated grapes will result (Onache, 2018).

The quality of the wine is given by the physico-chemical composition of the wine and its organoleptic properties. In case of wine, that has a very complex composition, the quality remains a random feature, difficult to define and to establish (Geana, 2016).

Red wine is a tannic drink, because it contains polyphenols, which is not the case of other alcoholic beverages. Polyphenols are, in fact, very important constituents of wine and a greater interest is related to their antioxidant action. Polyphenols settle the taste and colour of wine. The most sustained beneficial action of polyphenols from wine is their antioxidant effect, which is achieved by the capture by polyphenols of free radicals circulated through the blood. (Woraratphoka, 2007; Valkom, 2007; Yang, 2009; Visnja, 2010; Bunea, 2012). Consequently, a vigorous research activity was initiated regarding the analysis of these

antioxidants in different grape products and on the preparation of extracts and wines with a high content of phenolic antioxidants (Heinonen, 1998).

MATERIALS AND METHODS

In this experiment, grape production and the resulted wines of 6 wine cultivars were studied in 3 winegrowing areas on the specific climatic conditions of the year 2019. The wine cultivars studied were: Riesling Italian, Fetească Regală, Sauvignon blanc, Fetească Neagră, Merlot and Pinot Noir. Climate determinations have been made for each vineyard using meteorological stations, as follows: Goleasca station (topographic data: 44°85'75"N and 24°95'77"E, 300m); Babadag station (Dobrogea) (topographic data: 44°94'05" N and 28°65'09"E, 250m) and Drăgășani station (topographic data 44°69'56"N and 24°23'57"E, 195m). The climate data were collected between January and September 2019.

A very large set of chemical analyses were performed. For each wine was determined the following parameters: minimum alcohol content, total acidity and anthocyanins content. The alcohol content, one of the most important parameters of wine quality, was determined by indirect method (hydrostatic balance method), after prior separation of alcohol from wine by distillation. Acidity provides physico-chemical stability of wine, gives colour, brightness and freshness of taste. To characterize the acidity of wine the following types of acidity were taken into consideration. The determination of total acidity was made by titration with bromothymol blue (Giosanu, 2011).

The total content of polyphenolic compounds (CTCF) was determined by the Folin-Ciocalteu method. With the help of the oenological analyzer Mindray BS200 the organic acids were determined. (Țârdea, 2007).

The samples were analyzed according to the technique reported by Brand-Williams and others (1995), with some modifications. Briefly, 1 volume of sample (5 μ L for red wine [1 : 1, v/v with methanol]) was added to 1 volume of 2,2-diphenyl-1-picrylhydrazyl (DPPH•) (Sigma) 0.094 mM in methanol up to completing 1 mL. The free radical scavenging activity using the free radical DPPH• reaction was evaluated by measuring the absorbance at 515 nm after 60 min of reaction at 20°C using a spectrophotometer. The reaction was carried out in closed Eppendorf tubes shaken at 20°C and the results were expressed in gallic acid (Woraratphoka, 2007).

For the statistical interpretation of the results, the data were included in an Excel database and then statistically interpreted with the SPSS 14.0 program, which uses the Duncan test (multiple range test) for a 5% statistical assurance. All the biochemical determinations were carried out in three repetitions.

RESULTS AND DISCUSSIONS

The climatic values recorded in Ștefănești vineyard centre showed some peculiarities whose effects were found both in the course of the vegetative cycle and especially in the level and quality of the grape harvest. Among these specific features we can mention, as the most significant, the following: the low temperatures in the period of April – May, leading to a delay of the flowering by one week (3°C / April 1st, 5.9°C / May 1st, 6.1°C / May 7th); the temperature in June didn't exceed 35°C, until 2 days (37°C June 25 and 35.6°C June 27) and in July there were not reported very high temperatures (maximum 37.8°C / July 21 and July 26); in two months (June and July) the temperatures during the night were quite low (14°C / June 03 - June 10 and 8.2°C / July 11) leading to the extension of the ripening period of the grapes (Table 1).

Table 1. Temperature dynamic during April-August 2019 in the three vineyard centres

Month	Air temperature			Rainfal l (mm)	Huglin Index	Days without precipit ation> 10 mm	Σ T global (°C)	Σ T active (°C)	Σ T useful (°C)
	T med (°C)	Average T min (°C)	Average T max (°C)						
Drăgășani									
April	11.92	6.53	17.83	39.9	146.25	1	357.5	314.5	64.5
May	14.08	9.42	19.06	14.9	203.67	-	436.5	436.5	166.6
June	22.81	17	29.23	139.2	480.6	7	684.5	684.5	384.5
July	22.82	15.84	30.16	63.8	511.19	3	707.5	707.5	397.5
August	25.13	17.39	32.87	1	589	-	779	779	469
Babadag									
April	13.3	8.43	17.97	810.2	163.05	8	401	354.5	124.5
May	17.5	13.1	22.29	518	241.65	4	542.5	542.5	232.5
June	20.5	16.2	24.73	707.1	378.45	7	614.5	614.5	314.5
July	27.3	21.45	32.42	602.7	615.66	6	845	614.7	304.7
August	27.35	20.58	31.94	199.2	609	3	848	848	538
Ștefănești									
April	11.2	5.4	19.1	42.2	171	1	338.1	244.4	53.4
May	16.3	9.8	24.6	93.6	323.95	2	504.1	494.5	194.5
June	22.1	15.5	32.0	193.6	511.5	6	664.6	664.6	364.6
July	22.2	14.5	32.2	70.6	531.95	1	687.1	687.1	377.1
August	24.6	15.7	35.8	6.6	626.2	0	762.1	762.1	452.1

Huglin Index = $[(T_{med} - 10) + (T_{max} - 10)] / 2 \times \text{no. days of the month}$.

ΣT global = sum of average positive daily temperatures.

ΣT active = sum of average daily temperatures > 10°C.

ΣT useful = sum of differences between average daily temperature > 10°C and the biological threshold for starting in the vegetation of the vine (10°C).

The climatic data in Drăgășani vineyard didn't show any peculiarities in terms of temperatures, which were kept within the normal limits, specific for the Drăgășani area. In March small peculiarities represented by a minimum temperature of -2°C (in March 15) and a maximum of 25°C (in March 18) and poor rainfall (only in March 18 were recorded 18.7 mm) were noticed. April was characterised by a minimum temperature of 2°C (April 3 and 21), a maximum of 25°C (April 27) and poor precipitation (with 15.4 mm rain in April 18). In May, climate data remained normal (22-28°C) for this rain-free area, only on May 31 was recorded a maximum temperature of 20°C. The ripening period of grapes (June-August) was deficient in terms of precipitation. Concerning the temperatures, only in August there were higher temperatures (36°C /August 10 and 11). Climate data from the Dobrogea vineyard showed some peculiarities, such as the low temperature in March (T_{max} 5°C /March 25) and high rainfall (99.5mm /March 16 and 17; 99.8 mm / March 21 and 22). April was evidenced by low maximum temperatures (7-18°C) and heavy rainfall (99.8 mm /April 25, 26 and 29). On May had normal temperatures and heavy rainfall (99.5 mm/May 4, 10, 24 and 31). June recorded high temperatures (above 30°C) and heavy rainfall due to storms (99.3 mm /June 4, 8, 13, 20 and 28). The months of July and August had no specific features in terms of temperatures, but there were storms with high precipitation (99.5 mm/ July 2, 13

and 24; 99.0 mm / August 6 and 26). The statistical analysis of the wines concerned the following biochemical indicators: alcoholic concentration (% vol), total acidity (g/L tartaric acid), dry extract (g/L), reducing sugars (g/L), the content in polyphenols (mg GAE/L) and their antioxidant activity (mg GAE/L).

Table 2 shows the correlations between the indicators taken into study. We can highlight the following items:

- The alcoholic concentration correlates positively, significantly distinct, with the total extract ($r=0.628^{**}$) and negative with density, total acidity and volatile acidity ($r=-0.284$, $r=-0.298$, $r=-0.088$).

Table 2. Matrix of "r" correlation (Pearson correlation coefficients "r") of the main physical and biochemical indicators (average for the 6 wine cultivars from the 3 vineyard centers).

Indicators		Alcohol streight	Dry extract g/L	Dens at 20 degrees C	Tot. acid g/L AT	Vol. Acid. g/L AA	Sugar g/L	Total anthoc yanins content (mg/L)	Total polyph enol content (mg GA/g)	Antiox Activit y mg GAE/L
Alcohol Streight Dry extract, g/L Dens at 20 degrees C Total acidity g/L AT	Pearson Correlation	1	.628 (**)	-.284	-.298	-.088	.088	.171	.106	.260
	Pearson Correlation	.628 (**)	1	.067	.059	-.532 (**)	-.048	.538 (**)	.253	-.089
	Pearson Correlation	-.284	.067	1	-.054	.148	.814 (**)	.116	-.439 (*)	-.072
	Pearson Correlation	-.298	.059	-.054	1	-.145	-.281	.338	.051	-.232
Vol. acidity g/L AA Sugar g/L Total anthocy anins content (mg/L) Total polyphe nol content (mg GA/g)	Pearson Correlation	-.088	-.532 (**)	.148	-.145	1	.477 (**)	-.196	-.084	.643 (**)
	Pearson Correlation	.088	-.048	.814 (**)	-.281	.477 (**)	1	-.034	-.557 (**)	.250
	Pearson Correlation	.171	.538 (**)	.116	.338	-.196	-.034	1	.474 (**)	.116
	Pearson Correlation	.106	.253	-.439 (*)	.051	-.084	-.557 (**)	.474 (**)	1	.385 (*)
Antiox. activity mg GAE/L	Pearson Correlation	.260	-.089	-.072	-.232	.643 (**)	.250	.116	.385 (*)	1

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

- The sugar content correlates negatively with the total acidity ($r = -0.281$), the dry extract ($r = -0.048$) and the anthocyanin content ($r = -0.034$) and distinctly significant with the total polyphenols ($r = -0.557^{**}$).

-The pH correlates positively with the alcoholic content, volatile acidity and antioxidant activity, ($r = 0.237$, $r = 0.185$, respectively $r = 0.064$) and significant positive to sugar ($r = 0.432^{*}$), which explains that there is a balanced ratio between these indicators.

-Total polyphenols from wine are correlated significantly negative to sugar ($r = -0.557^{**}$) and to pH ($r = -0.431^{*}$), but the anthocyanin content ($r = 0.474^{**}$) and antioxidant activity ($r = 0.385^{**}$) are distinct positively correlated with sugar.

In figure 1 is presented the differences between the Dobrogea vineyard and the other two vineyards (Drăgășani and Ștefănești) regarding the alcoholic strength. Concerning Fetească Neagră cultivar from Dobrogea vineyard, the alcoholic strength was around 15.5% vol., from Ștefănești it reached 13.15% vol. and from Drăgășani vineyard was 13.36% vol. The lowest alcoholic concentrations were found in white wines, especially in Fetească Regală cultivar from Dobrogea vineyard, with 13.0% vol. and from the Drăgășani vineyard with 12.85% vol (fig 1). Regarding the alcoholic strength of the six analysed cultivars in the three geographical areas, the highest alcohol content was recorded at the Pinot Noir wine from Ștefănești vineyard centre (fig 2).

Figure 1. Influence of the cultivar on the alcoholic concentration of wine, depending on the geographical area

Figure 2. Influence of the geographical area on the alcoholic concentration of wine, depending on the cultivar

Figures 3 and 4 show us the influence of the area on the dry extract of wines. Considering the average value of the studied cultivars, it can be observed that the highest value of extracts were recorded at Drăgășani (Merlot = 29.1g/L) and Dobrogea (Pinot Noir=27.65g/L) vineyards, and the lowest at Ștefănești vineyard centre.

The differences of total acidity depend on the pedological composition of the soil in each vineyard and for each cultivar. The lowest value of the average total acidity (5.21g/L) was observed at the cultivars from Dobrogea vineyard (fig. 5, 6).

The pH of wine depends on the cultivar and on the geographical area. For example for Sauvignon blanc from Ștefănești it was 3.92 pH and for Drăgășani it was 3.05 pH (Fig. 7). Considering the average of the cultivars, the highest pH was recorded to the Ștefănești vineyard centre (3.56 pH) (fig. 8).

Figure 3. Influence of the cultivar on the dry extract of wine, depending on the geographical area

Figure 4. Influence of the geographical area on the dry extract of wine, depending on the cultivar

Figure 5. Influence of the cultivar on the total acidity, depending on the geographical area

Figure 6. Influence of the geographical area on the total acidity, depending on the cultivar

Figure 7. Influence of the cultivar on the pH of wine, depending on the geographical area

Figure 8. Influence of the geographical area on the pH of wine, depending on the cultivar

In figures 9 and 10 is showed the influence of the geographical area on the content of total polyphenols in wine, depending on the cultivar. For the red wines, the highest content of total polyphenols was recorded at Fetească Neagră (3549 mg GAE/L) from Dobrogea vineyard, while for Pinot Noir from Ștefănești vineyard center was recorded the lowest total polyphenols content (1846 mg GAE/L).

Figure 9. Influence of the cultivar on the content of total polyphenols, depending on the geographical area

Figure 10. Influence of the geographical area on the content of total polyphenols, depending on the cultivar

Figure 11. Influence of the cultivar on antioxidant activity, depending on the geographical area

Figure 12. Influence of the geographical area on the antioxidant activity, depending on the cultivar

Antioxidant activity was influenced by the climate and pedological characteristics. The antioxidant activity of the wines is directly proportional to the concentration of total polyphenols in wine. The cultivar with the highest antioxidant activity was Fetească Neagră (1.6582mgGAE/l) from the Dobrogea vineyard (fig. 12). For all the studied cultivars the highest values of this chemical parameter were recorded at Dobrogea vineyard.

CONCLUSIONS

- The experimental data showed differences concerning the alcohol concentration for the same cultivar due to the differences of soil, climatic conditions and winemaking technology.
- With regard to the alcoholic strength of the six cultivars analysed in the three geographical areas, the highest alcohol content was recorded for Pinot Noir wine in Ștefănești vineyard centre.
- Among the correlations between the studied indicators we highlight the following: the alcoholic concentration correlates positively, significantly distinct with the total extract ($r=0.628^{**}$) and negative with total acidity and volatile acidity ($r = -0.298, r = -0.088$); the dry extract of the wines correlates negatively (distinctly significant) with the volatile acidity ($r = -0.538^{**}$) and negative with antioxidant activity ($r = -0.089$); the total polyphenols from

wine are significantly negative correlated to sugar ($r = -0.557^{**}$) and to pH ($r = -0.431^{*}$), but to the anthocyanin content ($r = 0.474^{**}$) and antioxidant activity ($r = 0.385^{**}$) are distinctly positive correlated.

- Among the studied wines, the wines with high alcoholic concentrations are from Dobrogea vineyard (Merlot 15.6%vol. Riesling 14.8%vol), and the wines with the lowest alcoholic concentrations are from Drăgășani vineyard (Riesling 11.3% vol, Fetească Regală 12.85%vol).

- Antioxidant activity was influenced by the climate and pedological characteristics. The antioxidant activity of the wines is directly proportional to the concentration of total polyphenols in the wine. The cultivar with the highest antioxidant activity was Fetească Neagră (1.6582mgGAE/L) from Dobrogea vineyard. For all the studied cultivars, the highest values of this chemical parameter was recorded at Dobrogea vineyard.

REFERENCES

1. Bunea C. I., Pop M., Babes Anca Cristina, Matea C., Dulf F., Nunea Andrea. 2012 – Carotenoids total polyphenols and antioxidant activity of grapes (*Vitis vinifera*) cultivated in organic and conventional systems. Chemistry Central Journal. 1752-153x.
2. Geana Elisabeta Irina, Marinescu Adrian, Iordache Andreea Maria, Sandru Claudia, Ionete Roxana Elena, Bala Camelia. 2014 - Differentiation of Romanian Wines on Geographical Origin and Wine Cultivar by Elemental Composition and Phenolic Components Food Anal. Methods DOI 10.1007/s12161-014-9846-2
3. Giosanu D., Vijan L.E., Deliu I. 2011 - The analyses of Physico-Chemical parameters means to appreciate the typicity of some red wine. Food and Environment Safety - Journal of Faculty of Food Engineering, Ștefan cel Mare University - Suceava Year X. No1 Heinonen. I.M.; Meyer. A.S.; Frankel. E.N. Antioxidant activity of berryphenolics on human low-density lipoprotein and liposome oxidation. J. Agr. Food Chem. 1998.46.4107- 4112. Health Qviz.(Colocviu de sănătate) 1996. rezumat internet: Medical news and alerts.
4. Heinonen. I.M., Meyer. A.S., Frankel. E.N. Antioxidant activity of berryphenolics on human low-density lipoprotein and liposome oxidation. J. Agr. Food Chem. 1998.46.4107- 4112. Health Qviz.(Colocviu de sanatate) 1996. internet resume: Medical news and alerts
5. Onache Petronela Anca – 2018- Efectele schimbărilor climatice asupra producției de struguri de vin din zona de sud a României – HORTUS - Revista a horticulturilor și viticulturilor. Nr. 16/2018. Ed. CERES. București. ISSN 2601-9442. ISSN-L 2601-9442. pg 257-265.
6. Tănase. A., Onache Petronela Anca, Tănăsescu. C. (2019) - The influence of the climatic conditions on the content of polyphenolic compounds from the main grape cultivars in the Ștefănești vineyard. Tineri cercetători în horticultură, silvicultură și biotehnologii. vol. Jurnal Of Holticulture. Forestry and Biotechnology 19(4). B+. ISSN 2066-1797. index CABI și Copernicus
7. Valko, M., Leibfritz D., Moncolj., Cronin M.T., Mazur M., Tesler J.. 2007. Free radicals and antioxidants in normal physiological functions and human disease. Otherwise. International Journal of Biochemistry. Cell Biology 39: 44-84
8. Visnja Katalinic, Mozina Sonia Smole, Skroza Danijela, Generalic Ivana, Abramovic Helena, Milos Mladen, Ljubenkov Ivica, Piskernik S. Pezo Ivan, Terpinc Petra, Boban Mladen. 2010 - Polyphenolic profile, antioxidant properties and antimicrobial activity of grape skin of 14 *Vitis vinifera* cultivars grown in Dalmatia (Croatia). Food Chemistry 119.715-723.
9. Woraratphoka J., Intarapichet K.O., Indrapichate K. 2007 – Phenolic compounds and antioxidative properties on selected wines from northeast of Thailand. Food Chemistry 104. 1485-1490
10. Yang J., Martinson T.E., Liu R. H.. 2009 - Phytochemical profiles and antioxidant activities of wine grapes. Food Chemistry. 116. 332-339.