EVALUATION OF THE QUALITATIVE CHARACTERISTICS OF GRAPES AND WINE OF THE INDIGENOUS VARIETY OF RADOVAČA

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Abstract

Vines in Bosnia and Herzegovina are traditionally grown in the Herzegovina region, where, in addition to many international varieties, indigenous and domesticated varieties are also successfully grown. The most important varieties are Žilavka and Blatina, while others are found in a much smaller area. One of these is the Radovača variety, which is preserved in only one micro-locality in Herzegovina region.

The paper presents the results of a two-year analysis (2017 – 2018) of the qualitative characteristics of grapes and wines of the Radovača variety. The average cluster weight ranged from 195,50 to 308,97g, and the weight of 10 berries ranged from 23,67g to 29,79g. A favorable proportion of the weight of berries in the cluster weight (96,63 – 97,86 g/100 gcluster) compared to the proportion of petioles (2,14 – 3,37 g/100 g cluster) was observed. The year had a significant impact on the observed characteristics, considering that the analyzed parameters had a slightly higher value during 2017. Oscillations in the value of TSS consequently caused oscillations in the alcohol content of the wine (13,88 – 8,19 %v/v). The values of TTA in grape juice and TA of wine in the years of research were quite uniform, which may also indicate the genetic specificity of this variety in this respect. The content of phenolic compounds in grapes was also significant, especially in seeds (428,74 – 977,27 mg/kg).

Regardless of the fluctuations in the years of research, the Radovača variety has a certain oenological potential, which is especially important considering that it is an indigenous grape variety.

Key words: *grape, indigenous variety, quality, wine*

INTRODUCTION

Bosnia and Herzegovina is characterised by resprectable tradition of cultivating vine and wine production, which in the past as well as nowadays concentrated mostly in the Herzegovina region.The primary place in the structure of the assortment of viticulture production in Herzegovina still belongs to the old, indigenous varieties (Žilavka and Blatina). From a historical point of view, a significant role in the attempt to preserve indigenous varieties was played by wine-growing stations, which were established in Herzegovina at the end of the eighteenth century (Gnojnice, Mostar and Lastva, Trebinje) (Beljo et al., 2018). However, so far the greatest progress in terms of

preserving the genetic diversity of grapevines in the mentioned area has been achieved thanks to the activities implemented within the projects: SEEDNet (2004 - 2011) and the Program for the Preservation of Plant Genetic Resources (2009 - 2012), when about 30 indigenous varieties were inventoried and collected (Đurić et al., 2012; Djuric & Golub, 2018). In the mentioned period, research on the characteristics of the most common domesticated varieties, Žilavka and Blatina, was intensified (Tomić et al., 2012; Jovanović-Cvetković et al., 2016; Mićić et al., 2018), and later on other varieties, present only in certain micro-localities in Herzegovina (Jovanović-Cvetković et al., 2021). The subject of this paper was the evaluation of the quality of grapes and wine of a indigenous, sporadically grown variety that may have been unjustifiably neglected, in order to assess its production and technological potential, economic importance, as well as the possible choice of this variety in the breeding program.

MATERIALS AND METHODS

Experimental sites and material

The research was conducted in 2017. and 2018. on the samples of the grapes and wine of the white variety Radovača, cultivated on the Lastva region (42° 42′ 05″ N, 18° 28′ 32″ E), not far away from the town of Trebinje (Southern part of Herzegovina, Bosnia and Herzegovina). According to the methereological data for the Trebinje region (Institute of statistcs Republic of Srpska, Bosnia and Herzegovina, 2018; Institute of statistcs, Republic of Srpska, Bosnia and Herzegovina, 2019), it can be stated that methereological conditions over the years of research were different in terms of percipitation, that is, a higher amount of percipitation was recorded in 2018 during the vegetation period (Figure 1).

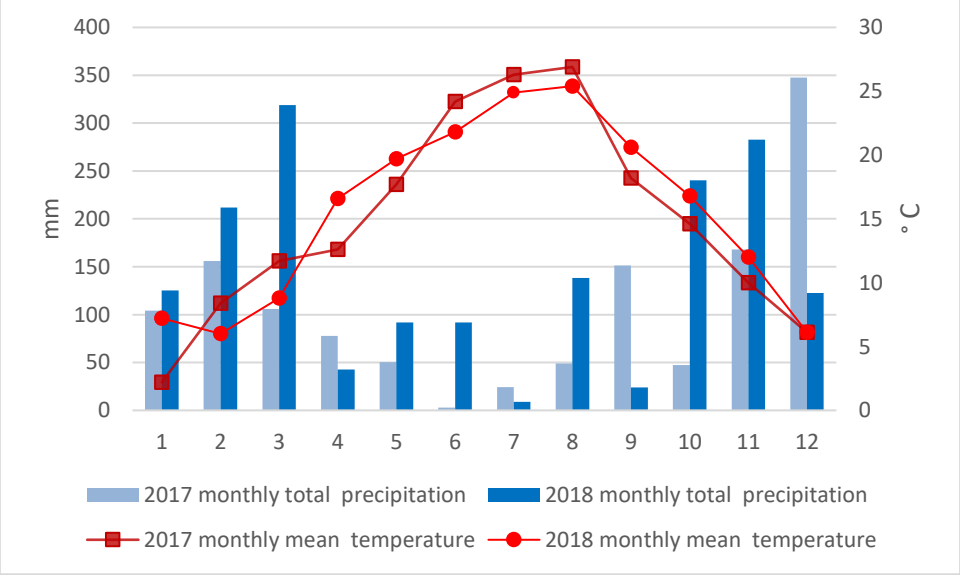

Figure 1. Meteorological parameters (air temperature and precipitation) for the area of Trebinje in years 2017 and 2018

Physico-chemical analyses

The analysis of 10 representative bunches and 10 berries per bunch determined the basic morphological and structural characteristics of the bunch (cluster weight, cluster length, cluster width, berry number/cluster, peduncle content/cluster and berries content/cluster), that is, of the berry (berry weight, berry length, berry width, seed number/10 berries, skin content/100 g berries, seed content/100 g berries and flesh content/100 g berries). The basic physico-chemical characteristics of grape juice were determined by measuring the content of total soluble solids-sugar (TSS) (% Brix) with a digital refractometer (Atago-Pal-3), determining total titratable acids (TTA) by the method of neutralization with 0.1N NaOH solution (g/l tartaric acid) and by measuring the pH value with a pH meter (Hanna HI2211). In addition, the phenolic potential of grapes was evaluated. Skin and seed samples were prepared according to the protocol defined within the project of characterisation of autochthonous varieties of Eastern and Western European countries, COST action FA1003 - "East-West Collaboration for Grapevine Diversity Exploration and Mobilisation of Adaptive Traits for Breeding". The analysis of the total polyphenol content in the extract of skins and seeds was performed using a modified method of Di Stefano et al. (1989), recommended by Rustioni et al. (2014). The results are expressed in the concentration of catechin equivalents (mg/l) and calculated into mg/kg of grapes. Microvinification was carried out according to the protocol for the production of white wines, using basic oenological preparations: potassium metabisulphite (10 g/100 - Vulcasulph, Vulcascot GHmbH&Co), yeast starter (Vitamon Combi, Erbislöh Geinsenheim AG) and selected yeast culture Saccharomyces cerevisia (20 g/ 100 l - Vulcaferm blanc, RM&Co, Vulcascot GHmbH&Co, KG). The fermentation process took place at a temperature of 18 ˚C, until the reducing sugar in the wine was 2g/l. The analysis of the young wine was carried out after 5 months, using standard methods defined by the International Organisation of Vine and Wine (OIV) (2012).

Biometrical analysis

Measured characteristics are presented in standard descriptive statistical measurements, i.e. mean and standard error of the mean. Comparison between studied groups was done by fitting the general linear models. Further study of groping and dispersion patterns of both measured characteristics and studied plants in the years of study is done by reducing the dimensionality of the data through Principal Components Analysis. Analysed differences were deemed statistically significant at $p<0,05$.

RESULTS AND DISCUSSIONS

Morphological and structural characteristics of clusters and berries

Knowledge of the morphological and structural characteristics of bunches and berries is significant from two aspects: ampelographic (systematisation of varieties based on morphological characteristics) an production-technological characterisation of varieties based on fertility, i.e. yield and

quality of grapes). The results of the basic morphological and structural characteristics of cluster and berries of the tested variety Radovača are shown in Tables 1 and 2.

Table 1. Morphological and structural characteristics of Radovača clusters in years 2017 and 2018, presented as mean with standard error of the mean (X±SD), with F and p values for comparison between studied years

Year	Cluster weight [g]	Cluster length [cm]	Cluster width [cm]	Berries [no./cluster]	Peduncle [g/100 g cluster]	Berries [g/100 g cluster]
	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE
2017	308,97 ± 32,28	16,11 ± 0,90	9,61 ± 0,81	110,78 ± 10,13	2,14 ± 0,15	97,86 ± 0,15
2018	195,50 ± 14,69	14,30 ± 0,88	8,73 ± 0,35	90,67 ± 8,27	3,37 ± 0,15	96,63 ± 0,13
F, p	10,23**, 0,006	2,07, 0,115	0,98, 0,336	2,36, 0,144	37,01**, <0,001	37,01**, <0,001

Table 2. Morphological and structural characteristics of Radovača berries in years 2017 and 2018, presented as mean with standard error of the mean (X±SD), with F and p values for comparison between studied years

Year	Berry weight [g]	Berry length [cm]	Berry width [cm]	Seed [no./10 berries]	Skin [g/100 g berries]	Seeds [g/100 g berries]	Flesh [g/100 g berries]
	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE
2017	29,79 ± 1,76	17,82 ± 0,40	15,93 ± 0,30	18,11 ± 0,63	5,63 ± 0,15	1,60 ± 0,10	92,77 ± 0,20
2018	23,67 ± 0,62	16,33 ± 0,23	14,40 ± 0,14	14,89 ± 1,05	7,84 ± 0,28	2,75 ± 0,16	89,41 ± 0,31
F, p	10,75**, 0,005	10,54**,0,005	21,79**, <0,001	6,94*, 0,18	48,05**, <0,001	38,09**, <0,001	84,98**, <0,001

There is statistically significant difference observed in following measured characteristics: cluster weight, number of berries per cluster, berry weight, berry length, berry width, seed number and flesh content/100 g berries. Significantly lower values were measured for peduncle content in clusters, seed content/100 g berries and skin content/100 g berries. Given that the examined characteristics are influenced by the genetic factor, environmental conditions of the growing environment (temperature, light, soil, etc.) and applied agrotechnical and ampelotechnical measures (Dai et al., 2011), the established variations are partially justified. The results of research on domesticated varieties, Žilavka and Radovača, grown in Herzegovina (Jovanović-Cvetković et al., 2021) also indicated the importance of genotype in terms of the examined morphological characteristics of cluster and berries. The average values of the investigated morphological parameters of Radovača in the previously mentioned research (cluster mass, number of berries/clusters, berry mass) were lower compared to the results of this research.

Basic characteristics of grape juice

The results of the analysis of the basic characteristics of grape juice (Table 3) showed that in the years of research, the greatest oscillations were manifested in terms of TSS. On the other hand, it was noticed that the value of TTA was relatively uniform during the research period, that is, differences in the level of TSS were not

reflected in the level of TTA. According to the results of previously conducted research (2014-2015), by Jovanović-Cvetković et al. (2021), the content of TSS in the grape juice of the Radovača variety was also significantly lower (15,1 %Brix, and 17,9 %Brix, respectively) compared to the determined value of this research in 2017 (22.39 ± 0.46 % Brix), while the TTA content was higher (7,20 g/l and 7,10 g/l, respectively).

Table 3. Basic physicochemical characteristics of Radovača grape juice in years 2017 and 2018, presented as mean with standard error of the mean (X±SD)

Year	TSS [%Brix]	TTA [g/l]	pH
	$\bar{X}$ ± SE	$\bar{X}$ ± SE	$\bar{X}$ ± SE
2017	22,39 ± 0,46	5,20 ± 0,19	3,39 ± 0,12
2018	15,77± 0,91	5,29 ± 0,08	3,06 ± 0,08

Although the content of sugar and organic acids in grapes is determined primarily by genotype (Liu et al., 2006), the influence of other factors is also irreplaceable. Research on the profile of organic acids of the most important domestic grape varieties in neighboring Croatia (Preiner et al., 2013) also indicated the uncontested influence of genotype, but at the same time the occurrence of oscillations of the examined parameters during the three-year study due to climatic factors and grape yield.

Phenolic potential of grape

In order to have a more comprehensive overview of grape quality, in addition to examining the basic characteristics of grape juice (sugar content, total titratable acids and pH value), as well as the absence of data on the phenolic potential of grapes of this variety, the subject of this research was also the assessment of the content of total phenolic compounds in the skin and grape seeds (Table 4). Statistically highly significant differences were observed for all measured characteristics. All characteristics had significantly higher values for 2017 in comparison to year 2018.

Table 4. Total phenols in skin and seed of Radovača in years 2017 and 2018, presented as mean with standard error of the mean (X±SD), with F and p values for comparison between studied years

Year	Skin phenolics [mg/kg]	Seed phenolics [mg/kg]
	$\bar{X}$ ± SE	$\bar{X}$ ± SE
2017	550,47 ± 12,10	977,27 ± 52,75
2018	380,27 ± 5,74	428,74 ± 75,03
F, p	35,76, <0,001	161,39, <0,001

The determined amount of phenolic compounds in the skin of Radovača grapes (550,47±12,10 mg/kg; 380,279±5,74 mg/kg) is compared to the results of the research on the characteristics of a number of autochthonous white varieties, carried out in Armenia and Georgia (Margaryan et , al., 2015; Aroutiounian et al., 2015; Abashidze et al., 2105) was generally lower, except for the case of a certain number of Armenian varieties where the content of phenolic compounds in the skin ranged from 209,2±22,2 mg/kg to 744,4±49,2 mg/kg, which is partially in consistent with the results of this research. Contrary to the above, the determined content of phenolic compounds in Radovača grape seeds (977,26±52,75 mg/kg; 428,74±75,03 mg/kg) was generally higher compared to the content of the tested varieties in Armenia and Georgia (33,0±13,5 mg/kg to 523,2 ± 40,9 mg/kg). The influence of various factors on the content of phenolic compounds in grapes (genetic, environment, method of production, degree of ripeness of the berries, etc.) has been the subject of numerous studies so far. Summarising the results of previous research, Downey et al. (2006) considered that the composition of grapes at the moment of harvest is the primary determinant that determines the content and composition of flavonoids in wine, while the dominant influence on the biosynthesis of phenolic compounds in grapes is among numerous factors: locality characteristics (primarily climatic - temperature and light) and the vintage.

Basic characteristics of wine

Based on the results of the physicochemical analyses of wine (Table 5), it is evident that in the years of research, the highest oscillations were manifested in terms of alcohol content in wine, due to high oscillations in the sugar content of grapes.

Table 5. Basic physicochemical characteristics of Radovača wine in years 2017 and 2018

Year	Alcohol [% v/v]	Sugar-free extract [g/l]	Reducing sugar [g/l]	Total acidity [g/l]	Volatile acidity (g/l)	pH
2017	13,88	21,00	2,00	5,29	0,33	3,32
2018	8,19	18,20	2,00	5,33	0,30	2,98

Contrary to the above mentioned, the values of the total acidity of wine (5,29 g/l and 5,33 g/l) were relatively uniform in the years of research, as well as in the case of grape juice, and did not differ significantly from the established, initial TTA values of grape juice (5, 20 ± 0,19 g/l and 5,29 ± 0,08 g/l), which indicates a high degree of stability of the natural acidity of grape juice and wine of this variety. Given the lack of literature data on the quality of Radovača wine, a comparison of certain investigated parameters was made with available data on the quality of the wine of the most common indigenous, white wine variety in Herzegovina, Žilavka. According to Herjavec et al. (2008), the alcohol content in Žilavka wine was 13,2% vol., the total acidity of the wine was 5,2 g/l and the pH value of the wine was 3,2, which is relatively consistent with the results of these studies in 2017. year. The results of a later study of the quality of Žilavka wine at different locations in Herzegovina (Knezović et al.,

2018) show that the determined value of alcohol in Žilavka wine (12,36%vol - 12,78%vol) was lower compared to the established value in Radovača wine, in 2017. (13,88%v/v), while the values of the total acidity of the wine (5,78 g/l – 5,98 g/l) were slightly higher compared to the values determined by this research (5,29 g/l and 5,33 g/l). In addition, based on the research results of the previously mentioned author, a high degree of similarity was observed in terms of the sugar- free extract level between the wine of Radovača (21,00 g/l and 18,20 g/l) and the wine of Žilavka (18,26 g/l – 20,58 g/l) was noted. Based on the low values of reducing sugars and the categorisation of wines based on the specified parameter by OIV (2021), the obtained wines are characterised as dry. Also, a low level of volatile acids indicates the normal course and completion of the fermentation process and is in accordance with the permissible values prescribed by OIV (2022).

In order to have a general overview of the grouping and dispersion of samples and characteristics, an analysis of the main components was performed. All measured samples with all measured properties were analysed. Principal Components Analysis (Figure 2) explained 59,57 percent of variation along the Principal Component (PC) 1 and additional 20,37 percent along Principal Component 2, which is high total of 79,94 percent of variation in the dataset of measured samples. Indicated is strong grouping of measured samples in accordance with the year of study. This strong impact is visible in the left part of the graph where Group 1 is exclusively with samples from the year 2018, while samples of Radovača variety from 2017 grouped separately within the Group 2.

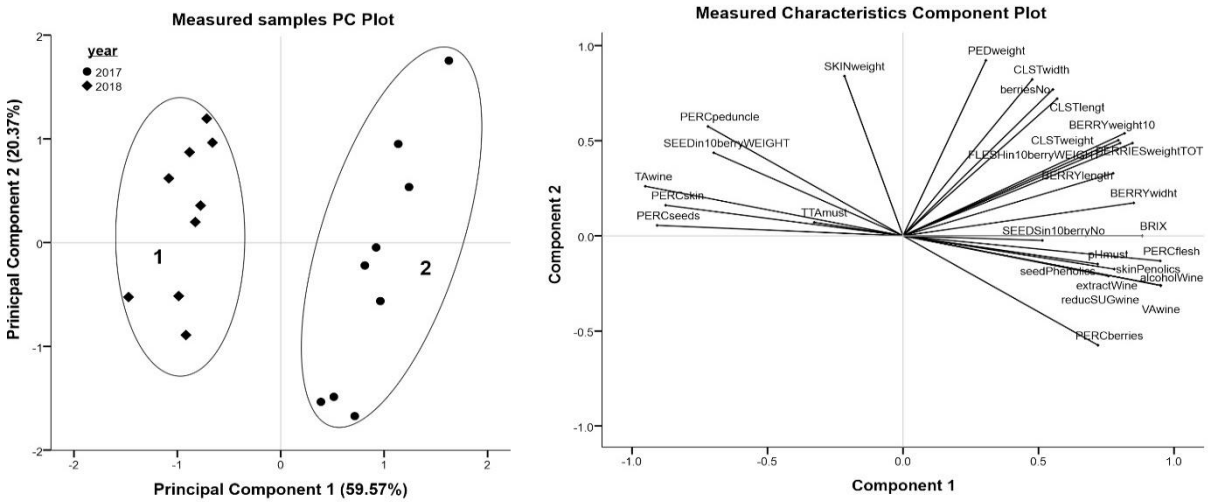

Figure 2. Principal Components Analysis of measured characteristics and samples of Radovaca variety in studied seasons (CLSTlengt - cluster length, CLSTwidth - cluster width, CLSTweight - cluster weight, berriesNo - no. berries, PEDweight - peduncle weight, BERRIESweightTOT - berries tot. weight, PERCpeduncle - peduncle, PERCberries - berries, BERRYlength - berriy length, BERRYwidht - berry width, BERRYweight10 - berry weight, SKINweight - skin weight, SEEDSin10berryNo - seed [no per 10 berries], SEED in10berryWEIGHT - seed weight [g per 10 berries], FLESH in10berryWEIGHT - flesh weight [g per 10 berries], PERCskin - skin percentage, PERCseeds – seed percentage, PERCflesh - flesh percentage, seedPhenolics - seed phonolics, skinPenolics - skin phenolics, TTAmust - must TTA [total titratable acidity], pHmust - must pH, alcoholWine - wine alcohol, extractWine - wine extract w/o sug., reducSUGwine - wine reducting sugars, TAwine - wine TA [total acids], VAwine - wine VA [volatile acids], pHwine - wine pH)

Grouping was observed mostly along principal component 1, characterised in positive direction with higher values of flesh content, berry content, %Brix, berry

width, berry length, berry weight, flesh weight, berries tot. weight, cluster weight, skin phenolics, seed phonolics, and must pH. In the negative direction along PC1, most characteristic values that were higher are seed and skin content and wine acidity.

CONCLUSION

Based on research into the qualitative characteristics of grapes and wine of the Radovače variety, it was concluded that in the years of research, a statistically significant difference was found in the following morphological and structural characteristics of grapes and berries: cluster weight, number berries per cluster, berry weight, berry length, berry width, seed number and flesh content/100 g berries. Statistically significantly lower values were noticed in terms of peduncle content in clusters, seed content/100 g berries and skin content/100 g berries.

In addition, greater oscillations in terms of the values of the investigated basic parameters of grape juice quality were recorded in the case of TSS, while the level of TTA of grape juice remained relatively stable during the research period.

It is obvious that statistically highly significant differences were also manifested in terms of the value of the phenolic potential of grapes. The values of the content of total phenolic compounds in the skin and seeds of grapes were significantly higher in the year 2017.

The observed oscillations in the alcohol content of the wines were a reflection of the TSS content in grape juice, while the TA of the wine, as in the case of the TTA of the grape juice, remained relatively stable over the years of research, which is significant from the genetic aspect. In principle, the value of the sugar-free extract does not lag behind the available data of the mentioned parameter in the wines of the most common white, indigenous variety in the region of Herzegovina, Žilavka. The values of reducing sugars and volatile acids in the wine were within the limit values established by the OIV.

From the general analysis, the influence of the year is completely evident. There is primarily an obvious positive influence of year on fruit flesh content, measured traits related to fruit size, sugars, alcohol and phenol concentration in the year that positively influenced the studied genotype. On the other hand, increased acidity is characteristic of the year in which the effects on Radovača were worse. This is extremely significant from the aspect of climate change and crop planning. It is mandatory to carry out appropriate planning in order to be able to react with appropriate interventions in years when conditions are less favorable.

In general, the positive qualitative characteristics of Radovača grapes and wine that were manifested in 2017 indicate that this variety has a significant genetic and economic potential, which requires more detailed research in the future. Given that there is significantly less data in the literature regarding the quality of grapes and wines of indigenous and autochthonous varieties compared to commercial ones, the conducted research is a contribution to the overall body of research on indigenous varieties both in the area of Herzegovina and beyond.

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