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Morphometrical and biochemical characteristics of red grape varieties (*Vitis vinifera* L.) from collection vineyard Ampelografski vrt

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ABSTRACT

Diversity of vine varieties is confirmed by different morphological and biochemical characteristics of each variety, especially in bunch and berry properties. The evaluation of mentioned characteristics supplements the chemotaxonomical classification and preservation of local and less known vine varieties. Morphometrical and biochemical characteristics were determined on grape berries of 14 different vine varieties, called 'Barbera', 'Merlot', 'Cabernet sauvignon', 'Syrah', 'Refošk', 'Sladki teran', 'Teran Istra', 'Pokalca', 'Plavina', 'Plovdina', 'Sladkočrn', 'Tinta Pinheira', 'Vranac' in 'Zweigelt', grown in Amphelographic vineyard. Morphological parameters were determined by morphometry, O.I.V. descriptors number codes 220, 221, 503 and with colorimeter, but biochemical parameters with several carbohydrates by HPLC and total acidity with titration. The obtained results confirmed some similarity among selected varieties, and multivariable analyses according to determined parameters group the varieties into 4 groups; in group I varieties 'Barbera Bovcon', 'Pokalca' and 'Barbera standard'; group II varieties 'Refošk', 'Syrah' and 'Teran Istra'; group III varieties 'Cabernet sauvignon', 'Merlot' and 'Zweigelt'; group IV varieties 'Sladkočrn', 'Tinta Pinheira' and 'Vranac'. The variety 'Plovdina' is not included in any group, what confirms its vast variability compared with other varieties taken into account.

Key words: berry, grapevine, quality, colour

IZVLEČEK

MORFOMETRIČNE IN BIOKEMIJSKE LASTNOSTI RDEČIH SORT VINSKE TRTE (*Vitis vinifera* L.) IZ KOLEKCIJSKEGA VINOGRADA AMPELOGRAFSKI VRT

Diverziteto sort vinske trte (*Vitis vinifera* L.) potrjujejo različne morfološke in biokemijske lastnosti rastlinskih delov, predvsem grozda in jagodah. Z vrednotenjem navedenih parametrov se dopolnjuje kemotaksonomsko klasifikacijo sort in posredno se pripomore k ohranjanju starih in manj znanih sort. Morfološke in biokemijske lastnosti smo določali na jagodah 14-tih sort vinske trte: 'Barbera', 'Merlot', 'Cabernet sauvignon', 'Syrah', 'Refošk', 'Sladki teran', 'Teran Istra', 'Pokalca', 'Plavina', 'Plovdina', 'Sladkočrn', 'Tinta Pinheira', 'Vranac' in 'Zweigelt', ki rastejo v Ampelografskem vrtu. Morfološke lastnosti smo določili po

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metodah ampelometrije, z O.I.V. deskriptorji 220, 221, 503 in kolorimetrom, medtem ko biokemijske z vrednotenjem količine posameznih ogljikovih hidratov s HPLC in skupne kisline s titracijo. Rezultati, se s statistično multivariatno analizo, glede na ovrednotene lastnosti gručirajo v štiri skupine s podobnimi lastnostmi, in sicer; skupina I sorte 'Barbera Bovcon', 'Pokalca' in 'Barbera standard'; skupina II sorte 'Refošk', 'Syrah' in 'Teran Istra'; skupina III sorte 'Cabernet sauvignon', 'Merlot' in 'Zweigelt'; skupina IV sorte 'Sladkočrn', 'Tinta Pinheira' in 'Vranac', kar kaže na njihovo podobnost. Sorta 'Plovdina' se ne uvršča v nobeno od skupin, kar dokazuje njeno večjo variabilnost od ostalih vzorčenih sort.

Ključne besede: jagoda, vinska trta, kakovost, barva

1 INTRODUCTION

There are around 10 000 different grape varieties and their number has been increasing in recent years, mostly at the expense of hybrids and less known local varieties (Martinez de Toda, 1991). Characterization of varieties has been made more difficult due to divergent morphological characteristics of individual parts of grapevine from different winegrowing areas or due to synonym and homonym use with the same varieties. Apart from these differences, these varieties share numerous similarities that are most frequently established by determining morphological and biochemical characteristics of grape and berries (Galet, 1990; Carreño *et al.*, 1997). Grapevine varieties could be evaluated in a number of ways, with morphological descriptions method (O.I.V. descriptors) and morphometrics being the most common (Galet, 1952; Cabello *et al.*, 1993).

Morphological features of grape and berries are of genotypic nature, although they are significantly influenced by environmental factors (air temperature, precipitation, wind etc.) (Smart and Robinson, 1992). Grape quality is both created and determined by carbohydrates, organic acids and phenolic substances (Winkler *et al.*, 1974; Mullins *et al.*, 1992).

The most important carbohydrates in terms of quantity are glucose, fructose and sucrose as they taken together account for around 95% of total sugar quantity. The most important organic acids, on the other hand, are tartaric acid, malic acid and citric acid that supply must and subsequent wine with their respective freshness. Sucrose is hydrolysed into fructose and glucose in berries, and their resultant concentration is in relation to that of fructose higher in the berries’ first phase of growth and maturation. Fructose is on average twice sweeter as compared to glucose, and the ratio of both sugars also depends on the genetic potential of grapevine varieties (Garcia-Romero *et al.*, 1993; Roubelakis-Angelakis, 2001; Clancy, 2002; Kennedy, 2002). Artes-Hdez *et al.* (2004) indicates the ratio between glucose/fructose on average between 0.98 and 1.05. More significance has been recently attached to phenolic substances or what is referred to as phenolic grape maturation. The latter is determined by phenolic substances and acids which are important in terms of quantity as they provide grape with colour and taste, aroma and bouquet (Stafford, 1990; Perez-Magariño in Gonzalez-San Jose, 2005). The very beginnings of grape maturation are accompanied by coloration of berry skin, and their colour intensity increases with maturation. This means that the aim is to attain the optimal coloration of berries when grape harvesting. Grape coloration depends on its variety (genotype) and environmental factors, mostly ultraviolet radiation, light and heat (Mullins *et al*., 1992).

By determining and evaluating both the differences and similarities of morphological parts of red grape varieties grown in collection vineyard Ampelografski vrt, an attempt has been made to upgrade the database on morphological and biochemical potential of individual variety as it is reasonable to maintain genetic variability in Slovenia and in doing so also retain specific characteristics of some older and less known varieties.

2 MATERIALS AND METHODS

2.1 LOCATION AND DESCRIPTION OF THE VINEYARD

The study was carried out on 14 red, old and also on the globally known grapevine varieties (*Vitis vinifera* L.) cultivated in the Ampelographic garden of Kromberk near Nova Gorica. The selected varieties include 'Barbera', 'Merlot', 'Cabernet Sauvignon', 'Syrah', 'Refošk', 'Sladki Teran', 'Teran Istra', 'Pokalca', 'Plavina', 'Plovdina', 'Sladkočrn', 'Tinta Pinheira', 'Vranac' and 'Zweigelt'. Grape production is a part of integrated production.

2.2 SAMPLING AND MEASUREMENTS OF MORPHOLOGICAL PROPERTIES OF BERRIES

2.2.1 Cluster Sampling

Berries and entire grapes were sampled in the morning. A random method was used for the selection of both clusters on grapevine, and berries on cluster. The average weight of the sample amounted to 1500 g per variety. Berries and grapes were immediately transferred to the laboratory, stored in PE bags and kept in the refrigerator at –20 °C until extraction and sample preparation for measurements and analysis.

2.2.2 Determining Morphometrical Properties of Berries

Similarities and differences between varieties were determined by way of the morphometry of berries and by way of the method employing O.I.V. descriptors. Berry samples were weighted, while length, width and size as stated in O.I.V. descriptors 220, 221 and 503 were also defined for individual berries. O.I.V. descriptor 220 sets out 5 berry sizes, i.e. very small, small, medium, large and very large berries. O.I.V. descriptor 503 determines single berry weight, with 1 g being considered as a very small weight, approximately 2 g as a small weight, approximately 4 g as medium, approximately 8 g as large and above 12 g as a very large berry weight. Berry length was determined in line with O.I.V. descriptor 221, i.e. very short (up to 10 mm), short (10-17 mm), medium (17-24 mm), long (24-31 mm) and very long (above 31 mm) berries (O.I.V. descriptors, 1983). The data is expressed in mean millimetres and milligrams by a standard error.

2.2.3 Determining Skin Colour of the Berry

Skin colour of the berry was determined by using O.I.V. descriptor 225 classifying grape colours into 7 groups, i.e. green-yellow, rose, red, red-grey, dark red-violet, blue-black and red-black (O.I.V. descriptors, 1983). The visual assessment of berry colour is performed by using and comparing the listed varieties in the descriptor.

A more precise method was applied for the determination of skin colour of the berry, and it involved the colorimeter Minolta CR-300 Chroma (Minolta Co; Osaka, Japan) with L*, a* and b* values as colour space coordinates (CIE L*a*b*). The colorimeter is first calibrated using a white calibration plate. L* values represent a black and white scale (0=black; 100=white) or relative 'darkness' of the colour. The value is low in cases of dark shades and high for light colour shades. A* and b* values change within a range between -60 to +60, with a* being negative for green colour and positive for red, while b* value is negative for blue and positive for yellow. The tint (H) is calculated on the basis of $tan^{-1}(b^*/a^*)$ and is expressed in degrees (°); 0^o = red, 90^o = yellow, 180^o = green and 270^o = blue (Lancaster, 1992; McGuire, 1992).

2.3 EXTRACTION FOR CARBOHYDRATE ANALYSIS USING HPLC

2.3.1 Sample Preparation for HPLC Analysis

Berries and grape juice were prepared to suit the needs of the analysis by employing the method described by Dolenc and Štampar (1997) with minor alterations. Purified deionised water (dd, water; MilliQ purification system, Millipore, France) was used for the extraction of individual carbohydrates. Grape juice was squeezed; 1 mL was pipetted off and diluted with 10 ml of dd water (*V*/*V*). The samples were centrifuged for 7 min at room temperature and 4200 rpm. The supernatant was used for analysis, and filtered to pass through a 0.45 µm membrane filter Chromafil A-45/25 (Macherey-Nagel) prior to on-column injection.

2.3.2 Chromatographic Conditions of Carbohydrate Analysis

HPLC system: Thermo Separation Products (TSP) - binary pump P2000 (Spectra system), automatic sample feeder AS 1000 (Spectra System), degassifier: A-ACT^{TM} Your Research; mobile phase: bidestilled water, flow rate of the mobile phase: 0,6 mL/min, injected sample volume: 20 µl; analytical column: Phenomenex (Rezex RCM-Monosaccharid Ca^+; 300 x 7.80 mm), working temperature of the column: 65 °C, detector: Shodex RI-71, time for sample analysis: 45 min; software: ChromQuest.

The concentration of soluble carbohydrates was calculated by using external standards. Glucose, fructose and sucrose standards were employed (Fluka).

2.3.3 Determining Total Sugar Contents and Titration Acid

Total sugar contents were determined by way of the manual refractometer (Atago, Kuebler, 30-130 °Öechsle). A drop of grape juice is dropped on the optical glass, and the sugar amount in the sample is read by facing the glass towards the light. The data was given in °Öe. Titration acid was determined by employing a traditional method also stated in Šikovec (1993). 12.5 mL of grape juice was pipetted off to the conical flask and some drops of the dye indicator were added. 0.1 M NaOH was used for titration. The used mL of lye was multiplied by a factor 0.75 to obtain the amount (mL) of titration acid in L of grape juice. The results are expressed in g per L.

2.4 STATISTICAL DATA ANALYSIS

The data was evaluated with the help of the programme Statgraphics plus 4.0 software and the multivariate analysis with clustering was performed. The results are given as means and standard errors.

3 RESULTS AND DISCUSSION

3.1 MORPHOMETRICAL PROPERTIES OF BERRIES

3.1.1 Berry Size and Weight

Table 1 compiles data on more important morphometrical properties of berries, such as average berry length (height), width and average weight. It has been observed that average berry length of the selected varieties is within the range from 12.4 to 18.1

mm. The shortest berries were found in 'Zweigelt', 'Merlot' and 'Cabernet Sauvignon' varieties, whereas the longest berries were determined for 'Barbera', 'Vranac' and 'Plavina' varieties. When comparing berry width, it was established that 'Vranac', 'Plavina' and 'Refošk' varieties have the widest berries, and 'Zweigelt', 'Sladki Teran' and 'Merlot' varieties the narrowest. The length/width ratio revealed that 'Barbera standard' variety has the maximum ratio, which points to the oval shape of the berry. The oval shape of the berry is also assigned to 'Barbera Bovcon', 'Plovdina', 'Pokalca', 'Refošk', 'Sladki Teran', 'Syrah' and 'Vranac' varieties (Table 1).

Table 1: Physical characteristics of grape berries of different red varieties. Means and standard errors are presented.

Variety	Length (L) (mm)	Weight (W) (mm)	Size (O.I.V. 220)	Ratio L/W	Berry weight (mg)
Barbera Bovcon	16.7 ± 0.6	15.1 ± 0.5	254.5 ± 14.8	1.1	2339.2 ± 101.9
Barbera standard	18.1 ± 0.3	15.4 ± 0.3	279.4 ± 9.4	1.2	2590.8 ± 42.5
Cabernet sauvignon	13.7 ± 0.3	13.2 ± 0.3	183.1 ± 8.5	1.0	1567.6 ± 33.6
Merlot	13.2 ± 0.4	13.1 ± 0.5	174.5 ± 11.3	1.0	1535.2 ± 44.5
Plavina	17.4 ± 0.5	16.5 ± 0.4	290.6 ± 15.3	1.0	2638.6 ± 52.5
Plovdina	17.0 ± 0.3	15.5 ± 0.4	264.4 ± 10.7	1.1	2232.2 ± 53.5
Pokalca	17.2 ± 0.6	15.2 ± 0.4	264.4 ± 15.8	1.1	2347.0 ± 63.7
Refošk	16.9 ± 0.6	15.8 ± 0.6	270.0 ± 19.3	1.1	2511.2 ± 56.6
Sladki teran	14.3 ± 0.4	13.0 ± 0.4	187.6 ± 11.5	1.1	1512.0 ± 38.1
Sladkočrn	15.3 ± 0.5	15.1 ± 0.5	234.7 ± 15.7	1.0	1129.3 ± 24.5
Syrah	15.5 ± 0.3	13.6 ± 0.3	212.8 ± 8.1	1.1	1719.0 ± 17.2
Teran Istra	14.1 ± 0.3	13.5 ± 0.3	192.7 ± 9.0	1.0	1734.6 ± 53.9
Tinta Pinheira	14.0 ± 0.4	13.8 ± 0.3	195.5 ± 9.5	1.0	1873.7 ± 194.6
Vranac	17.8 ± 0.6	16.7 ± 0.8	301.6 ± 22.5	1.1	3280.0 ± 69.3
Zweigelt	12.4 ± 0.5	12.1 ± 0.5	153.3 ± 11.8	1.0	1133.6 ± 33.5

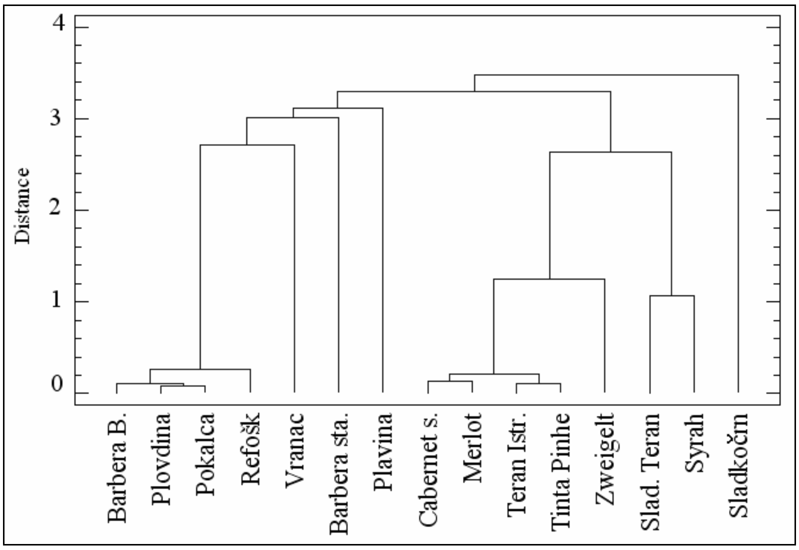

Figure 1: Dendrogram according to berry size, form and weight of selected grape varieties.

Taking into consideration the morphometric characteristics of berries as shown in Table 1, some similarities have been established between 'Barbera Bovcon', 'Plovdina', 'Pokalca' and 'Refošk' varieties (group 1), between 'Cabernet sauvignon', 'Merlot', 'Teran Istra', 'Tinta Pinheira' and 'Zweigelt' varieties (group 2), and between 'Sladki teran' and 'Syrah' varieties (group 3). All remaining varieties individually form their own groups (Figure 1).

Measurements have demonstrated that 'Vranac', 'Plavina' and 'Barbera standard' varieties have the heaviest berries, while 'Zweigelt', 'Sladkočrn' and 'Sladki teran' have the lightest berries. 'Barbera Bovcon' and 'Tinta varieties displayed the highest variability of average berry weight which in turn indicates unequal width of berries on grape.'

3.1.2 Colour of Berries

There are a number of methods in place for determining berry colour, with O.I.V. descriptor method and colour evaluation with different indexes based on colorimeter colour value being the most frequent. Table 2 illustrates the results of evaluating both methods.

O.I.V. descriptor 225 classifies varieties according to berry skin colour into 7 groups: group '1' greenish yellow, '2' reddish '*rose*', '3' red, '4' red-grey hue, '5' dark red-purple, '6' blue-black and '7' red-black.

Table 2: The average O.I.V., L* and hue angle (h) values of berry skin from red grape varieties. Means and standard errors are presented.

Variety	O.I.V. value	L* value	Hue angle (°)
Barbera Bovcon	4	29.1 ± 0.3	60.9 ± 13.6
Barbera standard	5 – 6	28.4 ± 0.3	69.3 ± 36.1
Cabernet sauvignon	5	30.9 ± 0.4	73.6 ± 31.7
Merlot	5	29.7 ± 0.3	78.0 ± 38.1
Plavina	/	/	/
Plovdina	1 – 2	32.6 ± 0.5	26.4 ± 4.2
Pokalca	4 – 5	30.1 ± 0.3	70.7 ± 26.6
Refošk	5	28.6 ± 0.4	69.1 ± 14.5
Sladki teran	/	/	/
Sladkočrn	5	32.9 ± 0.4	79.9 ± 19.8
Syrah	5	28.9 ± 0.3	64.8 ± 14.1
Teran Istra	6	30.8 ± 0.4	80.4 ± 35.1
Tinta Pinheira	4 – 5	29.9 ± 0.3	76.9 ± 26.2
Vranac	6	30.0 ± 0.3	83.1 ± 14.6
Zweigelt	5	30.5 ± 0.3	79.0 ± 22.5

Table 2 provides data on berry skin colour according to varieties. By using O.I.V. descriptor, varieties have been divided into individual groups, which more or less correspond with skin colours of varieties in the descriptor: 'Plovdina', the least coloured red grape variety, has been assigned value between 1 and 2. Most varieties have been classified into class 5, while 'Vranac' and 'Teran Istra' varieties have been ascribed the darkest colour of class 6.

When evaluating L* value, the biggest hues for lightness have been determined for 'Plovdina' and 'Sladkočrn' varieties, while the least value was established for 'Barbera standard', 'Refošk' and 'Syrah', which have been ascribed darker hues and correspond with the visual assessment with O.I.V. descriptors. When comparing hue angles (h (°)), the smallest hue angle was determined with 'Plovdina' variety which is attributable to a poorer berry skin coloration.

As expected, 'Vranac' and 'Teran Istra' varieties display the highest angle in terms of O.I.V. descriptor value and L* value. By taking into consideration all the results of different evaluation methods of berry skin colour, sampled varieties may in terms of their similarities divided into 4 groups. Minor differences in berry skin colour have been established between 'Barbera', 'Refošk' and 'Syrah' varieties (group 1), followed by those between 'Cabernet sauvignon', 'Zweigelt' and 'Merlot' varieties and 'Pokalca' and 'Tinta Pinheira' varieties as well as between 'Teran Istra' and 'Vranac' varieties (all in group 2), 'Sladkočrn' (group 3) and 'Plovdina' (group 4) (Figure 2).

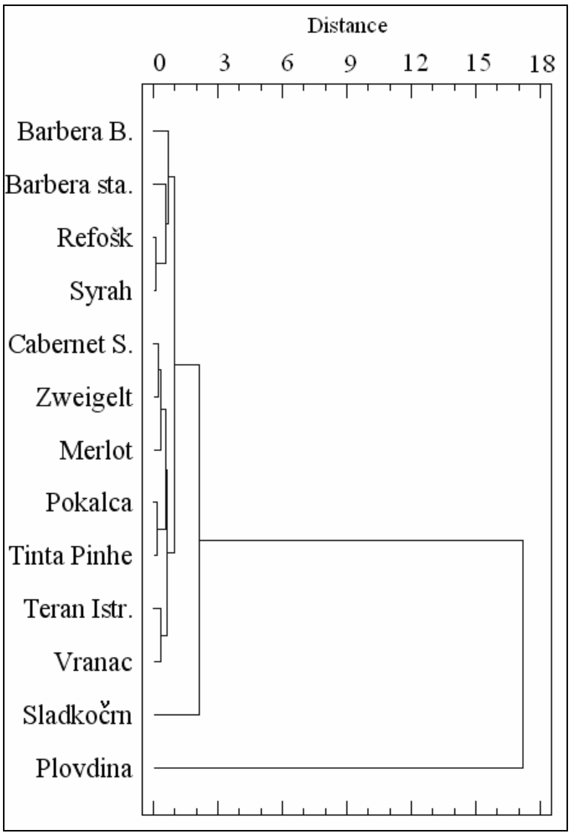

Figure 2: Dendrogram according to colour of berries of selected grape varieties.

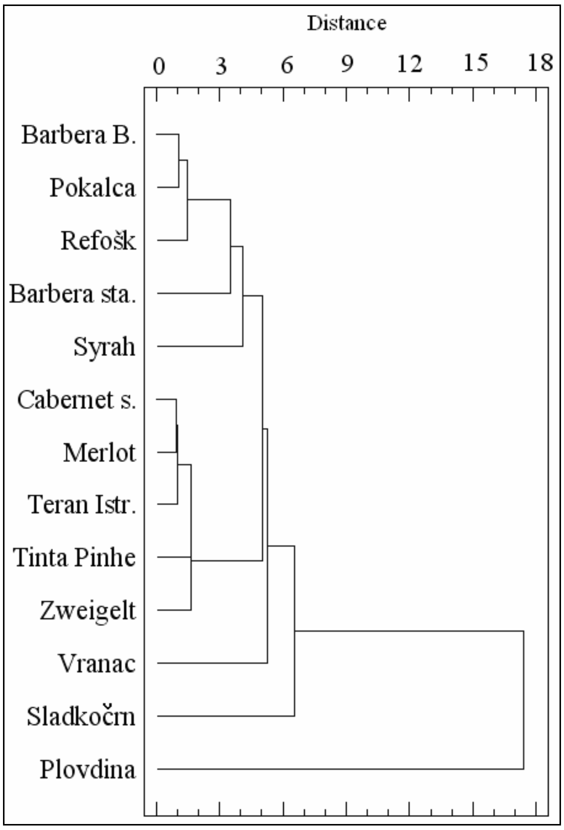

Figure 3: Dendrogram according to berry morphological characteristics of selected grape varieties.

Figure 3 illustrates the differences among varieties in all evaluated morphological characteristics of grape berry. It has been established that samples varieties can be combined at least into 2 groups with some similarities. Similarities in terms of morphological characteristics can be ascribed to 'Barbera Bovcon', 'Pokalca' and 'Refošk' varieties, as well as 'Cabernet sauvignon', 'Merlot', 'Teran Istra', 'Tinta Pinheira' and 'Zweigelt' varieties. All remaining varieties with major differences are not classified into these 2 groups.

3.2 BIOCHEMICAL CHARACTERISTICS OF GRAPE BERRIES

3.2.1 Carbohydrates and total acid contents

Sugar content which is determined with manual refractometer remains to be an increasingly more important indicator of grape quality and consequently of grape price. Sugar content in grape is also important in determining the time of technological maturity and grape-harvesting.

Figure 4 illustrates average sugar content in tests according to varieties. The smallest sugar content (Öe) has been determined in 'Plovdina', 'Tinta Pinheira' and 'Slakočrn' varieties, while the highest has been established in 'Zweigelt', 'Merlot', 'Barbera Bovcon' and 'Cabernet sauvignon'.

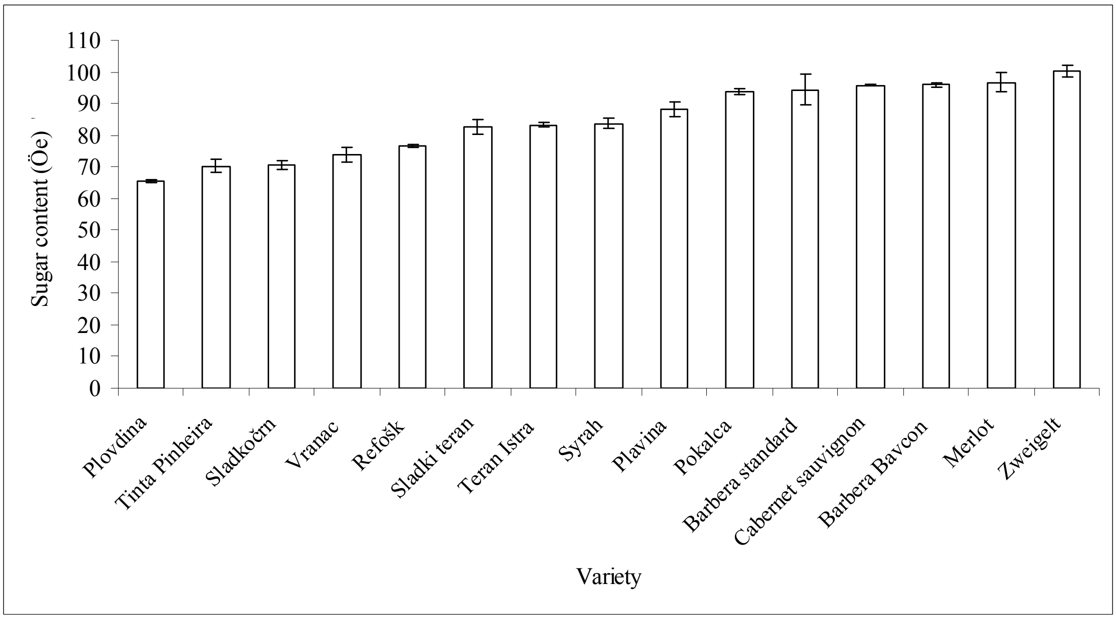

Figure 4: Total sugar content (Öe) with standard errors among different red vine varieties.

Table 3 illustrate average content of individual carbohydrate in grape juice. Major sucrose contents have been determined in 'Barbera standard', 'Teran Istra', 'Syrah' and 'Refošk' varieties, while all remaining varieties displayed 2 to 4 times lower sucrose contents. The biggest glucose contents has been established in 'Merlot' and 'Zweigelt' varieties, while the lowest content has been determined in 'Plovdina' and 'Sladkočrn' varieties. Similar contents for these varieties in glucose have been also determined in fructose content. 'Merlot' and 'Zweigelt' varieties have had the biggest content, while 'Plovdina', 'Sladkočrn' and 'Tinta Pinheira' have shown the lowest content of carbohydrates (Table 3).

Table 3: Selected carbohydrate contents in grapes of different red vine varieties. Means and standard errors are presented.

Variety	Sucrose	Glucose (G)	Fructose (F)	Total	Ratio G/F
Barbera Bovcon	3.6 ± 0.2	84.4 ± 1.8	80.2 ± 1.4	168.2 ± 2.9	1.0
Barbera standard	16.8 ± 1.0	81.5 ± 4.8	78.7 ± 4.3	177.0 ± 8.8	1.0
Cabernet sauvignon	3.2 ± 0.3	78.7 ± 0.8	75.8 ± 0.7	157.7 ± 1.7	1.0
Merlot	10.0 ± 2.9	89.9 ± 4.8	86.3 ± 5.4	186.2 ± 11.5	1.0
Plavina	3.4 ± 0.4	73.7 ± 3.0	73.9 ± 2.8	151.0 ± 5.8	1.0
Plovdina	3.1 ± 0.2	50.9 ± 0.8	55.3 ± 0.5	109.2 ± 1.4	0.9
Pokalca	6.0 ± 0.2	79.8 ± 1.7	77.6 ± 0.8	163.4 ± 2.3	1.0
Refošk	15.3 ± 0.6	59.5 ± 0.7	62.6 ± 0.6	137.4 ± 1.5	0.9
Sladki teran	4.7 ± 1.8	68.5 ± 2.3	72.4 ± 2.9	145.6 ± 4.2	0.9
Sladkočrn	4.7 ± 0.2	51.4 ± 1.4	56.8 ± 2.2	112.9 ± 3.4	0.9
Syrah	15.9 ± 1.6	67.8 ± 2.0	67.9 ± 1.9	151.7 ± 4.9	1.0
Teran Istra	15.0 ± 1.4	62.8 ± 0.8	70.3 ± 1.1	148.1 ± 2.4	0.9
Tinta Pinheira	3.3 ± 0.3	56.7 ± 2.6	54.8 ± 1.9	114.9 ± 4.8	1.0
Vranac	3.0 ± 0.2	65.3 ± 3.1	62.0 ± 3.0	130.4 ± 6.2	1.0
Zweigelt	7.1 ± 0.4	87.5 ± 1.5	83.9 ± 1.0	178.6 ± 2.2	1.0

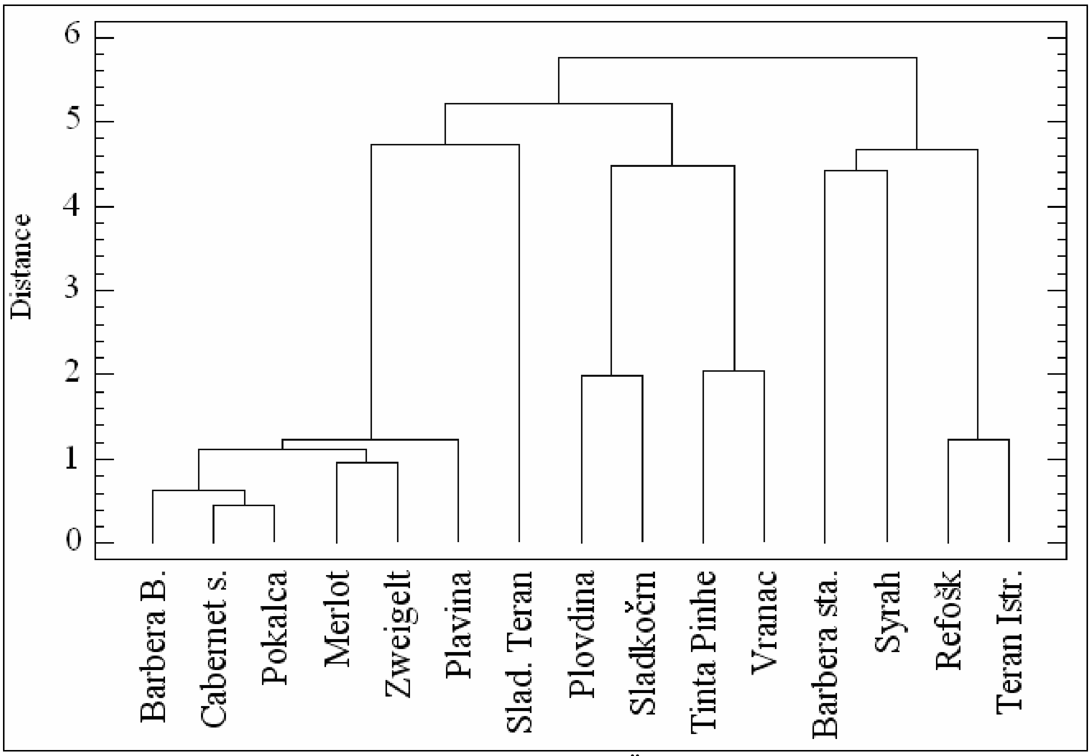

Figure 5: Dendrogram according to sugar content (Öe) and selected carbohydrates in grape juice of grape varieties.

The varieties can be in terms of sugar content and certain carbohydrates content combined into a number of groups. Similarities (figure 5) have been established between 'Barbera Bovcon', 'Cabernet sauvignon', 'Pokalca', 'Merlot', 'Zweigelt' and 'Plavina' (group 1) varieties, as well as by 'Plovdina', 'Sladkočrn', 'Tinta Pinheira' and 'Vranac' (group 2) varieties, and between 'Barbera standard' and 'Syrah' varieties (group 3), and lastly between 'Refošk' and 'Teran Istra' (group 4) varieties.

Besides carbohydrates, organic acids are also important in grape. The lowest content of organic acids has been determined in 'Plovdina' variety, while the highest content has been established in 'Zweigelt', 'Merlot', 'Barbera Bovcon' and 'Cabernet sauvignon' varieties.

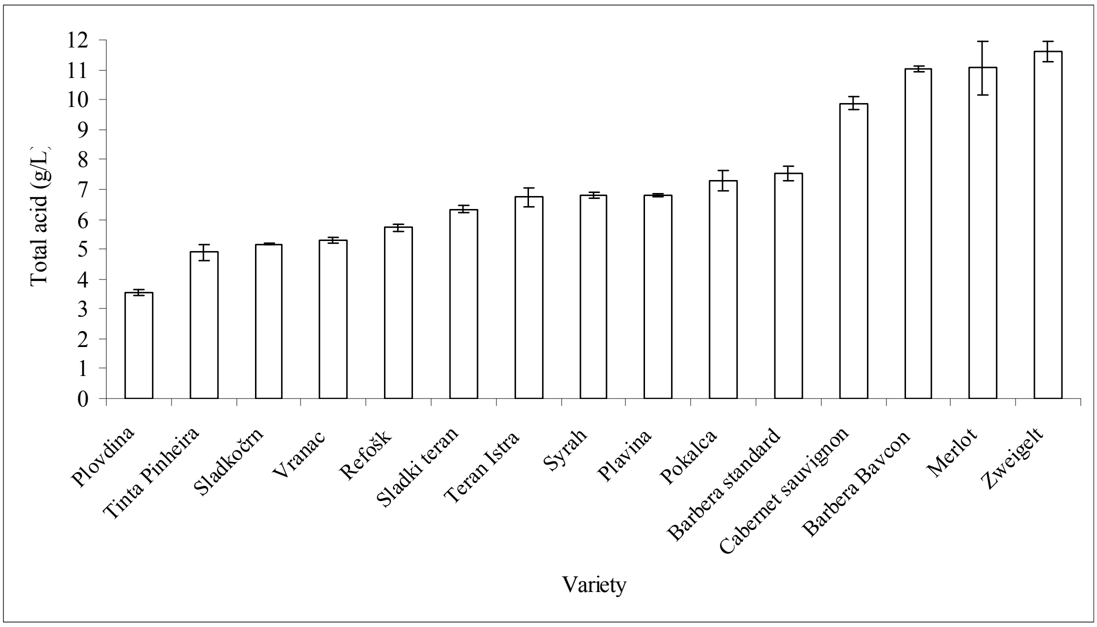

Figure 6: Total acid content (g/L) in grape juice of different red vine varieties. Means and standard errors are presented.

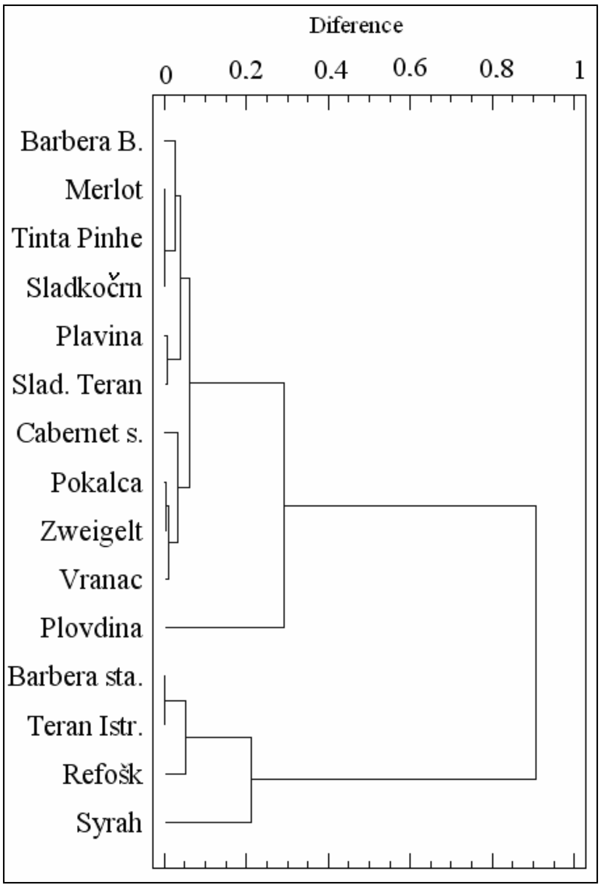

Figure 7: Dendrogram according to total acid (g/L) in grape juice of selected grape varieties.

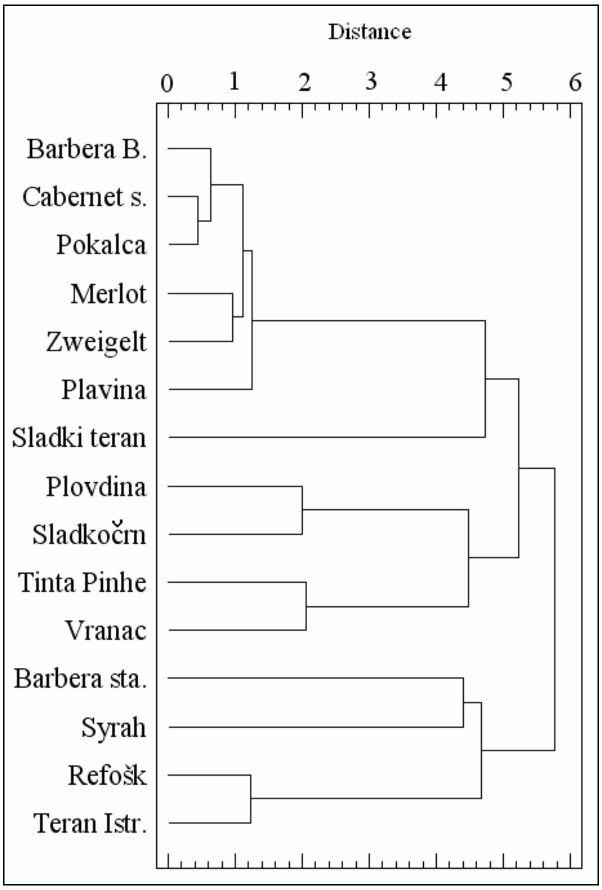

Figure 8: Dendrogram according to biochemical characteristics of grape berries.

When comparing varieties in terms of organic acids content in grape juice, it has been established that the varieties could be divided into 3 groups which display more or less the same acid content. Group 1 includes 'Barbera Bovcon', 'Merlot', 'Tinta Pinheira', 'Sladkočrn', 'Plavina', 'Sladki teran', Cabernet sauvignon', 'Pokalca', 'Zweigelt' and 'Vranac' varieties; group 2 consist of v 'Barbera standard', 'Teran Istra', 'Refošk' and 'Syrah' varieties, while 'Plovdina' makes up its own 3 group.

When comparing figures 7 and 8, it can be concluded that both dendrograms are the same. This means that organic acids make only a minor contribution to the variability of biochemical characteristics of berries, therefore it is suggested that also individual organic acids should be evaluated.

3.3 SIMILARITY OF RED VARIETIES

Figure 9 illustrates the differences among red grape varieties in terms of evaluated morphological and biochemical characteristics of grape berry. The selected varieties have been according to their characteristics divided into the following 4 groups: group I 'Barbera Bovcon', 'Barbera standard' and 'Pokalca'; group II 'Cabernet sauvignon', 'Merlot' and 'Zweigelt'; group III 'Refošk', 'Syrah' and 'Teran Istra', and group IV 'Sladkočrn', 'Tinta Pinheira' and 'Vranac'; 'Plovdina', on the other hand, has not been classified in either of these groups.

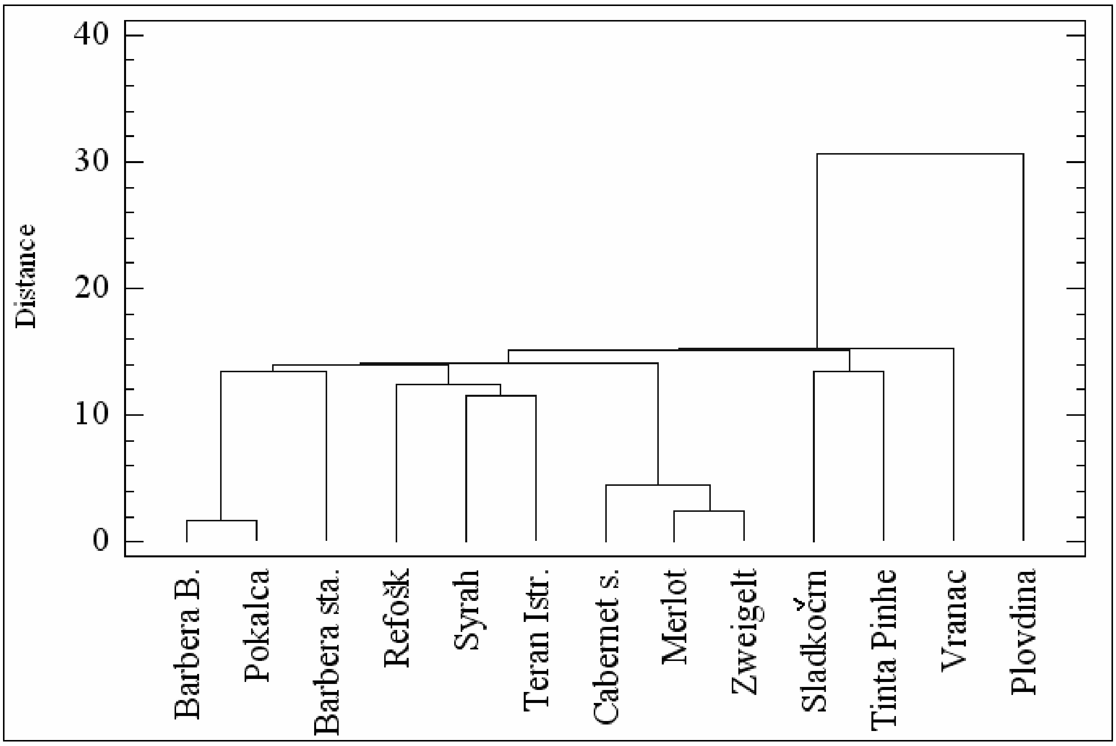

Figure 9: Dendrogram according to morphological and biochemical characteristics of berries of selected grape varieties.

Affinity in terms of morphological characteristics of berries is often connected with similarity of varieties in grape quality. Figure 9 vividly illustrates that the variety types of 'Barbera' are in the same group even though the difference between them is fairly substantial. 'Refošk' and 'Teran Istra' varieties have been ascribed similarity, a fact corroborated by our dendrogram.

4 CONCLUSIONS

Evaluating morphological and biochemical characteristics of grape berries is crucial mainly to chemotaxonomic classification of varieties, and by extension to maintaining variability of variety genotype, not least because the latter mostly differ in grape and berry characteristics. Despite various differences among varieties there are also some similarities which have in turn been corroborated by our results. 14 red grape varieties from the vineyard collection Ampelografski vrt Kromberk have been selected and they have been evaluated for their morphological and biochemical characteristics. Morphologic characteristics have been determined through berry morphometry, O.I.V. descriptor method and colorimeter, while biochemical characteristics have been pinpointed by evaluating carbohydrates and organic acids.

The varieties are in terms of their morphometrical characteristics could be divided into 4 groups, where the similarities between 'Barbera', 'Pokalca' 'Refošk' and 'Syrah' varieties on the one hand, and 'Cabernet sauvignon', 'Merlot', 'Teran Istra', 'Tinta Pinheira' and 'Zweigelt' on the other being most pronounced. As far as biochemicals characteristics are concerned, organic acids make only a minor contribution to the variety variability, therefore it has been recommended that in the future only individual organic acids are to be evaluated. Biochemical characteristics divide the varieties according to their similarities into 4 groups, with the most prevalent group being that with 'Barbera Bovcon', 'Cabernet sauvignon', 'Pokalca', 'Merlot', 'Zweigelt' and 'Plavina'. All evaluated morphometrical and biochemical characteristics divide the selected varieties into 4 groups, with similarities being established between 'Barbera Bovcon', 'Barbera standard' and 'Pokalca' varieties; between 'Cabernet sauvignon', 'Merlot' in 'Zweigelt' varieties; med between 'Refošk', 'Syrah' and 'Teran Istra' varieties and between Sladkočrn', 'Tinta Pinheira' and 'Vranac' varieties. Only 'Plovdina' fails to be classified into any one of all groups, which in turn confirms its variability in relation to other varieties.

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