BOOK OF PROCEEDINGS

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"Agrosym 2023"
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PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOUR CHERRY (*PRUNUS CERASUS* L.) CULTIVARS

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Abstract

In the experiment, fruit characteristics (fruit weight, fruit length, fruit width, fruit thickness, stone weight, stone share, stalk length and stalk weight) and contents of primary metabolites (soluble solids, total sugars, invert sugars, proteins, sucrose, titratable acidity and pH) of sour cherry cultivars were studied. The research included fruits of five cultivars ('Sofija', 'Iskra', 'Nevena', 'Šumadinka' and 'Čačanski Rubin') developed in a breeding program at the Fruit Research Institute in Čačak and 'Heimanns Konserven Weichsel' as a standard cultivar. During the experimental period, significant differences in the parameters tested were observed among the cultivars. Fruit weight ranged from 5.69 g ('Heimanns K.W.') to 7.68 g ('Sofija'), while stone weight ranged from 0.36 g ('Iskra') to 0.48 g ('Čačanski Rubin'). The cultivar 'Sofija' had the highest fruit dimensions and stalk length, whereas the highest value for stone share was found in 'Čačanski Rubin'. Among primary metabolites, soluble solids content (16.43%) was highest in 'Iskra', while total sugars and invert sugars were high in 'Čačanski Rubin' (10.17% and 9.15%, respectively). Also, 'Čačanski Rubin' was the cultivar with the highest content of sucrose, while 'Nevena', Šumadinka' and 'Sofija' had higher contents of proteins compared to the other cultivars studied. In contrast, the highest level of titratable acidity was obtained in 'Heimanns K.W.', and the highest fruit pH in 'Čačanski Rubin'. The present results indicate that tested sour cherry cultivars due to the numerous positive physical and chemical characteristics deserve a place in intensive orchards and breeding programs as cultivars with enhanced nutritional value of fruits.

Keywords: *Prunus cerasus L., cultivar, fruit size, primary metabolites.*

Introduction

Sour cherry (*Prunus cerasus* L.) is one of the most commercially important fruit species worldwide. The Republic of Serbia is among the top five producing countries of sour cherry, which together with raspberries, represents the country's main export fruit. Production is largely extensive, and includes mainly clones of 'Oblačinska' sour cherry and 'Cigančica' (85%), while the other cultivars with large fruit are less represented. However, the improvement of cultivar assortment, growing technologies and sour cherry processing, accompanied by creation of favourable environment, can lead sour cherry growing from extensive and semi-intensive to intensive production. Fruit of sour cherry is consumed generally after processing, while fresh consumption is quite low. Most produced fruit is used frozen (with or without stones) and canned, and many of them are used for juice, jams, liqueur or brandy production. Sour cherries are very popular because of their specific aroma, excellent organoleptic characteristics, high content of dry matter and total acidity. The ratio of sugar to acid determines the taste of sour cherry fruits, and their fruits have a characteristic astringent taste (Yilmaz *et al.*, 2018). The sweetness of the fruit is due to the presence of glucose and fructose, while sourness is mainly due to the presence of organic acids, especially malic acid. Furthermore, sour cherry fruits are rich in polyphenolic compounds such as flavonoids, anthocyanins, hydroxycinnamic acids, procyanidins, flavonol glycosides and flavonols (Kang *et al*., 2003; Chaovanalikit and Wrolstad, 2004; Ferretti *et al*., 2010). Numerous studies have shown that consumption of sour cherry reduces the risk of certain cancers, arthritic, systemic and local inflammation, cardiovascular damage, Alzheimer’s disease, inflammatory diseases, alleviation of muscle damage and risk of type 2 diabetes (Connolly *et al*., 2006; McCune *et al*., 2011; Kelley *et al*., 2018; Alba *et al*., 2019). Therefore, the objective of this study was to evaluate and compare the fruit characteristics and chemical properties of the fruits of the five sour cherry cultivars bred at the Fruit Research Institute in Čačak and 'Heimanns Konserven Weichsel' as a standard cultivar.

Material and Methods

The research was conducted at the Fruit Research Institute in Čačak, Western Serbia, during 2017-2019. The analysis included five sour cherry cultivars, including 'Sofija' ('Čačanski Rubin' × 'Heimanns Konserven Weichsel'), 'Iskra' ('Köröser Weichsel' × 'Heimanns Rubin'), 'Nevena' ('Köröser Weichsel' × 'Heimanns Konserven Weichsel'), 'Šumadinka' ('Köröser Weichsel' × 'Heimanns Konserven Weichsel') and 'Čačanski Rubin' ('Shasse Morello' × Köröser Weichsel') bred at the Fruit Research Institute in Čačak, and 'Heimanns Konserven Weichsel' as a standard cultivar. All cultivars were grafted on wild cherry (*Prunus avium* L.) seedlings and were represented in the orchard by five trees each. Fruits were sampled at the physiological maturity stage. A total of 100 g of fruits was sampled from 5 trees per replicate. Fruit, stone and stalk weights were determined on a Mettler precision scale with an accuracy of 0.01 g. For each **sour cherry** fruit, the three linear dimensions (length, width and thickness), as well as stalk length were measured using a ‘Digital Caliper within 300 mm’ with a sensitivity of 0.01 cm. Stone share in the total fruit weight was calculated.
Chemical analysis of the fruit included the following: 1. Soluble solids content was determined using a digital refractometer (Kruss, Germany); 2. Total sugars and invert sugars were analyzed using the Loof-Schoorl method (Egan *et al*., 1981); 3. Titrability acidity was determined by the 0.1 N NaOH titration method using phenolphthalein as an indicator; 4. Protein content was determined by the Kjeldahl method (Helrich, 1990); 5) pH value was measured by a pH Meter (Iskra MA 5707, Slovenia); 6) Sucrose content was calculated by multiplying the difference between total and reducing sugars contents by the 0.95 coefficient.
Data were presented as mean ± standard error. Differences between means were compared by LSD test in a two-way analysis of variance (ANOVA) using the MSTAT-C statistical computer package (Michigan State University, East Lansing, MI, USA). The significance of differences between means at a 5% level was considered significant.

Results and Discussion

The results on fruit characteristics of the tested sour cherry cultivars are presented in Table 1 and Figure 1. The studied cultivars showed differences in the tested parameters. During the three-year experimental period, fruit weight ranged from 5.69 g to 7.68 g, and stone weight from 0.36 g to 0.48 g. The highest value for fruit weight was obtained in 'Sofija' (7.68 g), whereas the highest value for stone weight was recorded in ''Čačanski Rubin' (0.48 g). Also, the high fruit weight was detected in 'Šumadinka' (7.15 g). The difference in fruit weight between cultivars was 17.7%, while the difference in stone weight was 19.2%. 'Sofija' is a cultivar with the highest values for fruit length, width and thickness (21.38 mm, 23.11 mm and 22.74 mm, respectively), while the lowest values were obtained in the cultivar 'Heimanns K.W.' (length – 17.31 mm, width – 19.37 mm and thickness – 17.56 mm). The stalk length was short in the cultivar 'Nevena' (34.81 mm) and medium in almost all tested cultivars, except in the cultivar 'Sofija' which was long (52.44 mm). Stalks weight varied from 0.09 g ('Čačanski Rubin') to 0.17 g ('Nevena').

Table 1. Fruit dimensions in sour cherry cultivars

Cultivars	Fruit weight (g)	Stone weight (g)	Stone share (%)	Stalk length (mm)	Stalk weight (g)
Sofija	7.68±0.45 a	0.38±0.04 c	5.45±0.15 d	52.44±2.83 a	0.14±0.03 b
Iskra	6.23±0.27 cd	0.36±0.01 c	5.83±0.27 d	43.28±2.37 c	0.12±0.02 c
Nevena	6.57±0.23 c	0.41±0.03 bc	6.78±0.39 c	34.81±1.79 e	0.17±0.06 a
Šumadinka	7.15±0.31 b	0.40±0.04 bc	6.97±0.41 c	39.28±1.95 d	0.15±0.04 b
Čačanski Rubin	5.96±0.15 de	0.48±0.08 a	8.36±0.72 a	42.84±2.58 c	0.09±0.01 d
Heimanns K.W.	5.69±0.19 e	0.45±0.06 ab	7.64±0.58 b	47.90±2.62 b	0.11±0.02 c
ANOVA Cultivar	**	**	**	**	**

Means followed by different letters within rows are significantly different at $P \leq 0.05$ according to LSD test

In terms of stone share, as an important parameter for the processing industry, the highest value was obtained in 'Čačanski Rubin' (8.13%), and the lowest in 'Sofija' (5.45%). The difference in stone share between cultivars was 19.5%.

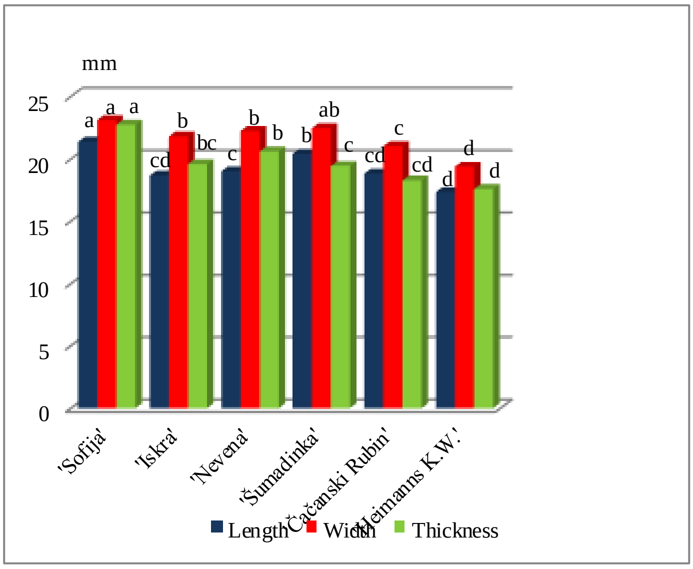

Figure 1. Fruit length, width and thickness in sour cherry cultivars

The present results are in agreement with Radičević *et al*. (2019), who found that the cultivar 'Sofija' has large fruit of high quality and attractive color. Under the agro-environmental conditions of the region of Belgrade, Nenadović-Mratinić *et al*. (2006) reported similar results for the cultivars 'Šumadinka' and 'Heimanns K.W.', while the results of Nikolić *et al*. (2000) differed slightly. In Montenegro, Šebek (2020) reported that 'Heimanns K.W.' and 'Čačanski Rubin' were the cultivars with large fruit weight (above 5 g), but shorter stalks length and lower stalk weight, which was not confirmed in the present study. These differences can be attributed to the effect of climatic factors in the studied sour cherry cultivars. Soluble solids, sugar and acid contents contribute to the sweetness and acidity of fruits and their products (Skrede *et al*., 2012). The results on the content of primary metabolites in the tested sour cherry cultivars are presented in Table 2 and Figure 2. The detected amounts of soluble solids varied from 12.47 to 16.43%, which is an important factor for consumer acceptance (Crisosto *et al*., 2003). Nikolić *et* *al*. (2000) during a ten-year study of 30 sour cherry cultivars showed a wide range of soluble solids content, from 12.5% to 16.2%.

Table 2. Contents of primary metabolites in sour cherry cultivars

Cultivars	Total soluble solids (%)	Sugar content		Acid content	
		Total sugar (%)	Invert sugar (%)	Titrability acidity (%)	pH
Sofija	14.88±0.43bc	9.52±0.17 b	8.44±0.29 b	1.75±0.10 b	3.18±0.06 cd
Iskra	16.43±0.61 a	9.93±0.40 ab	8.96±0.36 ab	1.37±0.06 d	3.23±0.08 ab
Nevena	15.39±0.56 b	9.78±0.31 b	8.53±0.45 b	1.80±0.08 ab	3.11±0.03 e
Šumadinka	13.29±0.38 d	8.82±0.19 c	7.68±0.22 c	1.67±0.04 b	3.14±0.05 de
Čačanski Rubin	14.65±0.40 c	10.17±0.22 a	9.15±0.47 a	1.51±0.03 c	3.26±0.09 a
Heimanns K.W.	12.47±0.23 e	8.54±0.13 c	7.09±0.13 d	1.92±0.12 a	3.20±0.07 bc
ANOVA Cultivar	**	**	**	**	**

Means followed by different letters within rows are significantly different at $P \leq 0.05$ according to LSD test

During the experimental period, the highest content of soluble solids was found in 'Iskra', and the lowest in 'Heimanns K.W.'. 'Čačanski Rubin' had the highest content of total sugars (10.17%) and invert sugars (9.15%), while 'Heimanns K.W.' (8.54% and 7.09%, respectively), had the lowest values. It is interesting to point out that in Šumadinka, the late-ripening cultivar, the content of soluble solids and sugar was relatively low, which is in agreement with the results of Nenadović-Mratinić *et al*. (2006).

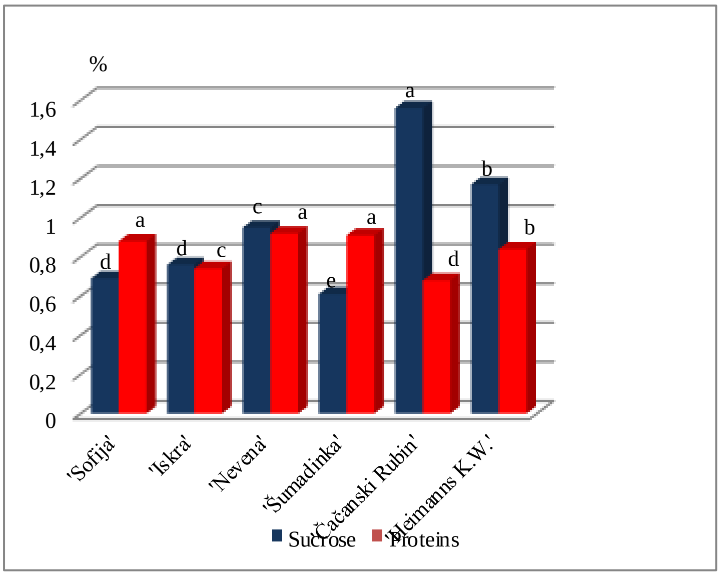

Figure 2. Content of sucrose and proteins of sour cherry cultivars

The content of proteins in the fruits ranged from 0.68 to 0.92%, while the content of sucrose varied from 0.67 to 1.56%. The highest protein content had 'Nevena' (0.92%), 'Šumadinka' (0.91%) and 'Sofija' (0.88%), whereas the highest sucrose content was found in 'Čačanski Rubin' (1.56%). Titratable acidity is one of the most important attributes of sour cherry, as it is directly related to consumer acceptance, and it is highly dependent on the cultivar (Serradilla *et al*., 2017). The highest values for titratable acidity were obtained in 'Heimanns K.W.' (1.92%), and the lowest in 'Iskra' (1.37%). On the other hand, ‘Čačanski Rubin’ had the highest fruit pH (3.26%), while ‘Nevena’ had the lowest (3.11), which is in agreement with the results of Serradilla *et al*. (2016), who reported that sour cherries are considered fruits with pH between 3.1 and 3.6. The analysis of the present data suggests that the content of the tested parameters is comparable with those of Nenadović-Mratinić *et al*. (2006), Nikolić *et al*. (2000) and Radičević *et al*. (2019). Šebek (2020) reported that soluble solids content ranged from 9.10% ('Čačanski Rubin') to 10.05% ('Heimanns Konservenweichsel'), and total acids from 1.65% ('Čačanski Rubin') to 1.81% ('Heimanns Konservenweichsel') in fruits of sour cherries grown in Montenegro, which was not confirmed in the present study. The differences in sugar and acid content can be attributed to microclimatic conditions, cultural practices, rootstock selection, planting systems and crop load, as well as differences in physiological stage as as a harvest criterion.

Conclusions

Knowledge of fruit characteristics and contents of primary metabolites in the fruits is very important when establishing commercial sour cherry orchards to make a proper choice of cultivars and improve fruit quality. The tested sour cherry cultivars are suitable for commercial production, due to their large fruits and good content of primary metabolites. The cultivar 'Sofija' a new sour cherry genotype deserves attention due to its exceptional fruit quality, and well-balanced parameters of fruit chemical composition. Also, the cultivar 'Čačanski Rubin' had a high content of most of the chemical properties tested. In general, the examined cultivars can be used in primary agricultural production when establishing commercial sour cherry orchards both under agro-environmental conditions in Serbia and worldwide. Also, their fruits can be used as natural agents in the pharmaceutical and food industries. Furthermore, the sour cherry cultivars developed in a breeding program at the Fruit Research Institute in Čačak represent an important basis for further breeding programs as parents for the creation of new cultivars.

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