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32000 ,
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The production and properties of some autochthonous plum cultivars suitable for brandy production in Serbia

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SUMMARY

Autochthonous plum cultivars have a high degree of share in plum assortment in Serbia. The main reasons for this are minor requirements regarding to growing technology, tolerance to drought, frosts and the most important diseases and above all tradition present among growers. Autochthonous plum cultivars are characterized by variable yields, fruit weight and fruit quality, therefore their main purpose is brandy production. These cultivars mostly have local character, because they are adapted to specific environmental conditions typical to each area. Within this paper, the production (the total number of trees and the growing area) and properties (yield per tree, yield per growing area and chemical characteristics of fruit) of autochthonous plum cultivars 'Trnova a', 'Požega a' and

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" " ,

(2004/2008).

-

" " ("Kraljica"). 9099

26.62 ha

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" " (7003 ; 20.10 ha),

" " (1365 ;

4.36 ha), " " -

(731 ; 10 ha).

-

kg) - (45.20

" (15.73 t ha⁻¹)

" " (35.06 kg

-⁻¹; 10.88 t ha⁻¹). -

(11,68%) -

(14,22)

" " "

-

(10.50%) -

(0.98%),

-

(10.86).

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'Crvena Ranka' in the Region of Kosjeri , Western Serbia during five years (2004/2008) are presented. Fruits of these cultivars are used for production of brandy of Protected Geographical Indication named "Kraljica". A total of 9099 trees of the aforementioned autochthonous plum cultivars are grown on the surface of 26.62 ha in this region. The most common is cultivar 'Trnova a' (7003 trees; 20.10 ha), followed by 'Požega a' (1365 trees; 4.36 ha), while the cultivar 'Crvena Ranka' is the least present (731 trees; 10 ha).

The highest yield per tree (45.20 kg) and per unit area (15.73 t ha⁻¹) was found in the cultivar Trnova a , and the lowest in the cultivar Požega a (35.06 kg tree⁻¹; 10.88 t ha⁻¹). On the other hand, the highest value of the total sugars content (11.68%) and value of the ratio between the total sugars content and total acids (14.22) were found in the fruits of 'Crvena Ranka' cultivar. 'Trnova a' was characterized by the lowest value of total sugars (10.50%), and the highest value of the total acids (0.98%), as well as the lowest value of the ratio between the content of total sugars and total acids (10.86).

Key words: autochthonous plum cultivars, yield, fruit quality, brandy, Region of Kosjeri

INTRODUCTION

(*Prunus domestica* L.)

(FAOSTAT,

2018).

,

(Miloševi et al.,

2017).

,

30% (Uroševi , 2015).

According to the annual production rate of domestic plum (*Prunus domestica* L.), Serbia ranks first in the Europe and the second in the world (FAOSTAT, 2018). Nevertheless, plum production in Serbia is characterized by low and variable yields as well as by fruits with inadequate size and quality (Miloševi et al., 2017a). One of the main reasons for this is a high number of autochthonous plum cultivars in production which are currently estimated to account for 30% (Uroševi , 2015). These cultivars are

characterized by oscillating cropping, inadequate size and poor fruit quality as well as traditional approach, most commonly used in their cultivation, implying minimal use of appropriate agro- and pomotechnical measures. Furthermore, these cultivars are mainly of local character. Their properties depend on environmental conditions, making them specific for each area (Milošević and Milošević, 2012).

The most important plum product for the Republic of Serbia is brandy. Around 75–80% of the total amount of the produced fruits is processed into brandy, whereas considerably lower quantities are used for fresh consumption, drying and processing into other products (Nenadović-Mratini et al., 2007a). The largest share of plum brandy is produced from autochthonous cultivars by extensive and outdated technology, thereby obtaining brandy of non-uniform quality, which considerably aggravates the export of this product into the world market (Nenadović-Mratini et al., 2007b). In order to overcome this situation, in the Fruit Research Institute, a task has been conducted the assessment of the most important characteristics of autochthonous plum cultivars with the aim to select genotypes that may be commercially important for cultivation, for the purpose of processing fruits into brandy (Milošević et al., 2017b). Studies have also been conducted to find an optimum technological procedure that will produce the best quality brandy (Popović et al., 2007; Popović et al., 2009).

In the Zlatibor District area, plum plantations cover 10766.68 ha, of which about 80% are extensive plantations (Statistical Office of the Republic of Serbia, 2017), which points to a high proportion of autochthonous cultivars. The Region of Kosjeri with a long tradition in plum cultivation and brandy production belongs to the Zlatibor District. The most famous distillery from this region is the "Zari" distillery, the producer of brandy

"Kraljica"), " "Kraljica", carrying the label of Protected Geographical Indication.

The aim of this paper was to show the production and the most important characteristics of autochthonous plum cultivars 'Trnova a', 'Požega a' and 'Crvena Ranka'. Fruits of these cultivars are processed using a precisely defined technological procedure into aforementioned brandy.

MATERIAL AND METHODS

Object. Five-years studies (2004/2008) covered the plantations of autochthonous plum cultivars in the Region of Kosjeri, whose annual yield, according to the contract, is processed in the "Zari" distillery. Plantations are located between 500 and 900 m above sea level, with different age and planting distance. The cultivation technology is characterized by a traditional approach, which implies natural crown, soil without cultivation and the use of organic fertilizers only. Furthermore, no protection measures against the causal agents of diseases and pests have been implemented as well.

Plant material. The studies included three top quality autochthonous plum cultivars 'Trnova a', 'Požega a' and 'Crvena Ranka'. 'Trnova a' originates from damson plum (*Prunus insititia* L.) and represents the most prevalent genotype in plum plantations of the Zlatibor District (Miloševi, 2002). It forms a pyramidal crown with branches that rarely crack under the weight of crop. Flowering time is early, on average in the middle of March, while ripening time is late, at the beginning of September. It is a self-fertile cultivar with high bearing potential. It bears regularly under conditions of minimal application of agro- and pomotechnical measures. Good results in cultivation on different types of soil and tolerance to economically the most important diseases and plum pests are characteristic for this cultivar. It is also

L.)
 (Miši , 1996).
 (Niki evi and Teševi , 2010).
 (Prunus domestica L.)
 (Miši , 1996).
 (ha),
 (kg tree⁻¹)
 (t ha⁻¹).

tolerant to the *Plum pox virus*. Compared to other cultivars, it gives a higher alcohol yield. The brandy obtained of this cultivar has very good quality, characteristic odour and taste.

'Pozega a' (*Prunus domestica* L.) has long been the leading plum cultivar in Serbia. It is a medium vigorous to vigorous cultivar, with pyramidal to broad-pyramidal crown with branches rarely cracking under the weight of crop (Miši , 1996). It blooms late and explosively and is a self-fertile cultivar. Its ripening time is late, at the end of August or early September. The fruits of this cultivar are characterized by excellent quality and it is suitable, among other things, for the production of top quality plum brandy (Niki evi and Teševi , 2010). The greatest deficiency of this cultivar is its susceptibility to *Plum pox virus*.

'Crvena Ranka' is one of the oldest brandy cultivars of domestic plum (*Prunus domestica* L.). It is a medium vigorous cultivar of a wide pyramidal crown with fragile branches that easily break under the weight of crop. The flowering time is medium-early. This cultivar is characterized by male sterility and must be grown together with appropriate pollenizer (Miši , 1996). The ripening time is medium, in the first half of August. It is tolerant to the *Plum pox virus* and is one of the most prominent plum brandy cultivars, but in comparison with other cultivars, it gives the smallest alcohol yield.

Presence of certain cultivars in the plantations. For each of the studied cultivars, the total number of trees and area (ha) in which is grown in the analysed area is shown.

Cropping and chemical traits measurement. Cropping of the studied plum cultivars is shown by yield per tree (kg tree⁻¹) and yield per unit area (t ha⁻¹). Ten trees in three replications for each plantation of each cultivar were randomly selected to determine average yield per tree using the electronic scale ACS

ACS System Electronic Scale (Zhejiang, China).

(%) Luff-Schoorl (Egan et al., 1981). 7.0 0.1 N NaOH,

2005 2006,

2007 Miši (1996)

700 1000 mm, 350 600 mm (Miši , 1996).

2004

System Electronic Scale (Zhejiang, China). Yield per unit of area is determined by calculation, multiplying yield per tree and number of plants per hectare. According different planting distances in the analysed plantations, the number of plants per hectare was different. For determining the yield per unit area, the average number of plants per hectare for each studied cultivar was determined on the base the total number of plants and total growing area of each cultivar. Based on the total number of plants and average yield per tree, the total yield in certain years of study was calculated.

The content of total sugars (%) was determined as fresh weight basis using the Luff-Schoorl method (Egan et al., 1981). Total acids were measured by neutralization to pH 7.0 with 0.1 N NaOH, the data being presented as a percentage of malic acid. Based on the data obtained, the ratio between total sugar content and total acids was calculated.

Climatic conditions. In the region of Kosjeri there is a moderate-continental climate. During the period of study climatic data from flowering time (March) to fruit ripening time (September) were provided by the nearest meteorological station and are shown in Table 1.

Based on the data shown in Table 1, an incidence of low temperature in March 2005 and 2006 was observed which might have led to certain degree of damage of plum flowering buds. Mean monthly temperature during summer months (June, July and August) in 2007 was above the values that Miši (1996) quotes as suitable for plum growing. The best results in the plum production achieved if it is grown in the areas with annual precipitation sum between 700 and 1000 mm, and the precipitation sum during vegetation between 350 and 600 mm (Miši , 1996). In accordance with the stated, precipitation sum in the vegetation

in 2004 was below optimal for plum and might have reflected on the study results.

1.

Table 1. Climatic conditions during the period of study in the Region of Kosjeri

Month	Year	Average month temperature (°)	Minimal monthly temperature (°)	Maximal monthly temperature (°)	Precipitation (mm)	Number of rainy days
March	2004	6.0	-2.5	16.8	28.1	10
	2005	3.7	-9.0	17.0	37.2	13
	2006	5.5	-6.1	17.8	112.6	15
	2007	7.6	2.2	16.3	65.7	9
	2008	6.6	1.3	14.6	51.4	13
April	2004	11.4	4.4	19.2	59.8	14
	2005	9.9	3.3	17.8	45.1	13
	2006	11.1	4.0	19.7	72.9	15
	2007	10.7	1.2	21.6	14.6	3
	2008	11.0	4.8	19.2	52.2	14
May	2004	13.1	6.6	21.3	65.8	14
	2005	14.9	5.8	25.2	89.4	19
	2006	14.6	6.6	25.6	49.3	15
	2007	16.5	8.8	24.9	95.5	17
	2008	16.2	5.9	27.1	85.4	14
June	2004	19.0	12.3	26.5	99.1	15
	2005	17.4	9.1	28.4	62.6	11
	2006	18.2	8.0	31.8	134.6	16
	2007	20.2	12.7	31.0	45.0	9
	2008	19.7	13.4	30.9	49.6	14
July	2004	20.5	13.3	30.6	100.5	12
	2005	19.96	14.0	29.9	59.9	17
	2006	20.3	12.3	30.9	107.7	14
	2007	21.6	11.9	32.8	37.3	4
	2008	29.3	13.2	29.7	71.8	12
August	2004	19.7	12.2	28.1	60.0	12
	2005	18.7	13.7	26.0	88.9	13
	2006	18.7	12.5	29.6	120.9	16
	2007	21.1	12.7	33.0	42.5	12
	2008	20.0	15.0	30.7	12.6	2
September	2004	15.5	9.5	24.5	50.2	4
	2005	16.4	13.4	26.0	73.9	14
	2006	15.9	11.0	25.5	36.8	10
	2007	13.2	7.7	21.2	110.1	14
	2008	13.9	7.4	30.6	77.6	12

(ANOVA),
Microsoft Office Excel 2003.

Data analysis. The obtained results were analysed using the Fisher model analysis of variance (ANOVA) using the software package Microsoft Office Excel 2003. The degree of relevance of differences between the treatments was determined using the LSD

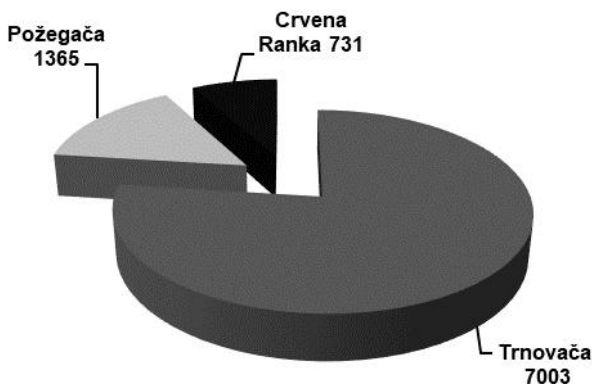
P <0,05.

LSD test, with the probability level of P 0.05.

RESULTS AND DISCUSSION

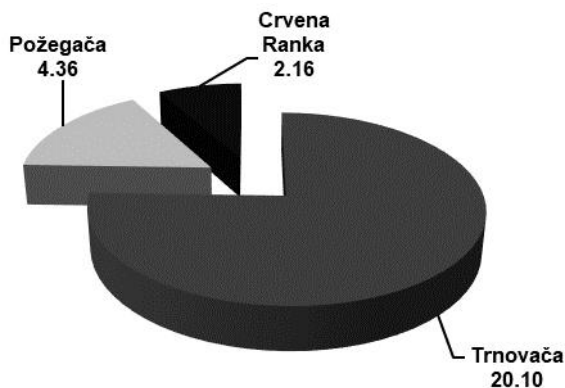
ha. - 7003
20.10 ha (1 2).
" " 1365
4.36 ha,
" - 731
2.10 ha.

Total contracted production of autochthonous plum cultivars in the Region of Kosjeri accounts for 9099 trees cultivated in the area of 26.62 ha. With 7003 trees cultivated in 20.10 ha, the cultivar 'Trnovača' is the most common (Figure 1 and 2). It is followed by 'Požegača' with 1365 trees cultivated in 4.36 ha, while the cultivar 'Crvena Ranka' is the least present, with 731 trees in the area of 2.10 ha.



. 1.

Fig. 1. Number of trees of studied autochthonous plum cultivars in the Region of Kosjeri



. 2.

(ha)

Fig. 2. Orchard area (ha) of studied autochthonous plum cultivars in the Region of Kosjeri

Yield per tree and per unit area varied depending on the cultivar, year of study and their interaction (Table 2). The greatest yield per tree (45.20 kg) and per unit area (15.73 t ha⁻¹) was found in the cultivar Trnova a, whereas the lowest values of the aforementioned parameters were obtained in the cultivar Požega a (on average 35.06 kg tree⁻¹; 10.88 t ha⁻¹).

Observed from the aspect of the studied year, the highest average yield values per tree and unit area were determined in 2007 (50.66 kg tree⁻¹; 17.63 t ha⁻¹), and the lowest in 2004 (31.66 tree⁻¹; 10.98 t ha⁻¹).

However, in certain cultivars, a different yield tendency is observed per certain year of study, which speaks in favor of the significant influence of the interaction between genotype and year of study on yield. This phenomenon is expected because the cropping is known to be controlled by numerous factors of biological and ecological nature such as genotype (Milošević and Milošević, 2011), the condition and age of trees, the amount of water in soil, temperature and light (Luić et al., 1996), as well as the applied cultivation technology (Blažek and Pišković, 2009). The lowest average yield in 2004 can be explained by the fact that the amount of precipitation during vegetation in this year was below the optimum for plum growing. Furthermore, the occurrence of the lowest yields for the 'Požega a' cultivar can be explained by the premature fruit drop due to the pronounced sensitivity of this variety to the *Plum pox virus* (Mišić and Ranković, 2002).

The Crvena Ranka' cultivar is distinguished by its high cropping, but due to the brittleness and cracking of branches in certain years, it is prone to alternative bearing (Milošević, 2002).

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2.

Table 2. Yield of the studied autochthonous plum cultivars

		Yield per tree (kg)	Yield per growing area (t ha ⁻¹)
/Genotype (A)			
	/Trnova a	45.20±9.10 a	15.73±3.29 a
	/Požega a	35.06±8.18 b	10.88±0.50 b
	/Crvena Ranka	36.80±3.56 c	11.68±0.43 c
/Year (B)			
2004		31.66±5.29 d	10.98±2.05 d
2005		37.66±5.18 bc	13.11±1.80 b
2006		37.11±3.86 c	12.91±1.34 c
2007		50.66±9.99 a	17.63±3.48 a
2008		38.00±2.92 b	13.22±1.02 b
Genotype (A) × Year (B)			
Trnova a	2004	38.00±0.86 de	13.22±0.30 de
	2005	43.00±1.73 c	14.96±0.60 bc
	2006	41.00±1.00 cd	14.27±0.35 cd
	2007	63.00±2.95 a	21.92±0.92 a
	2008	41.00±1.00 cd	14.26±0.35 cd
Požega a	2004	25.00±3.04 g	8.70±1.06 h
	2005	32.00±2.00 f	11.14±0.70 fg
	2006	32.33±0.57 f	11.25±0.20 fg
	2007	48.00±3.60 b	16.70±1.25 b
	2008	38.00±1.00 de	13.22±0.35 de
Crvena Ranka	2004	32.00±1.80 f	11.02±0.50 g
	2005	38.00±3.04 de	13.22±1.06
	2006	38.00±0.50 de	13.22±0.17 de
	2007	41.00±0.87 cd	14.27±0.30 cd
	2008	35.00±2.29 ef	12.80±0.79 f
ANOVA			
A		*	*
B		*	*
A×B		*	*

P ≤ 0.01 LSD

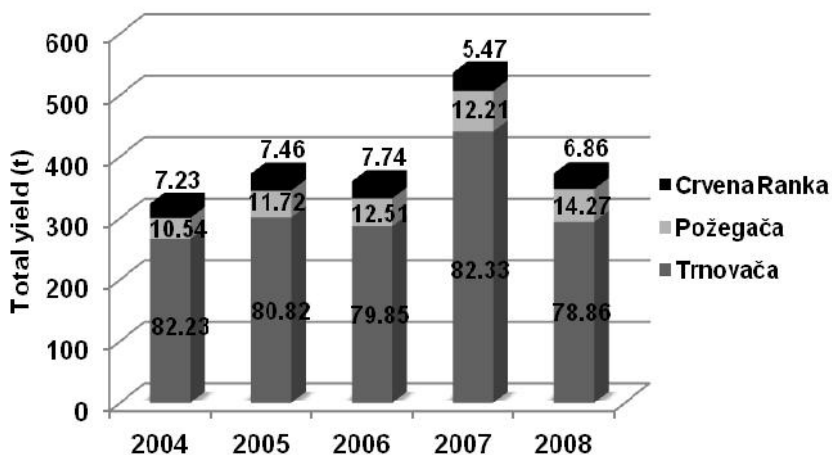
(*) P ≤ 0.05 (*)

The various lowercase letters in respective columns indicate significant differences at P ≤ 0.01 according to the LSD test.

Asterisks in columns indicate significant differences at P ≤ 0.05 (*) according to the F test.

The share of fruits of the studied autochthonous plum cultivars in total yield, by which processing the plum brandy of Protected Geographical Indication is obtained, was uniform by years (Figure 3). The share of 'Trnova a' cultivar ranged from 78.86% to 82.33%, followed by 'Požega a' with a share of 10.54–14.27%, while the smallest share was found in Crvena Ranka (5.47–7.74%).

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3. (t) (%)

Fig. 3. The share of fruits (%) of the studied autochthonous plum cultivars in total yield (t) in certain years

3.	(11,68%)	-
(14,22)	"	"
(0,98%)	"	"
(10,50%)	-	(10,86).
(11,43%),	-	2007 .
(10,50%).	-	2008 .
2006 . (0,92%),	-	
2004 2007 . (0,82%).	-	

The results of the chemical composition of autochthonous plum cultivars are shown in Table 3. The studied cultivars differed considerably in terms of the content of total sugars and total acids in fruits, as well as in terms of relation between these two parameters. The highest value of the total sugar content (11.68%) and the highest value of the ratio between the content of total sugars and total acids (14.22) were found in the fruits of 'Crvena Ranka' cultivar. The highest value of the total acids (0.98%) was determined in the fruits of 'Trnova a'. This cultivar was also characterized by the lowest value of total sugars (10.50%) and the lowest value of the ratio between the content of total sugars and total acids (10.86).

Chemical composition of fruit of the studied plum cultivars differed depending on the year of the study as well. The highest average value of the content of total sugars was determined in 2007 (11.43%), and the lowest in 2008 (10.50%). The average content of total acids in fruit was the highest in 2006 (0.92%), and the lowest in 2004 and 2007 (0.82%). The ratio between the content of

2007 . (14.03),
2008 . (11.81).

total sugars and total acids was highest in 2007 (14.03), and the lowest in 2008 (11.81). The mentioned regularity is not observed in all studied cultivars, which speaks in favor of the significant influence of the interaction effect between genotype and year of study on the analysed parameters of the chemical composition of fruit.

3.

Table 3. Chemical characteristics of the fruit of studied autochthonous plum cultivars

		/Total sugars content (%)	/Total acids content (%)	Total sugars/Total acids content
/Genotype (A)				
	Trnova a	10.50±0.27 c	0.98±0.11 a	10.86±1.41 c
	Požega a	10.88±2.84 b	0.79±0.07 c	13.77±1.42 b
	Crvena Ranka	11.68±0.43 a	0.82±0.08 b	14.22±1.72 a
/Year (B)				
	2004	11.30±0.63 a	0.82±0.63 d	13.97±2.46 a
	2005	10.93±0.47 b	0.86±0.11 c	12.92±1.91 b
	2006	10.93±0.72 b	0.92±0.19 a	12.48±2.89 c
	2007	11.43±0.55a	0.82±0.06 d	14.03±1.45 a
	2008	10.50±0.47c	0.89±0.09 b	11.81±1.22 d
() (B) Genotype (A) × Year (B)				
Trnova a	2004	10.70±0.10 fg	0.87±0.03 bc	12.31±0.29 f
	2005	10.50±0.10 gh	1.00±0.03 b	10.50±0.21 g
	2006	10.20±0.17 hi	1.15±0.06 a	8.88±0.41 h
	2007	10.80±0.26 ef	0.88±0.03 bc	12.29±0.68 f
	2008	10.30±0.17 hi	1.00±0.06 b	10.33±0.76
Požega a	2004	11.20±0.17 cd	0.90±0.02 b	12.44±0.14 f
	2005	10.80±0.17 ef	0.80±0.01 de	13.50±0.37 d
	2006	10.80±0.10 ef	0.70±0.03 f	15.44±0.48 b
	2007	11.50±0.10 bc	0.75±0.03 ef	15.34±0.43 b
	2008	10.10±0.10 h	0.81±0.04 d	12.49±0.65 f
Crvena Ranka	2004	12.00±0.50 a	0.70±0.02 f	17.16±1.09 a
	2005	11.50±0.20 bc	0.78±0.03 de	14.74±0.35 c
	2006	11.80±0.26 ab	0.90±0.02 b	13.11±0.09 e
	2007	12.00±0.17 a	0.83±0.03 cd	14.47±0.61 c
	2008	11.10±0.10 de	0.88±0.02 bc	12.61±0.17 ef
ANOVA				
	A	*	*	*
	B	*	*	*
	A×B	*	*	*

The various lowercase letters in respective columns indicate significant differences at $P \leq 0.01$ according to the LSD test.

Asterisks in columns indicate significant differences at $P \leq 0.05$ (*) according to the F test.

$P \leq 0.01$ LSD

(*)

$P \leq 0.05$ (*)

17,74% (Miši , 1996). 7-
 (Tanner and Brunner, 1998).
 " "
 " "
 - "
 Nenadovi -Mratini et al. (2007b), "
 " "
 Jordovi and Rankovi (1972). -
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 2007 ., -
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 (Nenadovi -Mratini et al., 2007b).

Edible part of plum contains 7–17.74% total sugars (Miši , 1996). For the production of top quality fruit brandys, it is essential that the fruits are characterized by high sugar content and to have a fully developed aroma typical for the species and cultivar (Tanner and Brunner, 1998). The obtained average values of total sugars and total acids content in the autochthonous plum cultivar 'Crvena Ranka' in our work are slightly lower than the results stated by Nenadovi -Mratini et al. (2007b), while the obtained results for the cultivar 'Požega a' are in agreement with the results of Jordovi and Rankovi (1972). If we observe the result tendency by years, it is noticeable that on average, the highest content of total sugars in fruits of the studied plum cultivars was determined in 2007, which was distinguished by the highest temperatures during summer months, i.e. during the period of intensive fruit development and ripening. The obtained results are in accordance with Mitrovi et al. (2006). Analysis of the obtained results showed that the chemical composition of the fruit was specific for each cultivar as well as for the conditions that were present in certain years of study. The obtained results can be explained by the fact that autochthonous cultivars are adapted to specific conditions of the environment, making them specific and different for each specific area (Nenadovi -Mratini et al., 2007b).

CONCLUSIONS

" "
 - "
 - "
 ("
 80% "
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Autochthonous plum cultivar 'Trnova a', which is characterized by the highest and most regular cropping, is predominantly represented in the Region of Kosjeri (West Serbia). It participates with about 80% of the total yield of all the studied plum cultivars, which are used to produce brandy of Protected Geographical Indication. The highest value of total sugars and the highest

values of the ratio between total sugars and the total acids in fruit were determined in the 'Crvena Ranka' cultivar. The results of the study indicate the possibility of exploitation of the existing extensive plantations of autochthonous plum cultivars as well as on the possibility of expanding production and establishing new plantations with genotypes tolerant to *Plum pox virus* in order to provide larger quantities of fruits that would be processed into high quality brandy. In this sense, it would be significant to perform clone selection within the existing population of autochthonous plum cultivars with the aim to allocate genotypes with the most favorable production traits that could be cultivated under conditions of intensive cultivation technology. Moreover, it is necessary to take certain steps with the aim to produce healthy planting material of the autochthonous cultivars.

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