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'Čačanska Rodna' – a plum cultivar for drying

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Abstract. The paper presents the results of the variability of quality of dried fruits of 'Čačanska Rodna' during the fourteen-year period, depending on the characteristics of the fresh fruits used for drying and climatic conditions during their ripening. Fruits from the plantations of Fruit Research Institute Čačak, at Preljinsko Brdo facility, where standard agro- and pomotechnical measures are regularly applied, were used for the examination. The fruits intended for drying of approximately same weight and adequate ripeness degree were picked selectively. Drying was performed in the experimental dryer at the air temperature 90°C until reaching 75% of the total dry matter in the dried fruit. Based on the results of examining chemical composition of fresh and dried plums, it can be concluded that the fruits of 'Čačanska Rodna' are suitable for drying regardless of climatic conditions during the summer period and that the desired sweet-sour taste of prunes can be obtained by processing fruits with soluble solids content higher than 18%.

Key words: plum, prune, chemical composition, sugar-acid ratio

Introduction

Prune is the most important plum product from the aspect of nutritional value. It is a significant source of energy for human body (Sijtsema et al., 2012), and due to the unique diversity of phenols and nutrients (chlorogenic acid, sorbitol, potassium, vitamin K), it has a beneficial effect on bone health (Wallace, 2017). Nevertheless, prune is an important source of various antioxidants (Pellegrini et al., 2006; Keservani et al., 2016; Miletić et al., 2019), that can inhibit harmful effects of free radicals and, thus reduce the risk of cardiovascular diseases and cancer. In order to be more represented in human diet, prunes need to satisfy the following sensory criteria – dried fruits should have a uniform weight, acceptable taste and pleasant aroma (Mitrović et al., 2016a). The quality of prunes is conditioned by the processing, i.e. drying technology, but also by the quality of the raw material. Cultivars of combined properties, whose fruits can be consumed fresh (Nenadović-Mratinić et al., 2007; Lukić et al., 2015) or processed into different products, such as jam, frozen plum and plum spirit (Veličković et al., 2004; Janković & Mašović, 2000; Popović et al., 2012) are mainly used for drying process.

'Čačanska Rodna' is one of the leading plum cultivars in Serbia, and due to its positive characteristics in terms of yield and fruit quality, it is also grown in the surrounding countries (Apostol, 2000; Fajt & Usenik, 2010; Dragoyski et al., 2010; Božović & Jaćimović, 2011), Germany (Hartman, 2001) and Poland (Grzyb, 2000). Numerous studies have shown that fruits of this cultivar can be successfully used for drying (Mitrović et al., 2007; Vintila et al., 2013; Stojanova et al., 2017; Georgijev et al., 2017) whereby dried fruits of superior quality are obtained.

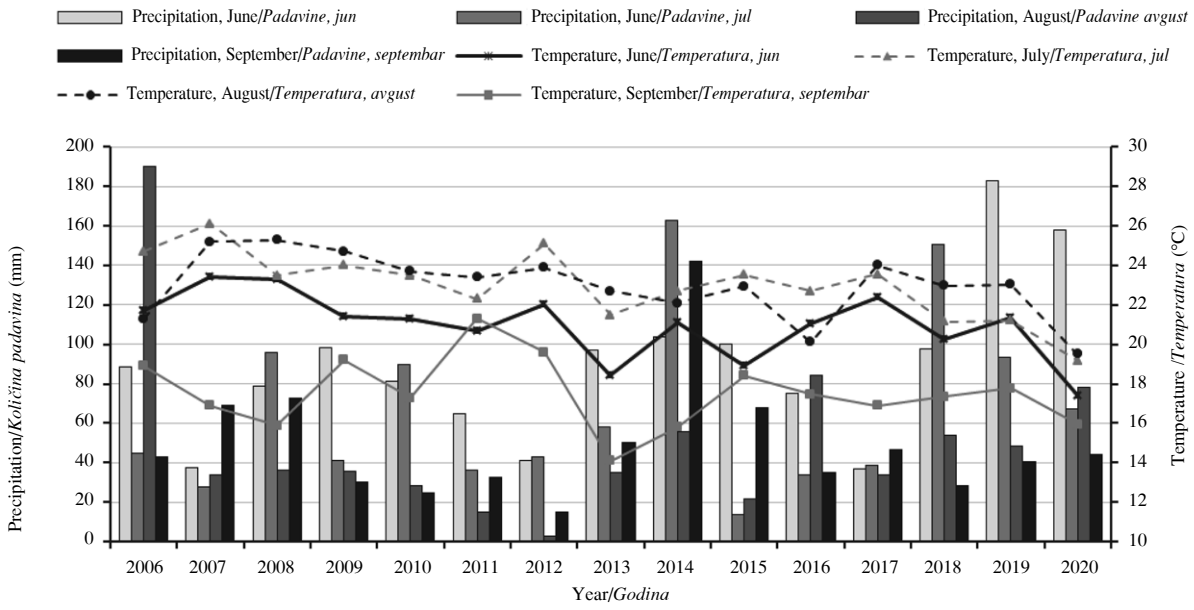
The aim of this study was to examine variability of the quality of dried fruits of 'Čačanska Rodna' during the fourteen-year period, depending on the characteristics of the fresh fruits used for drying as well as climatic conditions during their ripening.

Material and Methods

Fruits of cultivar 'Čačanska Rodna' (*Prunus domestica* L.) grafted on *Prunus cerasifera* L. seedling were collected from an experimental orchard established in 1996 in Preljina, the village situated in a plum-growing region of Čačak (43°55'26''N, 20°26'52''E). Due to non-uniform ripening, the harvest of fruits intended for drying from the same tree can last for almost 3 weeks. For the purposes of the experiment, the fruits were harvested selectively in the phase of technological maturity for drying, at the beginning of the drying season. Examinations were conducted in the period 2006–2020 except in 2012, when no tests were performed.

The drying was conducted in a laboratory convective air dryer (Kandić et al., 2007). Parameters of the mechanical composition of fresh plum fruits (fruit and stone weight), as well as the soluble solids content were determined before drying. Fresh fruits of uniform size and maturity were placed on a tray. An air-streaming drying process was applied at constant air temperature of 90°C and it was maintained throughout the drying process along with air velocity of 4 m s^{-1}. During the drying process, moisture losses from plum fruits were recorded at 60 min intervals by a digital balance. Drying was terminated when the dry matter content of the samples was about 75%.

Fresh fruits had been kept in plastic bags at -18°C until chemical analyses, whilst the dried fruits had been kept in plastic bags at room/ambient temperature (20°C) one month until chemical analyses, for conditi-



Graph 1. Climatic conditions in summer months during the examination period
Graf. 1. Klimatski uslovi u letnjim mesecima tokom perioda ispitivanja

oning. The dry matter content of the fruit was determined by a standard method, i.e. by drying at 105°C until the constant mass was reached, whereas the soluble solids content (SSC) was determined by a manual refractometer (3828, Carl Zeiss, Oberkochen, Germany). The content of total acids (TA) was determined by neutralization with 0.1 N NaOH to pH 8.2, using phenolphthalein as indicator and expressed as malic acid. The pH value was determined using a potentiometer (pH metre Mettler Toledo EL 20-Basic, Schwerzenbach, Switzerland). Sucrose, inverted sugars, and total sugars content were determined by Luff-Schoorl method (Tanner & Brunner, 1979).

The Čačak area is of temperate climate, with hot summers and cold winters. During the experimental period (2006-2020) climatic data were provided by the Experimental Meteorological Station of the Fruit Research Institute in Čačak. Monthly precipitation and average monthly temperatures for the period of intensive fruit growth (June and July) and the period of fruit ripening (August and September) are shown in Graph 1. Climatic conditions were within normal limits for most of the years in the observed period. The mean monthly air temperatures were 20.97°C, 22.98°C, 22.99°C and 17.55°C, respectively, for most of the observed years of the study, except for 2007, 2012 and 2017, which were very warm, whilst 2020 was a relatively cold year with temperatures lower than the mean values. Temperature was not a limiting factor for plum cultivation during the study period. The characteristic of the temperate continental climate is that the most rain falls in May and June, which was the case with all observed years, except 2006, 2014 and 2018. The wettest year was 2014, with the highest amount of precipitation during all observed months, and 2006, 2018, 2019 and 2020 were also considered as wet years. Extremely dry years were 2007, 2011, 2012 and 2017, which also represented the warmest years.

Results and Discussion

Fruits of uniform mass, harvested at the stage of technological maturity were used for drying. During the 14-year study period (2006–2020), the average fruit weight was 36.34 g (Tab. 1), except in 2015 and 2018, when the fruits were significantly smaller (27.20 g) and larger (44.85 g), respectively. This is in line with the results of Nenadović-Mratinić et al. (2007) and Božović & Jaćimović (2011), who examined fruits harvested for fresh consumption. As for the drying, the best results in terms of prune quality were shown by fruits with an average weight of 30–40 g (Scotile et al., 2010) due to the best drying yield achieved (Mitrović et al., 2007) and more favourable drying rate compared to smaller and very large fruits (Mitrović et al., 2013a).

Tab. 1. Harvesting dates and mechanical properties of fresh plum fruits
Tab. 1. Momenat berbe i mehanički sastav svežih plodova šljive

Year *Godina*	Harvesting date *Datum berbe*	Fruit mass *Masa ploda* (g)	Stone mass *Masa koštice* (g)	Stone ratio *Udeo koštice* (%)
2006	06. 08.	35.50	1.37	3.86
2007	20. 08	37.40	1.56	4.17
2008	19. 08.	38.50	1.44	3.74
2009	26. 08.	36.70	1.45	3.95
2010	31. 08.	39.22	1.42	3.62
2011	29. 08.	37.65	1.61	4.27
2013	28. 08.	35.93	1.35	3.76
2014	01. 09.	32.55	1.38	4.26
2015	03. 09.	27.20	1.43	5.25
2016	22. 08.	34.60	1.30	3.76
2017	22. 08.	34.10	1.74	5.10
2018	20. 08.	44.85	1.42	3.16
2019	23. 08.	36.54	1.46	4.00
2020	01. 09.	37.97	1.41	3.80
Average/*Prosek*	20. 08.	36.34	1.45	4.05

The fruits were harvested in the last decade of August (Tab. 1), regardless of climatic conditions, the amount of precipitation and average monthly temperatures, for the months of June, July and August. The exception was 2006, when the harvest was done on August 6, which was the earliest harvest date for this cultivar during the study period. The average harvest time of the fruits intended for fresh consumption is mid-August (Nenadović-Mratinić et al., 2007; Fajt & Usenik, 2010; Glišić et al., 2016), whilst for those processed into plum spirit, harvest can be done until mid-September (Popović et al., 2012). Considering that the harvest of the fruits for processing into prunes can be extended to 3–4 weeks (Mitrović et al., 2019), the displayed harvest dates were the dates of the drying season beginning, i.e. the moments when fruits have reached the adequate dry matter content for this type of processing. The average content of total dry matter in the observed period was 20.80% (Tab. 2), taking into account that the fruits in 2019 had only 18.05% of total dry matter. According to our previous study on the suitability of this cultivar for drying, it had been shown that the fruits with a total dry matter content less than 20%, or soluble solids content less than 18% (Mitrović et al., 2007; Mitrović et al., 2016b) gave poorer quality of prunes in terms of sensory properties, with lower drying yield as well. The content of total sugars ranged from 12.08% (2020) to 14.95% (2008), or an average of 13.26%, which was in the line with the results of Miletić et al. (2007) 12.4–14.4%, Božović & Jaćimović (2011) 13.39%, i.e. 12–15% depending on the ripeness degree (Usenik et al., 2008).

The content of total acids in the plum fruit during 14 years of examination ranged from 0.53 to 0.95% (Tab. 2). Describing the characteristics of this cultivar, Lukić et al. (2016) stated that the average content of total acids was 0.97%, which was in accordance with the results of Nenadović-Mratinić et al. (2007), Miletić et al., (2007) and Stojanova et al. (2017). Examining the change in plum fruit quality during ripening, Usenik et al. (2008) concluded that, with increasing maturity the content of the most dominant malic acid decreased. Therefore, the content of total acids in fruits with higher dry matter, i.e. in more mature fruits, ranged from 0.53% (Popović et al., 2012; Mitrović et al., 2019) to 0.71–0.77% (Minev & Stojanova, 2012; Mitrović et al., 2013b).

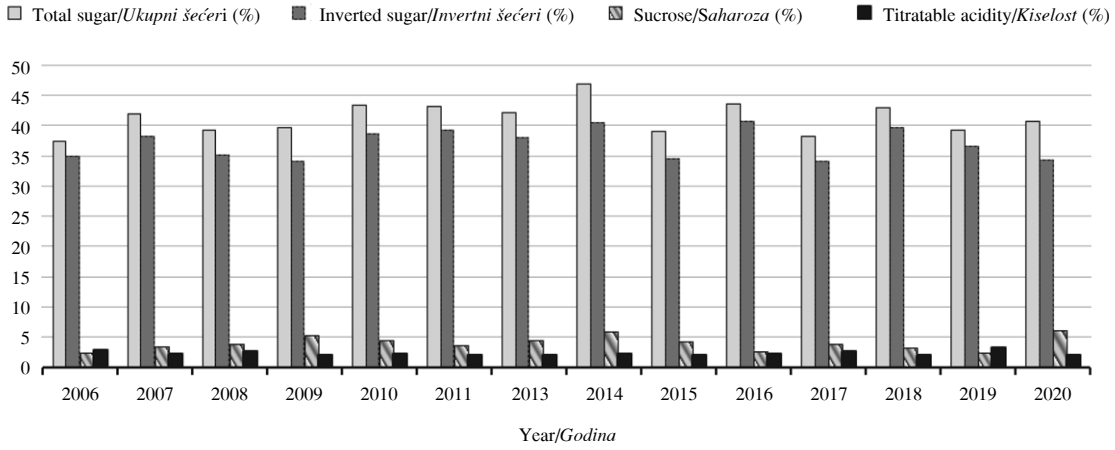
The 14-year study period included different climatic conditions (dry and rainy years), although, in the period of June, July and August, the average daily temperatures were similar, ranging from 20–23°C

Tab. 2. Chemical composition of fresh plum fruits
Tab. 2. Hemijski sastav svežih plodova šljive

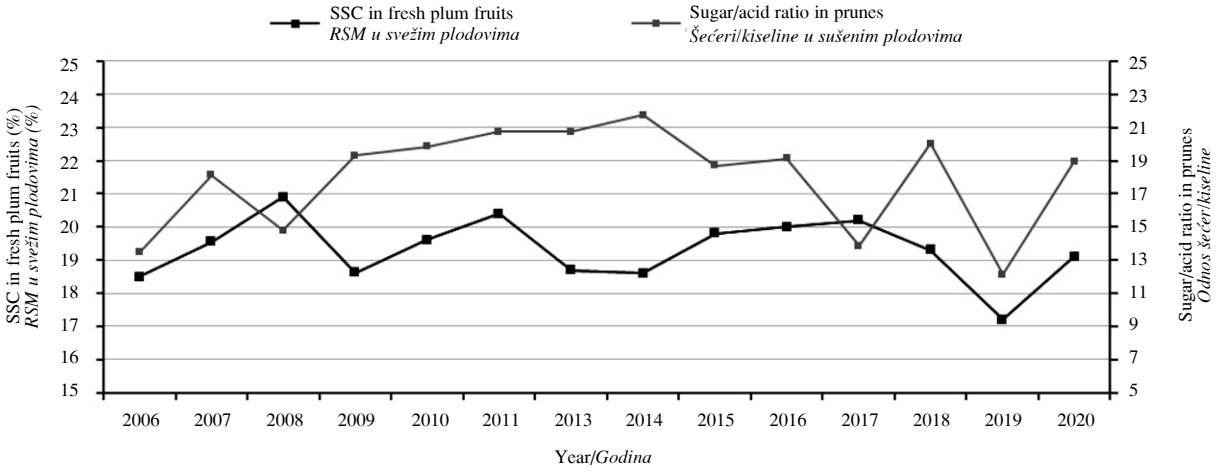
Year *Godina*	Total dry matter *Ukupna suva meterija* (%)	pH *pH*	Total acids *Ukupne kiseline* (%)	Total sugars *Ukupni šećeri* (%)	Inverted sugars *Invertni šećeri* (%)	Sucrose *Saharoza* (%)	SSC/TA ratio *Odnos RSM/UK*	Sugar/TA ratio *Odnos šećer/UK*
2006	19.60	3.03	0.86	12.45	6.85	5.32	21.51	14.48
2007	21.62	3.75	0.62	13.95	7.73	5.91	31.53	22.50
2008	21.88	3.68	0.89	14.95	7.85	6.75	23.48	16.80
2009	20.08	3.53	0.95	12.82	8.35	4.25	19.60	13.49
2010	20.65	3.62	0.75	13.20	7.48	5.43	26.13	17.60
2011	21.86	3.43	0.70	13.70	7.73	5.67	29.14	19.57
2013	20.20	3.69	0.53	13.45	8.03	5.42	35.28	25.38
2014	20.91	3.83	0.63	13.70	7.10	6.27	29.52	21.75
2015	21.77	3.68	0.67	12.20	8.10	3.90	29.55	18.21
2016	21.58	3.63	0.74	13.95	7.98	5.67	27.03	18.85
2017	21.85	3.70	0.82	13.20	8.98	4.01	24.63	16.10
2018	21.24	3.70	0.70	13.58	7.85	5.44	27.57	19.40
2019	18.05	3.50	0.94	12.45	5.66	6.45	18.30	13.24
2020	19.87	3.41	0.86	12.08	6.48	5.32	22.21	14.04
Average *Prosek*	20.80	3.58	0.76	13.26	7.58	5.41	26.09	17.96

(Graph 1). Mišić (1996) stated that plums during summer months were best suited to an average air temperature of 18 to 20°C. Considering that plum tolerates air temperature up to 35°C and that for the purposes of testing in our study, a selective harvest was performed from trees in intensive orchards (with applied sharp pruning and appropriate protection against diseases and pests), fruit quality was suitable for drying during the entire study period (except 2019).

The chemical composition of prunes is shown in Graph 2, with observation that there are no large deviations in the content of the examined parameters depending on the year, i.e. on the climatic conditions. The average content of total sugars was 41.12% (range 39–42%), except in 2006 (37.46%) and 2014 (46.96%), which was in line with the results of Družić et al. (2007) and Mitrović et al. (2013b; 2019). Regardless of the climatic conditions during the observed years and the initial content of total dry matter in fresh fruits, all examined parameters of chemical composition were within the limits typical for prunes. However, there were differences in terms of sensory characteristics, primarily the taste of prunes, characterized by the sugar-acid ratio (Graph 3).



Graph 2. Chemical composition of prunes (75% dry matter content)
Graf. 2. Hemijski sastav sušene šljive (75% ukupne suve materije)



Graph 3. Soluble solids content (SSC) in fresh plum fruits and sugar/acid ratio in prunes
Graf. 3. Sadržaj rastvorljive suve materije (RSM) u svežim plodovima i odnos šećer/kiseline u sušenim plodovima šljive

Mitrovic et al. (2016a) stated that the harmonious taste of prunes was obtained when the sugar-acid ratio was in the range from 20 to 30, and the sour taste when this parameter was between 16 and 20. In our study, a large number of samples had the value of this parameter in the range from 19 to 21, which means that the fruits were sour to sweet-sour and had harmonious taste. The exceptions were 2019, 2006 and 2008, in which the values of this parameter were 12.14, 13.47 and 14.79, respectively. Fruits with a value less than 16 have a sour taste, which is, according to consumers, less acceptable. The results of this research showed that prunes of 'Čačanska Rodna' with a favourable sugar-acid ratio (values above 16) were obtained by drying the fruits with the soluble solids content higher than 18% (Graph 3), which was in accordance with the results of Mitrović et al. (2016b) who have examined the influence of ripeness degree on the quality of prune.

Conclusion

Based on the results during 14 years of research, it can be concluded that the fruits of 'Čačanska Rodna' are suitable for drying regardless of climatic conditions during the summer period. Results of testing the chemical composition of fresh and dried fruits revealed that the desired sweet-sour taste of prunes can be obtained by processing the fruits with the soluble solids content higher than 18%.

Acknowledgements

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ČAČANSKA RODNA – SORTA ŠLJIVE ZA SUŠENJE

Olga Mitrović[1*], Branko Popović[1], Ivana S. Glišić[1], Aleksandra Koričanac[1], Aleksandar Leposavić[1], Darko Jevremović[1], Nemanja Miletić[1]

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Rezime

Čačanska rodna je jedna od vodećih sorti šljive u Srbiji, a zbog svojih pozitivnih osobina u pogledu rodnosti i kvaliteta ploda koristi se za potrošnju u svežem stanju, ali i za preradu u različite proizvode, kao što su suva šljiva, džem, smrznuta šljiva i rakija šljivovica. U radu su prikazani rezultati ispitivanja varijabilnosti kvaliteta osušenih plodova sorte Čačanska rodna tokom perioda od 14 godina, a u zavisnosti od osobina svežih plodova korišćenih za sušenje i klimatskih uslova tokom njihovog sazrevanja.

Za ispitivanje su korišćeni plodovi iz zasada Instituta za voćarstvo, Čačak (lokalitet Preljinsko brdo), gde se redovno primenjuju agro- i pomotehničke mere uobičajene za ovu vrstu voćaka. Probirno su ubrani plodovi približno iste mase i stepena zrelosti koji odgovara preradi sušenjem. Sušenje plodova je obavljeno u eksperimentalnoj sušari na temperaturi vazduha od 90 °C do postizanja 75% ukupne suve materije u osušenom plodu. Period ispitivanja od 14 godina obuhvatio je različite klimatske prilike u letnjem periodu (sušne i kišne godine).

Na osnovu rezultata ispitivanja hemijskog sastava sveže i suve šljive može se zaključiti da su plodovi sorte Čačanska rodna pogodni za sušenje bez obzira na klimatske prilike tokom letnjeg perioda. Iako je u našim ispitivanjima sadržaj rastvorljive suve materije u svežem plodu bio različit, od 17,20% do 20,90% (prosek 19,32%), sušenjem su dobijeni suvi plodovi kod kojih se svi ispitivani parametri hemijskog sastava nalaze u granicama karakterističnim za suve šljive. Međutim, značajne razlike postoje u pogledu odnosa šećer/kiseline, koji u velikoj meri određuje ukus ploda suve šljive. Rezultati istraživanja pokazuju da se sušenjem plodova sorte Čačanska rodna sa sadržajem rastvorljive suve materije većim od 18%, dobijaju sušeni plodovi sa povoljnim odnosom šećer/kiseliine koji daje poželjni slatko-nakiseli ukus suve šljive.

Ključne reči: šljiva, sušena šljiva, hemijski sastav ploda, odnos šećer/kiseline