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SUITABILITY OF CHOSEN PLUM CULTIVARS (*Prunus domestica* L.) FOR FRUIT WINE PRODUCTION

POGODNOST ODABRANIH SORTI DOMAĆE ŠLJIVE (*Prunus domestica* L.) ZA PROIZVODNJU VOĆNOG VINA

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ABSTRACT

The aim of this study was to assess the suitability of the selected plum varieties for production of fruit wine. In the study, three plum varieties: Čačanska rana, Čačanska lepotica and Požegača, with different fruit ripening time, were used as raw material. The analysis of plums mechanical content showed that Čačanska lepotica and Požegača have a significantly larger share of skin in the fruit compared to Čačanska rana. The most favourable flesh/stone ratio was determined in variety Čačanska lepotica (17.8). The tested plum varieties are characterized by a favourable ratio of sugar (134-163 g/kg of pomace) and fruit acids (from 6.5 to 8.8 g/L of juice). The level of fermentable nitrogen in the analysed samples was the highest in Čačanska lepotica (385 mg/L) and the lowest in Čačanska rana. Based on the obtained results it can be concluded that Čačanska lepotica and Požegača have great potential for the fruit wine production.

Key words: *plum, fruit wine, quality, mechanical composition, chemical composition.*

REZIME

Cilj ovog rada bio je da se oceni pogodnost odabranih sorti domaće šljive za proizvodnju voćnog vina. U istraživanju su, kao sirovina, korištene tri sorte domaće šljive različitih epoha sazrevanja: Čačanska rana, Čačanska lepotica i Požegača. S obzirom da je plod šljive korišten kao polazni materijal za proizvodnju voćnog vina, bilo je potrebno izvršiti analizu njegovog mehaničkog i hemijskog sastava. Analizom mase pokožice, tj. njenog procentualnog udela, uočeno je da sorte Čačanska lepotica i Požegača imaju značajno veći udeo pokožice u plodu u odnosu na Čačansku ranu. Najpovoljniji odnos mezokarpa i koštice utvrđen je kod sorte Čačanska lepotica (17,8). Ispitivane sorte šljive karakteriše povoljan odnos šećera (134-163 g/kg kljuka) i voćnih kiselina (6,5-8,8 g/l soka). Sadržaj asimilabilnog azota u ispitivanim uzorcima šljive bio je najviši kod sorte Čačanska lepotica (385 mg/l) a najniži kod Čačanske rane. Utvrđene mehaničke i hemijske karakteristike kljuka i soka ispitivanih sorti šljive ukazuju da se korišteni plodovi Čačanske lepotice i Požegače mogu smatrati kvalitetnim sirovinama za proizvodnju voćnog vina.

Ključne reči: *šljiva, voćno vino, kvalitet, mehanički sastav, hemijski sastav.*

INTRODUCTION

Fruit wine is an alcoholic beverage produced by complete or partial alcoholic fermentation of the juice or pomace obtained from fresh and technologically mature fruits. Because of its light, fruity and refreshing character this wine type is becoming more popular in the world. The trend of production and consumption of fruit wines in the Republic of Serbia is practically negligible, despite large annual production of various kinds of fruit. Plum (*Prunus domestica* L.) is certainly the most important and most widely grown fruit species in Serbia, with an average annual yield of 600,000 tons (*Milić et al., 2011*; *Faostat, 2013*). The largest part of the plums produced is exported fresh for table consumption, dried (*Milić and Sredojević, 2007*) or processed into soft drink, jam and, above all, internationally recognised plum brandy (*Nikićević and Paunović, 2013*).

The dry matter content in domestic plums ranges from 14 to 21 %, while the share of soluble solids is from 13 to 18.5 %. Plums are characterized by a favourable ratio of sugar (8-16 % w/v) and fruit acids (5-14 g/kg). The pH value in mature plum fruit ranges from 3.3 to 3.6. The most common sugars are glucose (3.5-5.5 %), fructose (0.9 to 2.8 %) and sucrose (3.5-4.5%), while malic acid makes up 70 % of total acid in the fruit (*Mišić, 2006*; *Mitrović et al., 2006*; *García-Mariño et al., 2008*). Plums are good source of vitamin A and C, as well as of potassium and other mineral compounds (*Hui et al., 2006*). Consumption of plums, despite the significant content of total sugars, does not lead to a rapid increase in the amount of glucose in blood, which can probably be explained by the high content of dietary fibre, fructose and sorbitol (*Walkowiak-Tomczak, 2008*). Dietary fibres of plums are mainly composed of soluble fraction (about 80 %), which mainly include pectic substances, hemicellulose, cellulose and small amounts of lignin (*Milala et al., 2013*).

There is a lack of available relevant data about plum wine production and characterisation. Technologically, production of fruit wine do not differ significantly from the production of grape wine, but considering the specifics of plum as raw material, primarily in terms of its physico-chemical and sensorial characteristics, the investigation of entire vinification process will allow producing the final product of the highest and standardized quality. As the first phase of the extensive research, the aim of this paper was to assess the suitability of the selected plum varieties grown in Serbia for production of fruit wine, based on their mechanical and chemical composition.

MATERIAL AND METHOD

Three plum varieties with different fruit ripening times: Čačanska rana, Čačanska lepotica and Požegača, were used as raw material for production of fruit wine. Those represent one of the best and most abundant plum varieties grown in Serbia. Plums are procured from local, registered fruit producers from Fruška gora region. Plums were harvested at the stage of technological maturity, so Čačanska rana in late July, Čačanska lepotica middle of August, and Požegača in the first half of September. Plum fruits were analysed, processed and used for microvinification immediately after harvest. The representativeness of different plum samples which were used

for fruit wine production is provided by homogenization of the entire amount of pomace obtained after crushing of fruits without stones.

Mechanical and chemical composition of tested plums varieties was analysed during three consecutive years (vintages 2011, 2012 and 2013). The values of these fruit quality parameters are expressed as the mean values of determinations carried out during above mentioned three years.

Under the mechanical composition of the plum fruit, the share of its main constituents (skin, flesh and stone) was determined and expressed in mass percents. The average weight of the fruits from different plum varieties was expressed as the mean value from measurement of ten random samples.

Samples of plum pomaces were analysed for dry matter, ash total sugar, reduced sugars, sucrose, total acids, pH and using standard OIV methods (*OIV, 2013*). The content of malic and citric acid was determined by enzymatic methods (*OIV, 2013*) using a commercial enzyme tests (Megazyme, CO, Wicklow, Republic of Ireland). Total nitrogen was determined by the Kjeldahl method (*MEBAK, 1997*). The fermentable nitrogen was determined by the Formol titration method (*Zoecklein et al., 1999*). The amount of total pectin in plum pomace samples was determined colorimetrically with 3-phenylphenol (meta-hydroxydiphenyl) (*List et al., 1985*). The degree of pectin esterification (DE) in the examined samples was determined according to the method described in detail in the paper *Hou et al.* (*2008*).

RESULTS AND DISCUSSION

Percentage ratio of certain parts of the fruit (skin, flesh and stone) depends on the plum variety, as well as on health and ecological conditions of cultivation and harvesting time. The weight ratio of fruit flesh, skin and stone can have a significant impact on a number of wine quality parameters such as yield, colour, composition and content of phenolic and aromatic compounds etc. Mechanical composition of fruits from investigated plum varieties in presented in Table 1.

Table 1. Mechanical composition of used plums' fruits

Variety	Fruit weight (g)*	Flesh (% w/w)	Stone (% w/w)	Skin (% w/w)	Flesh / stone ratio
Čačanska rana	36.2 ± 3.1^{c}	87.5 ± 0.4^{c}	5.8 ± 0.3^{b}	6.7 ± 0.5^{a}	15.1^{b}
Čačanska lepotica	28.9 ± 1.5^{b}	85.6 ± 0.2^{b}	4.8 ± 0.3^{a}	9.4 ± 0.7^{b}	17.8^{c}
Požegača	13.1 ± 0.9^{a}	83.8 ± 0.8^{a}	6.2 ± 0.7^{b}	9.8 ± 0.3^{b}	13.5^{a}

$^{a, b, c}$ different letter in the same column means statistically significant differences among values ($p<0.05$).

**fruit weight respresent the mean value of ten random samples mesurment.*

The average fruit weight varies significantly among the varieties, the largest is for Čačanska rana (36.2 g) and the lowest for Požegača (13.1 g). The analysis of plums mechanical content showed that Čačanska lepotica and Požegača have a significantly larger share of skin in the fruit (9.4 % and 9.8 %, respectively) compared to Čačanska rana, which have the largest share of flesh (87.5 %). The tested plum varieties were characterized by easy separation of stones from the flesh. The most favourable flesh/stone ratio was determined in variety Čačanska lepotica (17.8), which mean that this variety has potential to give larger wine yield than other two varieties. In relation to the common plum (*Prunus domestica* L.) fruit, flesh and skin make 94.1 to 96.3 % of the total weight while the rest goes on the stone (*Mišić, 2006*). Chemical composition of raw material largely determines the quality of the produced wine. Insight into the most important characteristics of raw material (plum pomace), such as pH, sugar content, content of fermentable nitrogen etc. indicate the possible need for correction of chemical composition in order to led alcoholic fermentation adequately and to ensure the best quality of wine. Chemical characteristics of investigated plum varieties are shown in Table 2.

Table 2. Chemical characteristics of juices and pomaces obtained from used plum varieties

Characteristic	Variety		
	Čačanska rana	Čačanska lepotica	Požegača
Dry matter (% w/w)	20.7 ± 07^{ab}	18.3 ± 0.8^{a}	21.7 ± 0.2^{ab}
Total sugar (g/kg)	134.1 ± 4.1^{a}	152.2 ± 3.4^{b}	163.6 ± 2.8^{c}
Reducing sugars (g/kg)	73.9 ± 3.1^{a}	89.2 ± 4.9^{b}	111.4 ± 9.2^{c}
Sucrose (g/kg)	52.7 ± 2.5^{b}	53.1 ± 1.7^{b}	42.8 ± 3.3^{a}
pH	3.5 ± 0.0^{a}	3.45 ± 0.05^{a}	3.6 ± 0.0^{a}
Total acids (g/l)	8.8 ± 0.1^{c}	7.8 ± 0.1^{b}	6.5 ± 0.2^{a}
Malic acid (g/l)	5.3 ± 0.8^{b}	5.6 ± 0.1^{b}	3.9 ± 0.4^{a}
Citric acid (g/l)	1.9 ± 0.2^{b}	1.1 ± 0.2^{a}	0.8 ± 0.3^{a}
Total nitrogen (mg/l)	700 ± 33^{a}	800 ± 18^{b}	650 ± 25^{a}
Fermentable nitrogen (mg/l)	280 ± 12^{a}	385 ± 20^{c}	322 ± 9^{b}
Ash (% w/w)	0.47 ± 0.01^{b}	0.39 ± 0.03^{a}	0.59 ± 0.02^{c}
Pectin (g/kg fw*)	37 ± 1^{b}	25 ± 3^{a}	30 ± 3^{a}
Degree of pectin esterification (%)	55 ± 3^{bc}	47 ± 4^{b}	28 ± 3^{a}

**fw – per kg of fruit fresh weight, without stone.*

$^{a, b, c}$ different letter in the same row means statistically ignificant differences among values ($p<0.05$).

The tested plum varieties are characterized by a favourable ratio of sugar (134-163 g/kg of pomace) and fruit acids (from 6.5 to 8.8 g/L of juice). As expected, the lowest sugar content and the highest total acid content were determined in Čačanska rana, considering that it is the plum variety with early fruit ripening time. The share of reducing sugars (glucose and fructose) in total sugar was for Čačanska rana and Čačanska lepotica around 55-60 %, while in Požegača it was about 70 %. The rest of total sugar makes sucrose (25-40 %). The obtained results are in accordance with previously published data (*Mišić, 2006*; *Mitrović et al., 2006*). The pH values determined in pomaces of all three plum varieties (3.45-3.60) are in the optimal range for wine fermentation (3.1-3.6) according to literature (*Jackson, 2008*). Malic acid was the most dominant acid in investigated plum varieties, and its share in the total acid content ranged from 60 % at Čačanska rana and Požegača to up to 70 % at Čačanska lepotica. This is in agreement with values determined in other plum varieties (*García-Mariño et al., 2008*). Pomaces of tested plums also contained significant concentrations of citric acid (0.8-1.9 g / l). The highest content of ash was determined in Požegača (0.59 %). The obtained values are consistent with previously published results (*Nergiz and Yildiz, 1997*) which reported that the average ash content in plums amounts 0.55 %. For

comparison, the average ash content in grapes is 0.45 % (*Ribéreau-Gayon et al., 2006*). Mineral compounds, expressed through the ash content, have a significant impact on the growth and metabolic activity of the yeast during fermentation (*Ribéreau-Gayon et al., 2006*).

Presence of nitrogen sources in raw material is very important for the alcoholic fermentation. The role of these compounds which in the metabolic activity of yeasts and in the formation of compounds that significantly contribute to the flavour and aroma of wine is especially emphasized (*Jackson, 2008*). The level of fermentable nitrogen in the analysed samples was the highest in Čačanska lepotica (385 mg/L) and the lowest in Čačanska rana. Fermentable nitrogen makes up about 50 % of the total nitrogen at Požegača and Čačanska lepotica, while this proportion was significantly lower in Čačanska rana (37 %). Given that the literature points out that the minimum content fermentable nitrogen required for normal activity of the yeast is 120-140 mg/L (*Henschke and Jiranek, 1993*), and that the values of this parameter in the pomace of tested plums varieties are significantly above mentioned minimum, a rapid yeast growth, increased fermentation rate, as well as a significant production of aromatic compounds, could be expected.

The highest content of pectin was determined in Čačanska rana (37 g/kg of fresh fruit without stone), while the value of this parameter was not significantly different in the other two varieties. The obtained values are in agreement with literature data for the content of pectin in common plum varieties (21-36 g/kg of fresh fruit without stone) (*Rop et al., 2009*). The high content of pectin is also characteristic of apples, 10-50 g/kg of fresh fruit (*Bailoni et al., 2005*) and quince, with the average of 30 g/kg (*Baker, 1997*). It is known that pectic substances have a high nutritional value as a component of dietary fiber. Their technological properties can be useful (in the production of fruit jams and jellies) as well as unfavorable (for the production of juices and alcoholic beverages). Great importance to the production of alcoholic beverages, in addition to the content of pectin, has a degree of their esterification with methanol (DE). This parameter has a direct impact on the amount of methanol (toxic effect for humans) formed during fermentation. The degree of pectin esterification at Čačanska rana i Čačanska lepotica (55 % and 47 %, respectively) was significantly higher compared to the Požegača (28 %). Regarding the degree of esterification, pectin can be divided into two groups: highly esterified (DE>50 %) and low esterified (DE<50 %).

CONCLUSION

Due to the largest mass fraction of skin in the fruit and the best relationship flesh/stone, it can be concluded that Čačanska lepotica has the best mechanical composition i.e. the greatest potential for the fruit wine production. Determined chemical characteristics of tested plums pomaces and juices indicate that the Čačanska lepotica and Požegača could be considered as better raw materials for the wine production compared to Čačanska rana.

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