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Quality changes during ripening of plums (*Prunus domestica* L.)

Valentina Usenik [a,*], Damijana Kastelec [b], Robert Veberič [a], Franci Štampar [a]

[a] University of Ljubljana, Biotechnical Faculty, Agronomy Department, Chair for Fruit Growing, Jamnikarjeva 101, 1000 Ljubljana, Slovenia
[b] University of Ljubljana, Biotechnical Faculty, Agronomy Department, Chair for Statistics, Jamnikarjeva 101, 1000 Ljubljana, Slovenia

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ABSTRACT

Quality changes during fruit ripening after the appearance of fruit colour of four *Prunus domestica* L. plum cultivars, 'Jojo', 'Valor', 'Čačanska rodna' and 'Čačanska najbolja', were investigated during 25 or 33 day periods. Fruit samples were analyzed for fruit weight, firmness, soluble solids content, fruit colour, content of sugars (glucose, fructose, sorbitol and sucrose), organic acids (malic, fumaric and shikimic acids), phenolics (neochlorogenic acid, *p*-coumaroylquinic acid, chlorogenic acid and rutin) and anthocyanins (cyanidin-3-rutinoside and peonidin-3-rutinoside). Ripening resulted in statistically increased fruit weight and soluble solids, decreased fruit firmness, darker colour of fruits, increased concentration of total sugars, decreased concentration of total acids, and increased concentration of anthocyanins. There was no influence of ripening on the content of phenols. The results show significant influences of cultivar on fruit weight, soluble solids content, firmness, fruit colour, concentration of total acids, SUAC index, concentration of total phenols and anthocyanins in European plums.

1. Introduction

Plums constitute the most numerous and diverse group of fruit tree species. The immense variety of plums, the distribution of the fruit through a wide area, and its adaptability to varying conditions make it, not only of great importance at present, but also for future development (Blažek, 2007). Plums also have the potential to contribute greatly to human nutrition because of their richness in fibre and antioxidants (Kim, Jeong, & Lee, 2003; Stacewicz-Sapuntzakis, Bowen, Hussain, Damayanti-Wood, & Farnsworth, 2001). Neochlorogenic acid and chlorogenic acid, two dominant phenolic compounds in prunes, were antioxidants toward isolated human LDL (Donovan, Meyer, & Waterhouse, 1998). Individual phenolics showed characteristic antioxidant capacities (Heo, Kim, Chung, & Kim, 2007). Consuming peaches, plums and nectarines is positively associated with nutrient intake, improved anthropometric measurements and reduced risk of hypertension (Beals, Fulgoni, & Fulgoni, 2005). Despite reports of plum benefits to human health, consumption remains low, which has been attributed to a lack of fruit ripening before consumption (Crisosto, Garner, Crisosto, & Bowerman, 2004).

It is not easy to determine the optimal time for picking, due to lack of a maturity index in plums. Colour of the skin is one of the most important criteria of ripening in stone fruits. In some plum cultivars, colour of the fruit skin is developed very early, when the fruit is still immature, with insufficient size and taste, and lack of flavour. Plum consumption may increase if fruit are ripe, tasty and have rich flavour (Crisosto et al., 2004). Fruit maturity controls quality attributes, such as soluble solids concentration, titratable acidity, firmness and market life potential (Crisosto, Mitchell, & Johnson, 1995). In general, ripe soluble solids concentration and ripe titratable acidity determine consumer acceptance (Crisosto et al., 2004). On other hand, fruit softening is one of the most important factors for market life potential. How can the best attributes for consumer acceptance and quality (firmness) be combined for market life potential?

The literature is extensive on parameters of fruit maturity of European (*Prunus domestica* L.) plums. There are some reports of phenolic composition (Donovan et al., 1998; Kim et al., 2003; Stacewicz-Sapuntzakis et al., 2001) and some postharvest studies (Cinquanta, Di Matteo, & Esti, 2002; Valero et al., 2004). More data are available for *Prunus salicina* plums (Crisosto et al., 2004, 1995; Taylor, Rabe, Jacobs, & Dodd, 1995; Valero, Crisosto, & Slaughter, 2007).

The aim of our study is to analyze the influence of maturation (after appearance of skin colour) on measured quality changes in

* Corresponding author. Tel.: +386 14231161; fax: +386 14231088.
E-mail address: valentina.usenik@bf.uni-lj.si (V. Usenik).

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European (*Prunus domestica*) plums and to find some correlations between measured parameters. The objective of our work was also to quantify chemical attributes (concentrations of sugars, acids, phenolic compounds and anthocyanins) of four European cultivars.

2. Materials and methods

2.1. Plant material

Fruits of plum cultivars (*Prunus domestica* L.) were collected in 2006 from the 4 year-old experimental orchard of the Agricultural Institute in Slovenia. Fruits of four plum cultivars ('Jojo', 'Valor', 'Čačanska rodna' and 'Čačanska najbolja'), grafted on Myrobalan (*Prunus cerasifera* Ehrh.), were included in the study.

Fruits were picked over 5 time points ('Valor', 'Čačanska rodna' and 'Čačanska najbolja') or 6 time points ('Jojo') at 6–8 day intervals during maturation (date 1: 17th of August (t1), date 2: 23rd of August (t2), date 3: 29th of August (t3), date 4: 4th of September (t4), date 5: 11th of September (t5) and date 6: 19th of September (t6)) in 2006. The period from t1 to t2 is 6 days, from t1 to t3 12 days, from t1 to t4 18 days, from t1 to t5 25 days and from t1 to t6 33 days. The last picking date of each cultivar coincided with fruit drop.

The variables (fruit weight, firmness, colour of skin and soluble solids (SS) content) were measured immediately after picking. 10 fruits from 1 tree were used for measurements: firmness (8 mm needle, penetrometer Chatillon) and soluble solids (SS) content (digital refractometer ATAGO WM-7). Firmness was measured on two sides of each fruit, left and right side of the fruit suture (the penetrometer tip inserted 5 mm into the flesh); an average of left and right side was calculated. Fruit colour was measured on the side opposite to the fruit suture with a Konica Minolta CR-10 Chroma Meter. CIRG index (CIRG), based on the CIELAB values; the parameters L^* (lightness), H (hue angle) and C (chroma), were calculated: $(180 - H)/(L^* + C)$. H values between 360° and 270° were considered as negative (e.g. 346° was taken as −14°) (Carreño, Martínez, Almela, & Fernández-López, 1995).

For each term and cultivar, 4 plums were randomly selected among 10 fruits for measurements of sugars, organic acids, phenols and athocyanins by HPLC. Samples were packed in plastic bags, frozen and kept at −20 °C prior to the extraction. Different compounds (sugars, acids, phenols, anthocyanins) were analyzed from the whole edible part of fruit. For each cultivar, four repetitions were carried out ($n = 4$); each repetition included 1 fruit.

2.2. Extraction and determination of sugars and organic acids

Fruit samples were analyzed for the contents of individual sugars (glucose, fructose, sucrose and sorbitol) and organic acids (malic, citric, shikimic and fumaric). Samples were homogenized with a manual blender (Braun). 10 g of mashed fruit were extracted with 50 ml of twice-distilled water for 30 min at room temperature. The extracted sample was centrifuged at 12,000 *g* for 7 min at 10 °C (Eppendorf centrifuge 5810 R, Hamburg Germany). The supernatant was filtered through a 0.45 μm cellulose ester filter (Macherey-Nagel), transferred into a vial and used for analyses.

An HPLC analysis of sugars was performed using a Thermo separation products (Riviera beach, USA) HPLC and refractive index (RI) detector. Separation of sugars was carried out using a Rezex RCM-monosaccharide column (300 × 7.8 mm) and the column temperature was maintained at 65 °C. The samples were eluted according to the isocratic method described by Šturm, Koron, and Štampar (2003).

Organic acids were analyzed by HPLC, using an Aminex HPX-87H column (300 × 7.8 mm) (Bio-Rad, USA) associated with a UV detector set at 210 nm according to the method described by Šturm et al. (2003).

Sugars and acids in cherry extracts were identified by their retention time characteristics, as well as by the internal standard method. Concentrations of sugars were expressed as g per kg of fresh weight (FW), fumaric and shikimic acids as mg per kg (FW). From the data of individual sugars and individual organic acids, sums of sugars and of acids were calculated. SUAC index was calculated as the quotient of the sum of sugars and sum of acids.

2.3. Extraction and HPLC analysis of phenolic compounds and anthocyanins

Samples were prepared according to the method described by Escarpa and Gonzalez (2000): 5 g of sample was extracted with 25 ml of MeOH containing 1% HCl and 1% 2.6-di-tert-butyl-4-methylphenol (BHT) using an ultrasonic bath. An HPLC analysis was performed using a Surveyor HPLC system and a diode array detector (DAD), controlled by a CromQuest 4.0 chromatography workstation software system (Thermo Finnigan, San Jose, CA). The phenolic compounds were analyzed at 280 nm and anthocyanins at 530 nm. The column used was a Phenomenex Gemini C_{18} (150 × 4.6 mm 3 μm), operated at 25 °C. The elution solvents were aqueous 0.01 M phosphoric acid (A) and 100% methanol (B). The samples were eluted according to the linear gradient described by Escarpa and Gonzalez (2000). The injection amount was 20 μl, and the flow rate was 1 ml/min. The phenolic compounds in cherry extracts were identified by their spectral and retention time characteristics, as well as by the internal standard method. The quantities of neochlorogenic acid were assessed from peak areas and calculated as equivalents of chlorogenic acid. *p*-Coumaroylquinic acid is a *p*-coumaric acid derivative, so the area of *p*-coumaroylquinic acid was calculated as equivalents of *p*-coumaric acid (Kim, Heo, Kim, Yang, & Lee, 2005). Concentrations were expressed as mg per 100 g of fresh weight (FW). From the data of individual phenolic compounds, sum of phenols was calculated.

Anthocyanins in plum extracts were identified with a HPLC-Finnigan™ MS detector, LCQ Deca XP MAX instrument. The quantities of identified anthocyanins, cyanidin-3-rutinoside (cyanidin rutinoside) and peonidin-3-rutinoside (peonidin rutinoside), were assessed from peak areas. Peonidin rutinoside was calculated as equivalents of cyanidin-3-rutinoside and expressed as mg cyanidin-3-rutinoside (CRE)/100 g of fresh plum. From the data of individual anthocyanins, the sum of anthocyanins was calculated.

2.4. Statistical analysis

In the cases where the variances of measured variables for the treatments could be assumed as equal (fruit weight, total acids, firmness, CIRG), the differences between four cultivars at the first and fifth time points of measurements (t1 and t5) were analyzed on the basis of the analysis of variance (ANOVA) for two factor experiment design: the first factor, "cultivar", has four levels and the second factor, "time", has two levels. The main effects and the interactions between "cultivars" and "time" were evaluated. Plums sampled in the first term were not the same as plums sampled in the fifth term, so we assumed that the data between the two levels of factor "time" are not correlated. In the cases where the variances of measured variables were different among the treatments (soluble solids, total sugars, phenols, anthocyanins), the general linear models (GLS) assuming different variances among the treatments were used. The averages of the mentioned variables were compared on the basis of contrast analysis or

Duncan's test. The univariate ANOVA or GLS were used instead of a multivariate approach, because there was no statistically significant correlation between considered variables.

3. Results and discussion

The results (except for anthocyanins) are presented for each term of picking of fruits (from Figs. 1–5 and Table 1), but statistical analyses have been done only for the differences between first and fifth time points of measurements (t1 and t5). The results for anthocyanins are presented for t1 and t5 only (Fig. 6).

The average fruit weight for four plum cultivars is shown in Table 1. Significant differences were ascertained among cultivars. Statistically, the highest fruit weight was measured in 'Valor' and 'Jojo' - there were no significant differences between them. Compared to 'Valor' and 'Jojo', significantly lower fruit weight was measured in 'Čačanska najbolja' and 'Čačanska rodna'; the latter had the statistically lowest average fruit weight among the four cultivars. Ripening (comparison of t1 and t5) resulted in statistically increased fruit weight for all four cultivars. In the 'Jojo' ripening process (t1–t5) resulted in 21.4% and (t1–t6) in 32% increased average fruit weight, 'Čačanska najbolja' in 11%, 'Čačanska rodna' 19% and 'Valor' 4%, but these differences between the cultivars were not statistically different (interaction between "time" and "cultivar" is not statistical significant $p = 0.283$). Average fruit weight did not increase linearly during the observed period (e.g. 'Jojo', t2 and t3). Deviations of average values in some time points from the positive trend can in our study be ascribed to unequal ripening of fruits on the tree, which causes large variability in the data and the sample size of $n = 10$ seems to be small. When destructive measurements are used, the tendency is to use as small samples as possible, which often results in less accurate results (Valero et al., 2007).

The content of soluble solids is shown in Table 1. Ripening (comparison of t1 and t5) resulted in statistically increased content of soluble solids. In 'Jojo', ripening (t1–t5) resulted in 37.0% and (t1–t6) resulted in 56% increased content of soluble solids, in 'Čačanska najbolja' 33%, in 'Čačanska rodna' 63% and in 'Valor' 31%. As in the case of fruit weight, there was no statistically significant interaction between "time" and "cultivars", so these differences in SS increase between cultivars were not statistically significant. Cultivars have a significant influence on the content

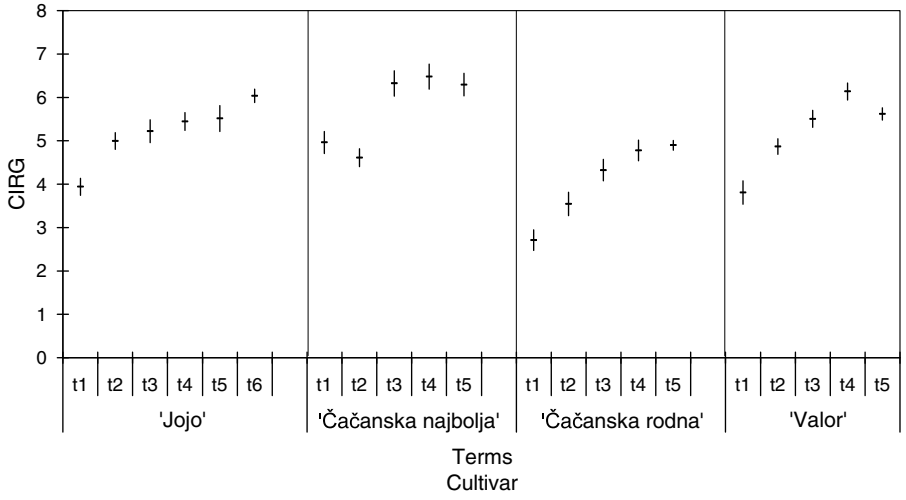

Fig. 1. Average CIRG with standard error ($\bar{x} \pm S_e$) for four plum cultivars, during 5 or 6 ('Jojo') terms of measurement.

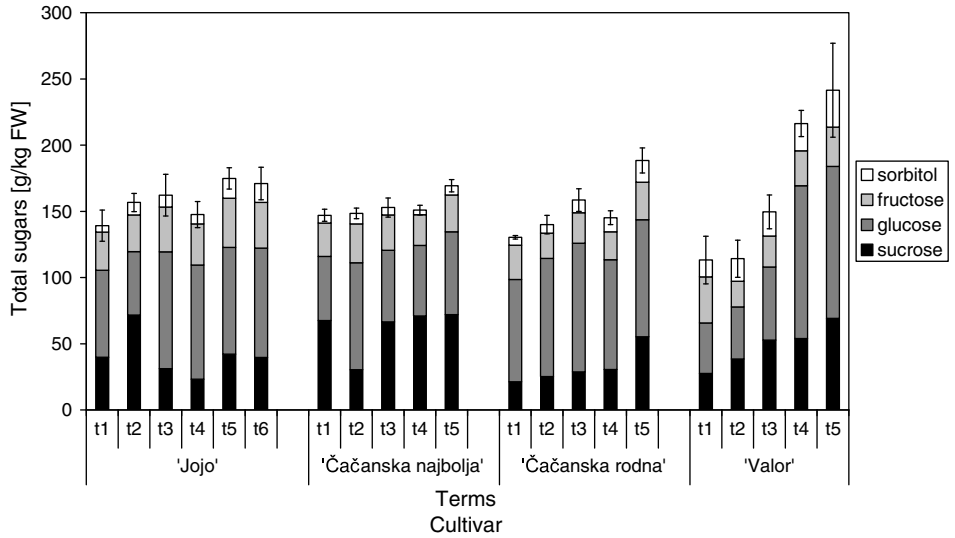

Fig. 2. Average total sugar amounts with standard errors ($\bar{x} \pm S_e$) and average individual sugar amounts for four plum cultivars during 5 or 6 ('Jojo') terms of measurements.

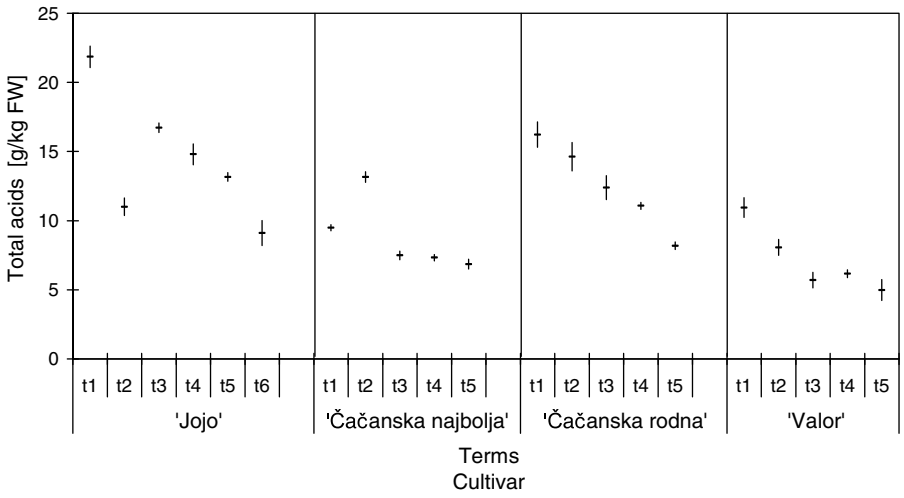

Fig. 3. Average total acid amounts with standard errors ($\bar{x} \pm S_e$) for four plum cultivars during 5 or 6 ('Jojo') terms of measurements.

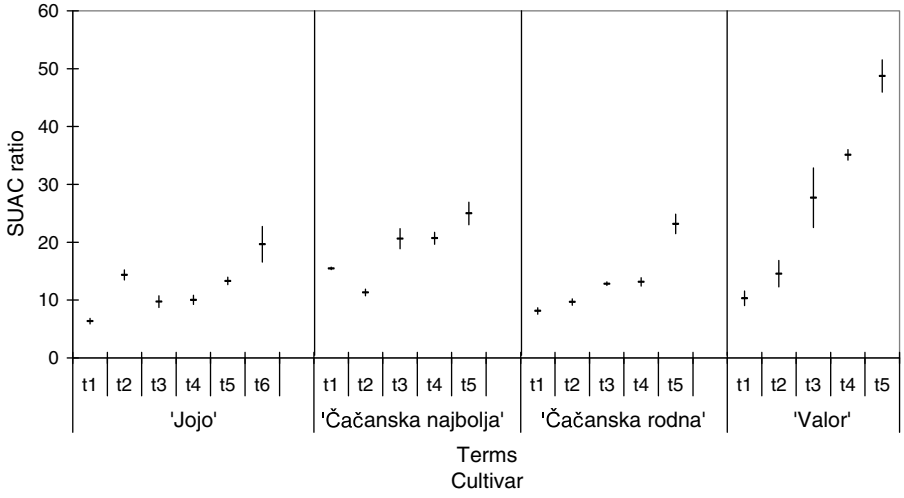

Fig. 4. Average SUAC ratios with standard errors ($\bar{x} \pm S_e$) for four plum cultivars, during 5 or 6 ('Jojo') terms of measurements.

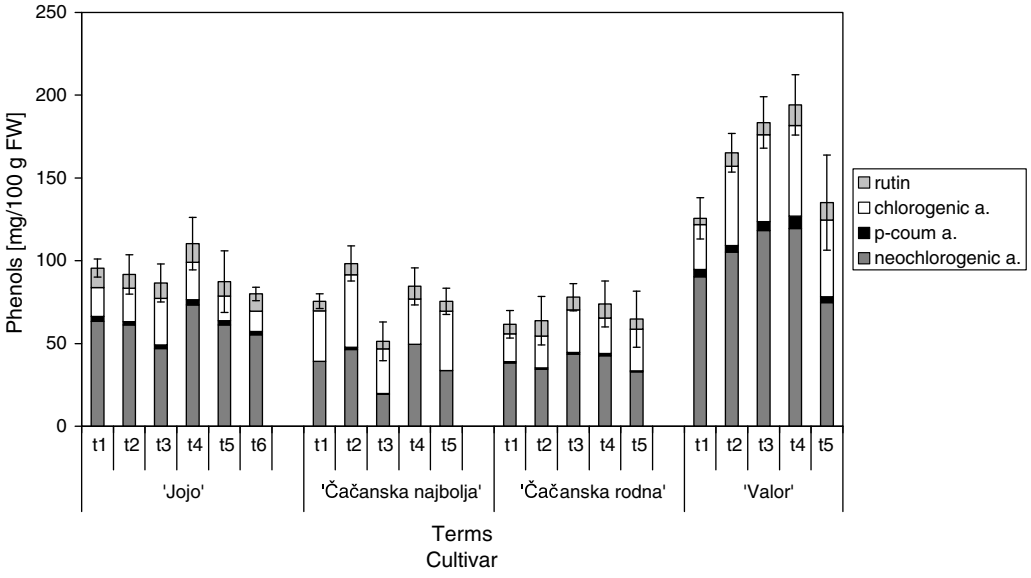

Fig. 5. Average total phenol amounts with standard errors ($\bar{x} \pm S_e$) and average individual phenol amounts for four plum cultivars during 5 or 6 ('Jojo') terms of measurements.

of soluble solids. 'Čačanska najbolja' and 'Valor' had similar contents of soluble solids, significantly higher than 'Jojo' and 'Čačanska rodna'. 'Jojo' had statistically the lowest content of SS among observed cultivars.

Fruit firmness (Table 1) was significantly reduced in the observed period for all cultivars, from t1 to t5. The loss of fruit firmness is a physiological process that occurs during fruit maturation on the tree (Abbott, 1999). Significant differences among cultivars in both time points were ascertained for fruit firmness. Statistically, the fruits of 'Jojo', were firmer than those of other cultivars. Fruits of 'Čačanska rodna' and 'Valor' were less firm than 'Jojo' and more firm than 'Čačanska najbolja'. 'Čačanska najbolja' had (significantly) the lowest values of firmness. For the fresh market, measurements of firmness are important for controlling ripening (Valero et al., 2007) but lack of reference data, particularly for European plums, make this inapplicable. Three classes were created for mature *Prunus salicina* L. fruits. Plums with >26 N would be considered 'mature' or 'immature', plums between >13 N and <26 N would be classified as 'ready to buy', and plums <13 N as 'ready to eat' (Valero et al., 2007).

It would be of commercial interest to describe the colour of a fruit by means of an optimized index (a single numerical point), principally in fruits whose quality is directly related to their external colour (Carreño et al., 1995). Our results show the usefulness of the index CIRG in plums, but we can compare our data only with the data from grapes (Carreño et al., 1995). Ripening (comparison of t1 and t5) of four plum cultivars resulted in significantly increased CIRG (Fig. 1). Colour of fruits was, at the last picking time point, more developed compared with t1, what proved that fruits at t5 were more mature than at t1. The results also show significant influence of cultivar on CIRG. The highest CIRG was measured in 'Čačanska najbolja' and the lowest in 'Čačanska rodna'. There were no differences in CIRG between 'Jojo' and 'Valor'. 'Čačanska rodna' is the least coloured cultivar. Visual observation of colour of plum fruits in our study was blue–violet at t1 and dark blue at t5 for 'Jojo', 'Čačanska najbolja' and 'Valor' and, for 'Čačanska rodna' at t1, pink and at t5 dark violet.

Ripening resulted in statistically increased concentrations of total sugars (Fig. 2) from t1 to t5. Interaction, "cultivar"*"time", was statistically significant. Average total sugars content in 'Valor' was greater than in other cultivars in the observed period. At term 1, the total sugars was higher in 'Čačanska najbolja' than in 'Čačanska rodna' ($p = 0.0018$) or 'Valor' ($p = 0.0815$). At term 5, the total sugars in 'Valor' was significantly higher than in 'Jojo' ($p = 0.0798$) and 'Čačanska najbolja' ($p = 0.0552$), and in 'Čačanska najbolja' higher than in 'Čačanska rodna' ($p = 0.0833$). Those limit statistically significant differences are the consequence of small numbers of samples and the variability among them. Glucose, fructose, sorbitol and sucrose contents were analyzed in the study. Generally, glucose was found to be highest (ranging from 38.2 to 115 g/kg FW), followed by sucrose (21.2–71.9 g/kg FW), fructose (19.1–34.8 g/kg FW) and sorbitol (3.5–27.8 g/kg FW). In Slovenian autochtonous plum selections, fructose was detected in a range from 10.1 to 19.5 g/kg FW, glucose 29.8–41.8 g/kg FW, sucrose 37.4–53.6 g/kg FW and sorbitol 34.0–50.7 g/kg FW (Usenik, Fajt, & Štampar, 2007).

There were significant differences among cultivars in total acids (Fig. 3). Generally, significantly the highest content of total acids was measured in 'Jojo', followed by 'Čačanska rodna' and the lowest in 'Valor' and 'Čačanska najbolja'. 'Valor' and 'Čačanska najbolja' had statistically similar contents of total acids. There were no significant differences between 'Valor' and 'Čačanska najbolja' at t1 and t5 among 'Čačanska najbolja' and 'Čačanska rodna'. There were significant differences between other pairs of cultivars. On average, the concentrations of total acids decreased during a 25 day period (33 for 'Jojo'). Interaction, "cultivar"*"time", was statistically significant. Average content of total acids did not decrease equally during the observed periods, a consequence of random sampling and unequal ripening of fruits on the tree of some cultivars (e.g. 'Jojo', 'Čačanska najbolja'). Malic, shikimic and fumaric acids were detected in plum cultivars (Table 2). Generally, malic acid was the predominant acid. We can conclude that ripening first of all decreased the content of malic acid.

SUAC index, calculated as a quotient of the sum of sugars and sum of acids, consequently increased during the observed period of ripening, there were also differences between the cultivars (Fig. 4). SUAC index varied from 6.4 to 19.4 in 'Jojo', from 10.3 to 48.7 in 'Valor', from 8.1 to 23.2 in 'Čačanska rodna' and from 11.3 to 25.0 in 'Čačanska najbolja'. The highest SUAC index was measured in 'Valor', followed by 'Čačanska najbolja, 'Čačanska rodna' and 'Jojo'. Higher values of SUAC index mean sweeter and less acidic fruits. The taste of 'Jojo' fruits is more acidic with regard to the lowest SUAC index and the taste of 'Valor' is more sugared and less acidic than that of other cultivars.

The content of phenolic compounds detected in plum fruits is shown in Fig. 5. Neochlorogenic acid, *p*-coumaroylquinic acid and chlorogenic acid (hydroxycinnamic acids), and rutin (flavonol) were analyzed in the study. Neochlorogenic acid was the major hydroxycinnamic acid derivative, ranging from 19.3 to 120 mg/100 g FW, followed by chlorogenic acid, ranging from 12.3 to 54.7 mg/100 g FW, rutin, ranging from 3.8 to 12.4 mg/100 g FW and *p*-coumaroylquinic acid, ranging from 0.0 to 7.6 mg/100 g FW. In pitted Californian prunes, 131 mg/100 g of neochlorogenic acid, 1.5 mg/100 g of *p*-coumaroylquinic acid, 43.0 mg/100 g chlorogenic acid and rutin, 3.3 mg/100 g, were measured (Donovan et al., 1998). Our results show significant differences between cultivars in the total content of phenols. Significantly the highest content of total phenols was at t1 and t5, measured in 'Valor', followed by 'Jojo'. 'Čačanska najbolja' and 'Čačanska rodna' had similar contents of total phenols in both terms ($p = 0.1515$) and significantly lower contents than 'Valor' and 'Jojo'. There were no significant changes in the contents of phenols from t1 to t5 ($p = 0.5176$). Our results show that ripening had no influence on the content of phenolics in plum fruits. There was no clear trend in phenolic content with ripening of peach, nectarine and plum cultivars (Tomás-Barberán et al., 2001). The present results agree

Table 1
Sample average with standard errors (SE) for fruit weight (g), soluble solids content (SS, °Brix) and firmness (N); $n = 10$, except for SS 'Jojo' t1 ($n = 9$)

Cultivar	Term	Fruit weight		Soluble solids		Firmness	
		Average	SE	Average	SE	Average	SE
'Jojo'	t1	25.2	1.4	9.1	0.2	59.0	11.4
	t2	24.1	0.8	12.6	0.2	35.1	3.4
	t3	31.3	1.5	10.7	0.4	42.3	7.9
	t4	29.4	1.2	11.4	0.5	32.9	1.9
	t5	30.6	0.9	12.5	0.5	35.3	6.3
	t6	33.2	1.9	14.2	0.5	22.2	3.4
'Čačanska najbolja'	t1	23.1	1.1	11.4	0.3	34.7	4.1
	t2	27.6	1.7	9.9	0.3	57.9	10.0
	t3	22.3	0.6	13.1	0.2	29.8	4.6
	t4	22.6	0.4	13.6	0.3	22.3	2.3
	t5	25.7	1.1	15.2	0.5	21.3	3.6
'Čačanska rodna'	t1	16.5	0.5	8.2	0.2	44.3	4.9
	t2	15.1	0.7	8.6	0.2	48.7	7.9
	t3	18.5	1.1	10.8	0.8	38.0	3.0
	t4	16.7	0.9	10.2	0.8	34.0	4.8
	t5	19.7	1.2	13.4	0.7	30.4	7.1
'Valor'	t1	27.5	1.1	12.0	0.6	49.7	8.9
	t2	27.3	1.7	13.5	0.8	46.7	8.9
	t3	30.8	2.7	15.4	1.1	35.1	8.0
	t4	25.7	1.6	15.4	1.3	25.2	6.7
	t5	28.5	1.5	15.6	1.2	31.0	8.5

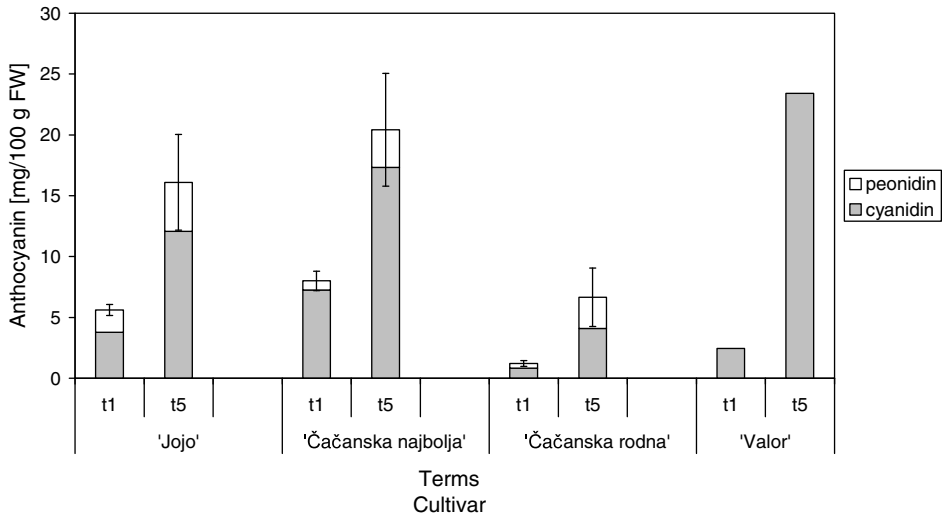

Fig. 6. Average contents of total anthocyanins with standard errors ($\bar{x} \pm S_e$) and average individual anthocyanin amounts for four plum cultivars at 1st and 5th terms of measurements.

Table 2
Sample averages with standard errors (SE) for malic, shikimic and fumaric acids; ($n = 4$)

Cultivar	Term	Malic acid (g/kg FW)		Shikimic acid (mg/kg FW)		Fumaric acid (mg/kg FW)	
		Average	SE	Average	SE	Average	SE
'Jojo'	t1	21.8	0.8	59.7	5.7	36.8	4.0
	t2	10.9	0.6	63.3	8.5	8.0	1.2
	t3	16.6	0.3	56.9	2.5	30.1	2.5
	t4	14.7	0.8	57.5	10.5	31.0	3.0
	t5	13.1	0.3	64.0	6.0	28.8	4.4
	t6	9.0	0.9	55.1	1.8	29.7	6.7
'Čačanska najbolja'	t1	9.4	0.2	52.8	2.4	7.8	0.4
	t2	13.1	0.4	55.6	7.1	11.6	0.8
	t3	7.4	0.3	42.6	7.1	8.9	1.0
	t4	7.3	0.2	46.0	4.5	9.9	0.4
	t5	6.8	0.4	44.0	4.9	6.1	0.3
'Čačanska rodna'	t1	16.2	0.9	40.0	1.2	12.7	0.7
	t2	14.6	1.0	44.3	2.5	10.1	0.3
	t3	12.4	0.9	39.6	0.9	8.7	0.3
	t4	11.0	0.3	39.7	0.8	10.7	0.9
	t5	8.1	0.3	34.9	2. 2	12.9	1.3
'Valor'	t1	10.9	0.7	62.7	7.3	8.0	0.6
	t2	8.0	0.6	76.1	5.4	9.5	2.8
	t3	5.6	0.6	69.3	5.0	13.7	4.5
	t4	6.1	0.3	25.5	9.0	6.1	2.2
	t5	4.9	0.8	25.8	4.0	9.6	1.0

with previous reports that neochlorogenic acid and chlorogenic acid are the two predominant phenolic compounds (Tomás-Barberán et al., 2001), followed by *p*-coumaroylquinic acid and rutin as the predominant flavonol (Donovan et al., 1998). Our results show that hydroxycinnamates constituted 85.2–96.9% and neochlorogenic acid 32.5–71% of the sum of identified phenolics, and are in agreement with Donovan et al. (1998). The sum of neochlorogenic acid, chlorogenic acid, *p*-coumaroylquinic acid and rutin in sweet cherries varied from 15.8 to 18.9 mg/100 g FW (Usenik, Fabčič, & Štampar, 2007) and is lower than the sum of phenols from our study in European plums. Our results agree with the report of Mattila, Hellström, and Törrönen (2006).

Ripening resulted in a statistically increased concentration of total anthocyanins (Fig. 6) (analyzed without 'Valor'). In 'Valor', a non-identified compound was detected as an ingredient in the peak of peonidin rutinoside (MS detector), particularly on the first and second sampling dates. For this reason, we decided not to include data of peonidin rutinoside for 'Valor'. Statistically significant differences were ascertained among cultivars in our study. The highest content of total anthocyanins was at t1 and t5, measured in 'Čačanska najbolja', and the lowest in 'Čačanska rodna'. The arrangement of cultivars according to the content of total anthocyanins is similar to the arrangement of cultivars based on the index CIRG (without 'Valor'). Two anthocyanins were identified in plum cultivars: cyanidin rutinoside and peonidin rutinoside. In plum cultivars (*Prunus salicina*), two main anthocyanins; cyanidin glucoside and cyanidin rutinoside (Tomás-Barberán et al., 2001; Wu & Prior, 2005) have been detected. The presence of cyanidin 3-glucoside and 3-rutinoside, as well as the occurrence of peonidin analogues, has been reported in plums, although *Prunus salicina* contained only the cyanidin derivatives (Macheix, Fleuriet, & Billot, 1990). In our study the major anthocyanin was cyanidin rutinoside, which ranged from 0.8 to 26.6 mg/100 g FW, followed by peonidin rutinoside, ranging from 0.0 to 6.1 mg CRE/100 g FW.

4. Conclusions

The results show significant influence of cultivar on fruit weight, soluble solids content, firmness, CIRG, concentration of total acids, SUAC index, concentration of total phenols and anthocyanins, in four European plum cultivars. Ripening (comparison of data from first and last sampling date) of four plum cultivars (*Prunus domestica*) resulted in statistically increased fruit weight and soluble solids, decreased fruit firmness, increased CIRG (fruit colour), increased concentration of total sugars, decreased concentration of total acids, and increased concentration of anthocyanins. On the base of our data we suppose that plums picked at the first picking date were immature. With regard to increasing SUAC index during the observed period of ripening, plums were, 25 or 33 days ('Jojo') after the appearance of colour, sweeter and less acidic, so fruits were more mature compared to t1 and we suppose that plums at t5 ('Jojo' at t6) were also more tasteful and had more flavour. Our data show that the determination of fruit maturity on the basis of the visual estimation of fruit colour is not suitable for all plum cultivars. The results suggest the need to involve some measured parameters for determination of fruit maturity in plums (*Prunus domestica*), as are used in apples or in *Prunus salicina* plums. There are several differences in the main characteristics among cultivars. Therefore, measured parameters should be

prepared for specific plum cultivars or groups of cultivars with similar characteristics.

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