Sorbitol and sugar composition of plum fruit during ripening

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Abstract
Sorbitol and sugar composition in fruits were investigated in 6 different plum cultivars during ripening. The fruits were harvested at different maturity stage in the experimental orchard of the Agricultural Institute Osijek. Sugars (glucose, fructose and sucrose) and sorbitol in fruits were identified and quantified by high performance liquid chromatography (HPLC). Significant differences were found between sucrose, glucose, fructose and sorbitol depending on harvest date and on cultivar. The amount of sorbitol and sugars in fruits significantly increased during maturation. The individual sugars, glucose and sucrose were the highest in all harvest stages. Glucose was the predominant sugar in one cultivar. Fructose content remained relatively low. Plums with high total sugar content had higher content of sorbitol. The discriminant analysis (LDA) showed that plum cultivars were clearly separated according to sorbitol and sugars composition in fruit.

Key words: plum, cultivar, ripening, sorbitol, sugars

Introduction
Plums are the most extensively distributed of the stone fruits, the most varied in native and cultivated variety and the most adapted to a wide range of soils and climatic conditions. The fruits show a wide range of size, flavour, colour, and texture. Plums are primarily used for fresh consumption as well for processing. Varietal differences can also contribute to variations in the consumption of raw and finished product. Maturity at
harvest is the most important factor that determines final fruit quality and storage-life (Siddiq, 2006). Fruit ripening is a highly coordinated, genetically programmed, and an irreversible phenomenon involving a series of physiological, biochemical, and organoleptic changes that lead to the development of a soft and edible ripe fruit with desirable quality attributes. A wide spectrum of biochemical changes such as increased respiration, chlorophyll degradation, biosynthesis of carotenoids, anthocyanins, flavor and aroma components, increased activity of cell wall-degrading enzymes, and a transient increase in ethylene production are some of the major changes involved during fruit ripening (Prasanna et al, 2007).

In plums, traditional indices that have been commonly used to establish the best harvest time, are characteristics related to colour of the skin and flesh, fruit firmness, soluble solids content, and titratable acidity (Blažek and Pišteková, 2009; Guerra and Casquero, 2009; Nunes et al., 2009). Sugar content is the most relevant to consumer perception of maturity and it is factor closely related to the stage of maturity in plum fruits. Plum contain three predominant sugars: glucose, fructose, sucrose and sugar alcohol sorbitol and their content varied with cultivar (Wilford, Sabarez and Price, 1997; Usenik et al., 2008). The sorbitol content, peculiar in fruits of the Rosaceae family, is one of the criteria used when choosing the variety for drying. In fact, sorbitol, in addition to possessing a good laxative effect at low doses (70g/day), is not easily caramelized and is not a reactant molecule in the Maillard reaction, thereby preventing excessive browning in prunes (Cinquanta, Di Matteo and Esti, 2002).

The objective of this work was to investigate the influence of the harvest date on the level of sugars and sorbitol in different plum cultivars during ripening.

**Material and methods**

Six plum cultivars (*Prunus domestica* L.): “Cacanska ljepotica”, “Topstar”, “Toptaste”, “Jojo”, “Haganta”, “Tophit”, were harvested in 2009 from experimental four year old orchard of the Agricultural Institute Osijek. Plum trees were planted in a randomized block design with three replications per four trees in each. The fruit were harvested at three or four different times at six- to eight-day intervals during ripening (t1-t4). “Cacanska ljepotica” was harvested on date: 10th, 16th and 24th of July; “Topstar” on 16th, 24th, 30th of July and 6th of August; “Toptaste” on 24th, 30th, of July and 6th, 13th of August; “Jojo” and “Haganta” on 13th, 20th, 27th of August and 3rd of September; 2nd, 9th, 17th and “Tophit” on 26th of August and 2nd, 9th, 17th of September. In each harvest, 10 fruits were selected from each tree and these combined within each replication to yield 40 fruit per replication per harvest date. The samples were brought to the laboratory immediately after harvesting. Ten fruits from each replication were used to determine sorbitol, sucrose, glucose, fructose and total sugars.

Seedless plum fruits were thoroughly crushed in an electric mixer. Sugars and sorbitol from pulp were extracted with water at 50°C for 15 min. After filtration, extracts were passed through 0.45μm syringe filter, just before analyses. Sorbitol and sugars were analyzed by using a Perkin-Elmer High Performance Liquid Chromatography system series 200 equipped with degasser, isocratic pump, refractive index detector and TotalChrom Navigator (HPLC software). The separation was performed on MetaCharb Ca Plus column (300 x 7,8), thermostated at 90°C. 20 μL aliquots were injected into the column and eluted with deionized water at flow rate of 0,5 mL/min. Standard solution was composed of sucrose, glucose, galactose (internal standard), fructose and sorbitol at concentration of 5, 10 and 15 mg/mL. Sugars from aqueous sample extract were identified by their retention time and quantified by peak area using internal standard procedure. Total sugars were represented as the sum of sucrose, glucose and fructose. All measurements were conducted in four replications. Sorbitol and sugar content were expressed as a percentage of fresh weight of plum.

One-way analysis of variance (ANOVA) and multiple comparisons (Duncan’s post hoc test) were used to evaluate the significant difference of the data at P < 0,05. Comparative analyses of plum cultivars were performed using linear discriminant analysis. All statistical analyses were performed using statistical-graphic system "Statistica" version 7.0 (Stat Soft software Inc., Tulsa, OK, USA).

**Results and discussion**

Changes in sorbitol and sugars content during ripening of plum cultivars are shown in Fig.1. The sorbitol, individual and total sugars content in “Cacanska ljepotica” plums were the lowest at the first sampling date and then increased during the fruit ripening, for sucrose to 4,13%, for glucose 3,76%, for total sugar 10,19%
and sorbitol to 2.02% at the last sampling date. A one-way ANOVA showed significant difference (p<0.05) between all harvests for sucrose, fructose and total sugars content. Significant difference was not found between first and second sampling date for glucose and sorbitol. The predominant sugar in this plum cultivar at last sampling date was sucrose.

A one-way ANOVA showed significant difference (p<0.05) between sampling date for glucose and total sugar in cultivar “Topstar” and their levels at the last sampling date were 2.73% and 10.47%, respectively. The sorbitol detected at the second sampling date (0.85%) was not significantly different to the value determined on the first sampling date, while a level of sucrose and fructose was not significantly different on the second and third sampling date. In the last ripening stage contents of sorbitol, sucrose and fructose were 1.60%, 6.24% and 1.50%, respectively. Sucrose was the predominant sugar in this plum cultivar.

Sorbitol, sucrose and total sugars were changed significantly during ripening in “Toptaste” plum cultivar and their level at the last sampling date increased to 3.9%, 5.93% and 11.89%. Glucose and fructose were not significantly changed in first and second ripening stage and their values increased in last sampling date to 5.93% and to 2.55%.

Glucose and total sugars were changed significantly during ripening until the last harvest date in “Jojo” plum cultivar. Glucose was predominant sugar in this cultivar and its level increased to 4.88% at the last sampling date. Sorbitol, sucrose and fructose were not significantly changed in penultimate and last sampling data. At last sampling date sorbitol level was 1.96%, sucrose 3.81% and fructose 1.89%.

Glucose and fructose in cultivar “Haganta” were in increase during all sampling dates with no significant difference between third and last sampling date. The highest percentage for glucose and fructose was 4.69% and 2.32%. Sorbitol and sucrose were not significantly changed in second and third sampling date, but significant increase was noticed in the last stage of ripening (5.09% and 3.61%).

Sucrose, glucose and total sugar content in “Tophit” plums were the lowest at the first sampling date and then significantly increased during the fruit ripening for sucrose to 4.90%, for glucose 3.74%, for total sugar 10.99% at the last sampling date. Significant difference was not found between third and last sampling date for fructose and second, third and last date for sorbitol. In the last ripening stage contents of sorbitol and fructose were 3.79 and 2.49%. The predominant sugar in this plum cultivar at last sampling date was sucrose.
According to the concentration of total sugars in the last sampling date, the highest level was found in “Haganta”, followed by “Toptaste”, “Tophit”, “Jojo”, “Topstar” and the lowest in “Cacanska ljepotica”. High level of sorbitol was found in “Toptaste”, “Tophit” and “Haganta”. Obtained results showed significant influence of cultivar on concentration of sorbitol, sucrose, glucose, fructose and total sugars in investigated plum cultivars. Discriminant analysis using sorbitol and individual sugar content as the variables showed that plum cultivars were grouped according to their sorbitol and sugar composition (Fig.2).

Conclusion

The results showed significant influence of maturation and harvest date on sorbitol and sugars concentrations in investigated plum cultivars. The amount of sorbitol, individual and total sugars in plums significantly increased during maturation. The individual sugars, glucose and sucrose were the highest in all harvest stages. Glucose was the predominant sugar in one cultivar. Fructose content remained relatively low. Plums with high total sugar content had higher content of sorbitol. The discriminant analysis (LDA) showed that plum cultivars were clearly separated according to sorbitol and individual sugars content in fruit.
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References


