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Influence of Rain Protective Tree Covering on Sweet Cherry Fruit Quality

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Summary

The effects of rain protective tree covering on sweet cherry quality parameters: fruit weight, concentration of individual sugars, organic acids, anthocyanins and other phenolics, fruit colour and fruit decay because of fruit cracking and rotting were analyzed on 'Hedelfinger', 'Kordia', and 'Regina' sweet cherry (*Prunus avium* L.) on the rootstock 'Gisela 5' in 2006. Half of the trees of each cultivar were covered 5 to 6 weeks prior to harvest and the other half was grown without a covering. Tree covering reduced crop losses due to fruit cracking and rotting without negative effects on fruit quality. Covers significantly reduced percentage of cracked 'Hedelfinger' fruit (13.6 %) and of rotten 'Regina' fruit (4.6 %). Tree covers had no significant influence on sweet cherry fruit weight, fruit from covered trees had higher fruit weight (4.0 % in 'Hedelfinger', 19.9 % in 'Kordia' and 6.5 % in 'Regina'). Colour parameters L*, a*, and b* significantly changed by covering in 'Hedelfinger' and a* in 'Kordia'. Systematically higher (not significantly) concentrations of sugars (sucrose, glucose, fructose and sorbitol) and organic acids (citric, malic, shikimic and fumaric acid) were measured in fruits under covers. There was no significant effect of covering on the concentrations of phenols (neochlorogenic acid, *p*-coumaroylquinic acid, chlorogenic acid, epicatechin and rutin) and anthocyanins (cyanidin 3-glucoside, cyanidin 3-rutinoside, pelargonidin 3-rutinoside and peonidin-3-rutinoside).

Key words. sweet cherry – fruit – quality – sugars – organic acids – phenols – anthocyanins – fruit cracking

Introduction

In many sweet cherry production areas, rain occurs in the period of sweet cherry ripening. Fruit cracking, softening and rapid decay are major problems which cause crop losses in sweet cherry production (Usenik et al. 2005). Fruit cracking is one of the major factors limiting the production of sweet cherries. Cracking occurs during the last few weeks prior to harvest (Sekse 1995). Strain of the cuticular membrane results from rapid fruit surface expansion during stage III (Knoche et al. 2004). Exposure of the fruit surface to liquid water or high concentrations of water vapour resulted in formation of microcracks in the cuticular membrane (Knoche and Peschel 2006). Microcracks predispose fruit to subsequent rain-cracking (Peschel and Knoche 2005). Methods of cultural management that lower the risk of fruit loss due to rain-induced cracking are urgently needed to sustain the economic viability of this high-value crop in many countries where rain at harvest is a problem (Cline et al. 1995). Plastic tree shelters have been used in many countries but very little is known how covering influence the fruit quality of sweet cherries.

Børve et al. (2003) tested three different methods for covering sweet cherry to protect them from rain and discovered that all covering methods increased the percentage of marketable fruit but decreased soluble solids and juice colour and delayed ripening. The tree covering did not completely prevent cracking and rotting (Balmer 1998) but significantly reduced the number of cracked and rotten fruits (Børve and Meland 1998a) and delayed the ripening (Børve and Meland 1998b). Cline et al. (1995) discovered that plastic rain covers were very beneficial in reducing fruit cracking and improving fruit size and fruit firmness. Use of plastic rain shield reduced fruit decay and need for fungicides in sweet cherry (Børve and Stensvand 2003). By covering the trees 3–4 weeks prior to harvest, a late fungicide spray could be eliminated (Børve et al. 2007).

The objective of this experiment was to analyze the influence of tree covering on sweet cherry quality parameters: fruit colour, concentration of individual sugars, organic acids, anthocyanins and other phenols.

Materials and Methods

Plant material

'Hedelfinger', 'Kordia', and 'Regina' sweet cherries (*Prunus avium* L.) on the rootstock 'Gisela 5', planted in spring 1999 and spaced 4 x 2.5 m, were trained to a spindle at Fruit Growing Centre Gacnik (Slovenia). Geographic location is: 15 °39 '00 " geographical longitude and

46 °33 '30 " latitude. Trees were irrigated with under-tree drippers.

Tree covering

Fifteen trees of each cultivar were grown without a covering (control; T1), or were covered (T2) from 1 June to 10 July (5 to 6 weeks prior to harvest- in late stage II and throughout harvest) in 2006. Covered trees were grown under the new covering system (Overhead plastic Agrolene Prima A, Frustar, Landring Weiz, Austria) which covered row (length 93 m, width 4 m, no free slot between the row covers). Three trees per treatment were selected for measurements. On each tree two branches were chosen, first with position towards the middle of the row (oriented to the south-S) and second one away from the row (oriented to the east-E) to analyse the effect of orientation on measured parameters.

Picking and measurements

Cherry fruits were picked at commercial maturity on the basis of subjective estimation of fruit colour. Fruits were collected on July 5 for 'Hedelfinger' and 'Kordia' and July 10 for 'Regina' in 2006. Average fruit weight was calculated from a 50-fruit sample. Percentage of cracked and rotted fruits was calculated from the mass of cracked and rotted fruits and total yield per branch. Fruit colour was measured on 'Hedelfinger' and 'Kordia' fruits prior to picking on the opposite sites of the fruit suture with Konica Minolta CR-10 Chroma Meter. Thirty fruits were measured on each branch. Fruits were sampled on each of two branches (0.5 kg), packed in plastic bags, frozen and kept at −20 °C until the extraction. Total edible part of 10 fruits were used for measurements of the concentration of sugars, organic acids, anthocyanins and other phenols.

Extraction and determination of sugars and organic acids

Fruit samples were analysed to determine the concentrations of sugars (glucose, fructose, sucrose and sorbitol) and organic acids (malic, citric, shikimic and fumaric). Sweet cherries were stoned and homogenised with a manual blender (Braun). Mashed (10 g) fruit was extracted with 50 ml of twice distilled water for 30 min at room temperature. The extracted sample was centrifuged at 12,000 x g for 7 min at 10 °C (Eppendorf 5810 R centrifuge, Hamburg, Germany). The supernatant was filtered through 0.45 µm cellulose ester filter (Macherey-Nagel), transferred into a vial and used for analyses. **Analysis of sugars** was performed using a Thermo Separation Products HPLC with refractive index (RI) detector (Thermo Scientific, Waltham, MA). Separation of sugars was carried out using a Rezex RCM-monosaccharide column (300 x 7.8 mm, Phenomenex, Torrance, CA) with the column temperature maintained at 65 °C. The samples were eluted according to the isocratic method described by Šturm et al. (2003). **Organic acids** were analysed with HPLC, using an Aminex HPX-87H column (300 x 7.8 mm) (Bio-Rad, USA) and a UV detector set at 210 nm, according to the method of Šturm et al. (2003). Sugars and organic acids in cherry extracts were identified by their retention time characteristics as well as with the internal standard method. Concentrations were expressed as g per kg fresh weight (FW), fumaric and shikimic acids as mg per kg FW.

Extraction and HPLC analysis of anthocyanins and other phenolics

Samples were prepared according to the method of Escarpa and Gonzalez (2000): Five grams of sample was extracted with 25 ml MeOH containing 1 % HCl and 1 % 2.6-di-tert-butyl-4-methylphenol (BHT), using an ultrasonic bath. HPLC analysis was performed using a Surveyor HPLC system with a diode array detector (DAD), controlled by a CromQuest 4.0 software (Thermo Finnigan, San Jose, CA). The anthocyanins were analysed at 530 nm and the other phenolics at 280 nm. The column used was a Gemini C_{18} (150 x 4.6 mm 3 µm; Phenomenex) 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^{-1}. The phenolic compounds were identified by their spectral and retention time characteristics. The quantities of neochlorogenic acid were assessed from peak areas and calculated as equivalents of chlorogenic acid. *P*-cumaroylquinic acid is *p*-coumaric acid derivative, so the area of *p*-coumaroylquinic acid was calculated as equivalents of *p*-coumaric acid (Kim et al. 2005). Concentrations were expressed as mg per 100 g of fresh weight (FW). Pure stand-

Table 1. Effect of covering on fruit colour parameters L*, a* and b* (the mean ± SE).

Cultivar	T	L*	a*	b*
'Hedelfinger'	1	27.3 ± 0.3 b	2.2 ± 0.1 a	5.6 ± 0.4 a
	2	27.8 ± 0.2 a	2.0 ± 0.1 b	4.7 ± 0.3 b
'Kordia'	1	24.5 ± 0.3 a	1.9 ± 0.1 b	4.0 ± 0.4 a
	2	24.7 ± 0.2 a	2.1 ± 0.1 a	4.2 ± 0.2 a

T1: without cover, control; T2: with cover
Different letters indicate significantly different values at P≤0.05.

Table 2. Effect of covering on fruit weight (g) and percentage of cracked and rotted fruits (the mean ± SE).

Cultivar	T	Fruit weight	Cracked fruits	Rotted fruits
'Hedelfinger'	1	8.0 ± 0.8 b	14.3 ± 8.1 a	1.8 ± 0.3 b
	2	8.3 ± 0.3 b	0.6 ± 0.6 b	2.2 ± 0.1 b
'Kordia'	1	7.0 ± 0.3 b	1.5 ± 0.9 b	0.3 ± 0.3 b
	2	8.4 ± 0.2 b	0.0 ± 0.0 b	0.0 ± 0.0 b
'Regina'	1	9.8 ± 0.5 a	3.2 ± 2.5 b	5.7 ± 1.8 a
	2	10.5 ± 0.4 a	1.1 ± 0.7 b	1.1 ± 0.6 b

T1: without cover, control; T2: with cover
Different letters indicate significantly different values at P≤0.05.

ards of chlorogenic acid and rutin were purchased from Sigma Aldrich, *p*-coumaric acid, and (-)-epicatechin from Fluka Chemie GmbH. Anthocyanins were identified with LC/MS (LCQ Deca XP MAX, Thermo Finnigan). Concentrations of the cyanidin 3-glucoside, cyanidin 3-rutinoside, and peonidin-3-rutinoside (Sigma) were expressed as mg per 100 g FW. The concentrations of pelargonidin 3-rutinoside were assessed from peak areas and calculated as equivalents of peonidin 3-rutinoside.

Statistics

The data were analyzed using the analysis of variance procedure of the statistical program Statgraphics Plus 4.0 (Statgraphics, Herndon, VA). Differences between treatments were estimated with Duncan test (P≤0.05).

Results and Discussion

Fruit colour

Cultivar 'Hedelfinger' had significantly higher values of L*, a* and b* compared to 'Kordia'; fruit of 'Hedelfinger' was less dark and redder (Table 1). Tree covers influenced the 'Hedelfinger' fruit colour values of L* (P=0.0087), a* (P=0.0000) and b* (P=0.0003) parameters, but in 'Kordia' only a* (P=0.0357). 'Hedelfinger' fruit under cover was less dark, redder and more bluish, but 'Kordia' fruit was less red. Different response of cultivars to covering can be explained with different natural fruit skin colour of cultivars (Bargioni 1996). Position of the branch in the crown had significant influence only on a* of 'Hedelfinger' fruits (P=0.0094) so we can suppose that fruit colour of sweet cherry fruit is not influenced by the orientation of the branch. Fruit colour is regarded as the most reliable indicator of sweet cherry fruit maturity (Proebsting and Mills 1981). The results of fruit colour measurements show that ripening of 'Hedelfinger' was delayed by covering, which was also in agreement with Børve and Meland (1998b), but other results of our study do not support this statement, as discussed below.

Fruit weight, fruit cracking and decay

Average fruit weight of cultivar 'Regina' was significantly higher compared to 'Hedelfinger' and 'Kordia', differences we can ascribe to the cultivar characteristics (Table 2). The position of branch in the crown had no significant influence, neither on the fruit weight nor on the percentage of cracked and damaged fruits. Fruit from covered trees of all three cultivars had higher average weight (differences were not significant) compared to fruit from uncovered trees. Cline et al. (1995) discovered similarly that rain covers improving fruit size. The plastic covers reduced incoming light in Netherlands by 14 % (Balkhoven-Baart and Groot 2005), in Germany PAR was reduced in polytunnel by 40 % on sunny days (Dekova and Blanke 2007), but it is possible that plastic covers influence the quantity of dispersed light which possible influence fruit size. Balmer et al. (2005) reported that covering influenced smaller cherries but fruit of 'Burlat', 'Souvenir' and 'Samba' in the study of Dekova and Blanke (2007) were larger in the polytunnel. There were significant differenc-

Table 3. Effect of covering on fruit sugar concentrations (g kg^{-1} FW) and on fruit organic acid concentrations (the mean ± SE).

Cultivar	T	Sucrose	Glucose	Fructose	Sorbitol	Sum of sugars
'Hedelfinger'	1	6.0 ± 1.3 c	96.9 ± 4.6 bc	75.8 ± 6.0 bc	23.5 ± 1.7 b	202.1 ± 12.0 bc
	2	7.4 ± 0.9 bc	110.4 ± 6.7 ab	92.4 ± 5.9 ab	25.5 ± 2.2 ab	235.7 ± 15.4 ab
'Kordia'	1	8.5 ± 0.6 ab	89.0 ± 9.5 c	65.3 ± 7.5 c	21.3 ± 3.0 b	184.1 ± 20.5 c
	2	10.2 ± 0.6 a	104.3 ± 3.7 bc	77.2 ± 3.3 bc	26.7 ± 1.7 ab	218.3 ± 9.0 bc
'Regina'	1	8.1 ± 0.1 abc	113.3 ± 6.5 ab	84.2 ± 4.3 ab	26.1 ± 2.7 ab	231.7 ± 13.0 ab
	2	8.6 ± 0.5 ab	130.5 ± 5.3 a	97.2 ± 2.3 a	31.7 ± 2.7 a	268.1 ± 10.6 a
		Citric acid	Malic acid	Shikimic acid	Fumaric acid	Sum of acids
		(g kg^{-1} FW)		(mg kg^{-1} FW)		(g kg^{-1} FW)
'Hedelfinger'	1	0.1 ± 0.0 c	3.2 ± 0.4 b	12.1 ± 1.0	3.7 ± 0.5	3.3 ± 0.5 b
	2	0.1 ± 0.0 c	3.6 ± 0.3 ab	13.9 ± 1.8	3.9 ± 0.9	3.7 ± 0.4 ab
'Kordia'	1	0.1 ± 0.0 bc	4.1 ± 0.7 ab	9.8 ± 2.1	1.6 ± 1.2	4.3 ± 0.7 ab
	2	0.2 ± 0.0 ab	5.3 ± 1.0 a	15.2 ± 3.2	5.1 ± 2.0	5.6 ± 1.1 a
'Regina'	1	0.2 ± 0.0 ab	3.7 ± 0.2 ab	12.3 ± 1.7	4.2 ± 1.4	4.0 ± 0.2 ab
	2	0.3 ± 0.0 a	4.2 ± 0.3 ab	13.9 ± 2.7	4.5 ± 1.4	4.5 ± 0.3 ab

T1: without cover, control; T2: with cover
Different letters indicate significantly different values at P≤0.05.

es in fruit cracking between cultivars. Fruits from uncovered 'Hedelfinger' trees cracked significantly more compared to 'Kordia' and 'Regina'. Cultivars 'Hedelfinger', 'Kordia' and 'Regina' were medium to low regarding to cracking susceptibility by BARGIONI (1996). Covering treatment significantly reduced percentage of cracked fruits only of 'Hedelfinger'. In general, with regard to climatic conditions in our study, fruit cracking was relatively low. The amount of precipitation in June 2006 was 83 mm (11 days with precipitation) and in the first 10 days of July 28.5 mm (4 days with precipitation). Mean air temperature 2 m above ground was in June 19.7 °C and in the first 10 days of July 21.1 °C. Total precipitation from the beginning of the year 2006 was 470 mm. Covering resulted also in significantly lower percentage of rotten fruits in 'Regina'. In our study covering increased the amount of marketable fruit from 84 to 97 % in 'Hedelfinger', from 98 % to 100 % in 'Kordia' and from 91 % to 98 % in 'Regina'. In the study of BØRVE et al. (2003) covering methods increased the amount of marketable fruit from 54 % on uncovered to 89 % on covered trees in mean of two years.

Sugars and organic acids

The orientation of branch in the crown had no significant influence on the content of neither sugars nor organic acids, so the presented results are the average of two branches per tree (Table 3). Our results show systematically higher concentrations of sucrose, glucose, fructose, sorbitol, and sum of sugars and in citric, malic, shikimic and fumaric acid (Table 3) in fruits under covers for all cultivars, but differences were not significant. The results indicate that fruit under covers were more tasty because they had higher, although not significant, concentrations of sugars and organic acids compared to fruit from control trees. Cherries grown under cover tasted better due to increased both sugar and acidity (BALMER et al. 2005). BØRVE et al. (2003) ascertained that tree covering decreased soluble solids content (covers were mounted 3 weeks before harvest period).

Concentration of anthocyanins and other phenols

The concentration of four different anthocyanins was measured (Table 4). No significant differences were ascertained in the concentrations of individual anthocyanins as an effect of tree covering in fruits of any of the three varieties tested. 'Regina' fruit had higher concentration of all anthocyanins under covers, but opposite for 'Kordia', although no differences were statistically significant. Significant differences between cultivars in the anthocyanin composition were found as shown also by USENIK et al. (2008). Our results show that there was no

Table 4. Effect of covering on fruit anthocyanin concentrations (mg kg^{-1} FW) (the mean ± SE).

Cultivar	T	Cyanidin 3-glucoside	Cyanidin 3-rutinoside	Pelargonidin 3-rutinoside	Peonidin 3-rutinoside
'Hedelfinger'	1	33.7 ± 3.9 ab	52.3 ± 10.1 a	9.8 ± 2.7 c	6.7 ± 0.6 ab
	2	39.7 ± 3.2 a	45.6 ± 3.3 a	7.9 ± 1.0 c	7.0 ± 0.2 ab
'Kordia'	1	34.5 ± 5.4 ab	61.4 ± 5.6 a	31.4 ± 3.7 a	5.0 ± 0.6 b
	2	26.6 ± 1.9 abc	51.2 ± 2.4 a	22.6 ± 4.3 ab	6.0 ± 1.2 ab
'Regina'	1	18.8 ± 4.3 c	43.8 ± 8.3 a	14.3 ± 1.4 bc	6.7 ± 0.8 ab
	2	23.7 ± 5.0 bc	54.4 ± 6.8 a	22.8 ± 4.2 ab	8.3 ± 0.6 a

T1: without cover, control; T2: with cover
Different letters indicate significantly different values at P≤0.05.

Table 5. Effect of covering on fruit phenolic concentrations (mg kg^{-1} FW) (the mean ± SE).

Cultivar	T	Neochlorogenic acid	*P*-coumaroylquinic acid	Chlorogenic acid	Epicatechin	Rutin
'Hedelfinger'	1	292.5 ± 96.6 a	28.2 ± 12.9 a	39.4 ± 3.6 a	44.7 ± 11.0 ab	79.8 ± 4.8 a
	2	249.9 ± 37.4 a	22.7 ± 9.5 a	35.0 ± 2.8 a	27.1 ± 3.7 b	63.7 ± 1.9 a
'Kordia'	1	183.7 ± 20.3 ab	44.0 ± 3.5 a	33.8 ± 4.7 a	62.5 ± 11.3 a	77.4 ± 7.3 a
	2	147.8 ± 16.0 ab	49.0 ± 10.2 a	30.9 ± 1.8 a	42.6 ± 9.1 ab	70.4 ± 2.7 a
'Regina'	1	99.5 ± 17.9 b	25.6 ± 1.0 a	30.5 ± 4.2 a	42.4 ± 7.8 ab	80.6 ± 10.1 a
	2	91.3 ± 2.5 b	36.7 ± 11.9 a	30.8 ± 4.2 a	41.4 ± 2.0 ab	75.3 ± 6.3 a

T1: without cover, control; T2: with cover
Different letters indicate significantly different values at P≤0.05.

significant influence of covering on the concentrations of phenols (Table 5). 'Hedelfinger' fruit under covers had systematically lower, but not statistically significant, concentrations of all identified phenols. This was true also for 'Kordia', except for *p*-coumaroylquinic acid, and for 'Regina', except for *p*-coumaroylquinic acid and chlorogenic acid. Fruits of 'Regina' had independently to the tree covering significantly lower concentrations of neochlorogenic acid compared to 'Hedelfinger'. Differences in neochlorogenic acid were ascertained between sweet cherry cultivars in a previous study (Usenik et al. 2008).

Conclusion

Covering of sweet cherry orchards with rain protective tree covers lowers crop losses due to reduced fruit cracking and rotting and do not influence fruit quality negatively.

References

Balkhoven-Baart, J.M.T. and M.J. Groot 2005: Evaluation of 'Lapins' sweet cherry on dwarfing rootstocks in high density plantings, with or without plastic covers. Acta Hort. **667**, 345–351.

Balmer, M. 1998: Preliminary results on planting densities and rain covering for sweet cherry on dwarfing rootstocks. Acta Hort. **468**, 433–439.

Balmer, M., A. Kunz and M. Blanke 2005: Verfrühung von Süßkirschen unter geschlossener Folie. Erwerbsobstbau **47**, 78–86.

Bargioni, G. 1996: Sweet cherry scions: Characteristics of the principal commercial cultivars, breeding objectives and methods, p. 73–112. In: Webster, A.D. and N.E. Looney (eds.): Cherries. Crop physiology, production and uses. CAB Intl., Wallingford, U.K.

Børve, J. and M. Meland 1998a: Rain cover protection against cracking of sweet cherries. I. The effect on marketable yield. Acta Hort. **468**, 449–453.

Børve, J. and M. Meland 1998b: Rain cover protection against cracking of sweet cherries. I. The effects on fruit ripening. Acta Hort. **468**, 455–458.

Børve, J. and A. Stensvand 2003: Use of plastic rain shield reduces fruit decay and need for fungicides in sweet cherry. Plant Dis. **87**, 523–528.

Børve, J., E. Skaar, L. Sekse, M. Meland and E. Vangdal 2003: Rain protective covering of sweet cherry trees – Effects of different covering methods on fruit quality and microclimate. HortTech. **13**, 143–148.

Børve, J., M. Meland and A. Stensvand 2007: The effect of combining rain protective covering and fungicide sprays against fruit decay in sweet cherry. Crop Prot. **26**, 1226–1233.

Cline, J.A., L. Sekse, M. Meland and A.D. Webster 1995: Rain-induced fruit cracking of sweet cherries: II. Influence of rain covers and rootstocks on cracking and fruit quality. Acta Agric. Scand. Sect. B, Soil and Plant Sci. **45**, 213–223.

Dekova, O. and M. Blanke 2007: Verfrühung von Süßkirschen im Folienhaus. Erwerbsobstbau **49**, 10–17.

Escarpa, A. and M.C. Gonzalez 2000: Optimisation strategy and validation of one chromatographic method as approach to determine the phenolic compounds from different sources. J. Chromat. **A 897**, 161–170.

Kim, D.O., H.J. Heo, Y.J. Kim, H.S. Yang and C.Y. Lee 2005: Sweet and sour cherry phenolics and their protective effects on neuronal cells. J. Agr. Food Chem. **53**, 9921–9927.

Knoche, M., M. Beyer, S. Peschel, B. Oparlakov and M.J. Bukavac 2004: Changes in strain and deposition of cuticle in developing sweet cherry fruit. Physiol. Plant. **120**, 667–677.

Knoche, M. and S. Pechel 2006: Water on the surface aggravates microscopic cracking of the sweet cherry fruit cuticle. J. Am. Soc. Hort. Sci. **131**, 192–200.

Peschel, S. and M. Knoche 2005: Characterisation of microcracks in the cuticle of developing sweet cherry fruit. J. Am. Soc. Hort. Sci. **130**, 487–495.

Proebsting, E.L. and H.H. Mills 1981: Effects of season and crop load on maturity characteristics of 'Bing' cherry. J. Am. Soc. Hort. Sci. **106**, 144–146.

Sekse, L. 1995: Cuticular fracturing in fruits of sweet cherry (*Prunus avium* L.) resulting from changing soil water contents. J. Hort. Sci. **70**, 631–635.

Šturm, K., D. Koron and F. Štampar 2003: The composition of fruit of different strawberry varieties depending on maturity stage. Food Chem. **83**, 417–422.

Usenik, V., D. Kastelec and F. Štampar 2005: Physicochemical changes of sweet cherry fruits related to application of gibberellic acid. Food Chem. **90**, 663–671.

Usenik, V., J. Fabcic and F. Štampar 2008: Sugars, organic acids, phenolic composition and antioxidant activity of sweet cherry (*Prunus avium* L.). Food Chem. **107**, 185–192.

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