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Anthocyanins and hydroxycinnamic acids of Lambert Compact cherries (*Prunus avium* L.) after cold storage and 1-methylcyclopropene treatment

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Abstract

Sweet cherries cv. Lambert Compact were treated with 1-methylcyclopropene (1-MCP) at 0, 180 and 360 nL/L for 2 h at 25 °C and then stored at 2–4 °C in refrigerator. Their quality was measured after 12 days of storage in terms of the contents of total and individual anthocyanins and hydroxycinnamic acids, occurrence of rot, and colour change. Colour change was monitored at three day intervals during storage in the CIE L^*, a^*, b^* colour space. 1-MCP did not retard colour change. The contents of total and individual anthocyanins and hydroxycinnamic acids showed no correlation with the colour behaviour of the cherries. All cherries lost their initial shiny red colour on storage, regardless of the treatment. 1-MCP reduced sweet cherry rot at the highest concentration used (360 nL/L) – only 6% were rotten after 12 days in the refrigerator. This differed significantly ($P < 0.05$) from untreated fruits and those treated with 180 nL/L 1-MCP which resulted on average in 14 and 20% rot (not statistically different $P < 0.05$), respectively. The occurrence of rot was shown to be correlated with anthocyanin accumulation, ($R = 0.62$, $P < 0.10$). The profile of individual anthocyanins and hydroxycinnamic acids in sweet cherry was not affected neither by cold storage nor 1-MCP treatment.

Keywords: 1-MCP; Sweet cherries; Anthocyanins; Hydroxycinnamic acids; Post-harvest

1. Introduction

Sweet cherries represent a group of fruit that appears on the market as the first fresh fruits among all. They are known for the shiny red colour, an important quality attribute for the consumer, through which high quantities polyphenols' content is expressed (Drake, Kupfermanm, & Fellman, 1988; Mazza & Miniatti, 1993). The major polyphenol groups in cherries are anthocyanins and hydroxycinnamic esters (Chaovanalikit & Wrolstad, 2004; Gao & Mazza, 1995; Goncalves et al., 2004; Macheix, Fleuriet, & Billot, 1990; Mazza & Miniatti, 1993; Mozetič, Trebše, & Hribar, 2002).

Polyphenols are secondary metabolites evolved by plants as a natural defence system (Mazza & Miniatti, 1993). They are also known for their several positive effects on human health, through prevention of coronary diseases and cancer (Criqui & Ringel, 1994) or by acting as antioxidants towards LDL in liposomes (Frankel, Kanner, German, Parks, & Kinsella, 1993; Frankel, Waterhouse, & Teissedre, 1995; Meyer, Yi, Pearson, Waterhouse, & Frankel, 1997).

The consumption period for fresh cherries is, unfortunately, pretty short and their consummation value is limited by this factor comparing to other early seasonal fruits. They decay rapidly after harvest as a consequence

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of their high respiratory rate, which constitutes the main problem for successful transport and marketing. As seen by eye or instrumentally evaluated (CIE L^*, a^*, b^* colour space), cherries loose their shiny red colour post-harvest (Bernalte, Sabio, Hernández, & Gervasini, 2003; Esti, Cinquanta, Sinesio, Moneta, & Di Matteo, 2001). This was mainly thought in the past to be caused by total and individual anthocyanin decrease (Mazza & Miniatti, 1993). Lately, some new data clearly described non-correlation between anthocyanin change and colour loss of cherries. Other physiological and biochemical processes in the fruit, like loss of cell compartment and acid degradation are more crucial compared to anthocyanins in colour changes of cherries (Bernalte et al., 2003; Esti et al., 2001; Zhang, Quantick, & Grigor, 2000). The post-harvest quality of cherries is mainly maintained using atmospheres with low O_2 (3–10%) and high CO_2 (10–15%) and low temperatures (0–5 °C) (Kader, 1997).

The plant growth regulator 1-methylcyclopropene (1-MCP) has been found to delay ripening of many climacteric fruits and vegetables (Blakenship & Dole, 2003). It is thought to bind irreversibly to ethylene receptors at very low concentrations (nL/L), blocking or delaying the processes of maturation normally triggered with ethylene (Sisler & Serek, 1997).

The influence of 1-MCP has been studied less on non-climacteric than on climacteric fruits, showing variable results in the delay of fruit ripening (Blakenship & Dole, 2003). The different responses of climacteric and non-climacteric fruits to 1-MCP treatment has been suggested to lie in the different ethylene receptor(s) (McGlasson, 1985) and in the different regulatory functions of these receptors (Tian et al., 2000).

In practice, 1-MCP has been used successfully for perishable, non-climacteric strawberries, delaying rot (Jiang, Joyce, & Terry, 2001; Ku, Wills, & Ben-Yehoshua, 1999) and maintaining fruit firmness and colour (Jiang et al., 2001). In both studies, accelerated disease development was observed in fruit treated at high (500 to 1000 ppb) 1-MCP concentrations. Ku et al. (1999) assumed that 1-MCP blocks the defence processes in strawberries by influencing some polyphenol metabolic pathways that was also confirmed by Jiang et al. (2001).

Only Gong, Fan, and Mattheis (2002) have until studied the influence of 1-MCP to the post harvest changes of non-climacteric cherries. The results of their study have shown no impact of applied 1-MCP at three concentrations (0.1, 1 and 10 μL/L) on colour change and steam browning during storage.

The 1-MCP effects on sweet cherry polyphenols has never been described before. From that reason we decided to measure effects of lower 1-MCP concentrations on different sweet cherry cultivar compared to study of Gong et al. (2002) in terms of the major cherry anthocyanins and hydroxycinnamic acids content, colour change and occurrence of brown rot after 12 days of storage at 2–4 °C.

At the same time, we decided to study quantity of major sweet cherry polyphenols post-harvest, since the literature data are not consistent about the decrease or increase of polyphenols in cherries during storage (Bernalte et al., 2003; Esti et al., 2001; Goncalves et al., 2004). Only one of them (Goncalves et al., 2004) dealt with hydroxycinnamic acids that are also important polyphenols for antioxidant properties of cherries (Heinonen, Meyer, & Frenkel, 1998; Rice-Evans, Miller, & Paganga, 1997).

In addition, we tried to determine the effect of 1-MCP on polyphenol accumulation post-harvest reflecting its possible involvement in polyphenol biosynthesis and delaying rot.

2. Experimental

2.1. Plant material

A sample (7 kg) of sweet cherry (*Prunus avium* L.) Lambert Compact (at commercial maturity) was obtained from the orchard of the Agricultural Centre at Bilje, Nova Gorica, Slovenia. After 24 h storage at 25 °C (due to course of cherry supply) cherries were graded according to physical damage and placed randomly in 2.5 L glass jars (77 fruits on average, approximately 500 g), sealed with twist-off covers applied with two end closed teflon tubes.

2.2. MCP treatment and storage conditions

1-Methylcyclopropene gas was generated by mixing 180 mg Smartfresh powder (SmartFresh, Agrofresh™), containing 0.14% of 1-MCP and 20 mL of deionized water in a 2.5 L sealed glass jar to give a concentration of 45 ppm (stock gas, calculated by provided information from AgroFresh that 1.6 g of SmartFresh powder releases 1 mL of gas at 25 °C). After 25 min at room temperature (25 °C) (Blakenship & Dole, 2003) the required concentrations of 0, 180 nL/L (ppb) and 360 nL/L (ppb) 1-MCP in the glass jars (three replicates of each concentration) containing the cherries were obtained by injecting 0, 10 and 20 mL, respectively. The chosen concentrations were set on the preliminary experiment basis earlier that season where the positive visual appearance of cherries post 1-MCP treatment and storage was observed (data not shown). The stock gas was injected into the glass jars containing cherries, via teflon tubes on the twist-off cover. Cherries were held for 2 h at room temperature (25 °C) in the presence of 0 (control), 180 and 360 nL/L 1-MCP (in the following text noted as control, 180 ppb 1-MCP and 360 ppb

1-MCP) according to Jiang et al. (2001). After 2 h the twist-off covers were removed and the glass jars with cherries stored in normal atmosphere in a refrigerator at 2 to 4 °C for 12 days.

2.3. Fruit colour assessment

Each jar of cherries contained 15 labelled cherries for skin colour evaluation using a Chromameter Minolta CR-300 with an aperture size 8 mm. Labelled cherries were monitored for skin colour change on the 0, 1, 5, 7, 8, 12 day after treatment. The parameters L^*, a^* and b^* were measured, converted into hue angle ($H^\circ = \tan^{-1}(b^*/a^*)$) and chroma (chroma $= (a^{*2} + b^{*2})^{1/2}$)(McGuiere, 1992).

2.4. Fruit quality assessment

The proportion of brown rot cherries at the end of the experiment was determined by counting the rotten cherries. Rotten cherries were any of them with the brown rot affected surface regardless the area.

2.5. HPLC-DAD analysis

Anthocyanins and HCAs were assayed by high performance liquid chromatography coupled with diode array detector (HPLC-DAD) as already described (Mozetič et al., 2002), with some modifications in sample preparation step. Cherries from each replicate batch were analysed prior to 1-MCP treatment and at the end of the experiment (after 12 days storage in the refrigerator at 2–4 °C). There were not enough cherries in the jars to perform the minimum sufficient representative polyphenol extractions during the experiment on the same days as colour measurement (40 g of pitted cherries/per extraction, two extractions at least).

Compounds were characterised with HPLC-DAD and HPLC-MS as already described (Mozetič & Trebše, 2004).

The concentrations were calculated as mg of appropriate standards/kg of pitted sweet cherry fresh weight (kg FW). Calibration curves were prepared by injecting 20 μL of appropriately diluted standard stock solutions containing from 0.5 to 8.2 μg of cyanidin-3-rutinoside and 0.08 to 7.9 μg of chlorogenic acid (Mozetič, Trebše, Simčič, & Hribar, 2004).

2.6. Standards and reagents

Cyanidin-3-glucoside and cyanidin-3-rutinoside were purchased from Extrasynthèse (Genay, France), and chlorogenic acid from Sigma chemicals from local suppliers. Methanol (HPLC grade) was from J.T. Baker and formic acid (98–100%) from Riedel-de Haën (local suppliers).

2.7. Statistical analysis

Statistical analyses were performed using STATGRAPHIC® PLUS, version 4.0. The results were examined by analysis of variance (ANOVA) and the mean values were compared by the LSD Fisher's test with $\alpha = 0.05$, correlations being calculated by simple regression analysis.

3. Results and discussion

The obtained HPLC profile of hydroxycinnamic acids (Fig. 1, left) has shown two major peaks in the 0–17 minute region of chromatogram. They were primarily tentatively identified based on the comparison of recorded UV-Vis spectra of peak 1 and 2 to UV-Vis spectra published in the literature (Gao & Mazza, 1995) where major peaks from sweet cherry extracts were reported as neochlorogenic acid and 3′-*p*-coumaroylquinic acid. The recorded spectra of peaks 1 and 2 showed distinctive features in the 320 nm region and no absorbance at 520 nm. We concluded that peak 1 ($\lambda_{max} = 242$ nm and 322 nm, shoulder at 305 nm) corresponds to neochlorogenic acid and peak 2 ($\lambda_{max} = 312$) to 3′-*p*-coumaroylquinic acid. The electrospray mass spectrum of sweet cherry hydroxycinnamic acids produced ions with m/z ratios which corresponded to molecular weights of neochlorogenic acid (353) and 3′-*p*-coumarylquinic acid (337) (Mozetič & Trebše, 2004), thus confirming the previous tentative identification based solely on UV-Vis spectra. The area of chromatographily monitored HCAs was converted to chlorogenic acid equivalents with external calibration. The sum of both HCAs was presented as total HCAs.

Chromatograms of Lambert Compact sweet cherries methanol extract recorded at 520 nm (Fig. 1, 17–35 min time scale) showed two major and two minor peaks. Major peaks were identified against standards, as well with their UV-Vis/MS spectral characteristics as cyanidin-3-glucoside and cyanidin-3-rutinoside. The MS spectra of minor peaks exhibited the molecular (and fragment) ions with m/z values 579 (271) and 609 (301), corresponding to the molecular weights of pelargonidin-3-rutinoside and peonidin-3-rutinoside with corresponding anthocyanidins which were than tentatively identified accordingly (Mozetič & Trebše, 2004). These anthocyanins were already described in different sweet cherry cultivars (Esti et al., 2001; Gao & Mazza, 1995; Goncalves et al., 2004).

The total anthocyanin content in sweet cherries was examined by means of HPLC-DAD by summation of contributions from peaks 3–7 on Fig. 1 and expressed as cyanidin-3-rutinoside equivalents.

The quantification of total anthocyanins in Lambert Compact cherries after 12 days storage in the refrigera-

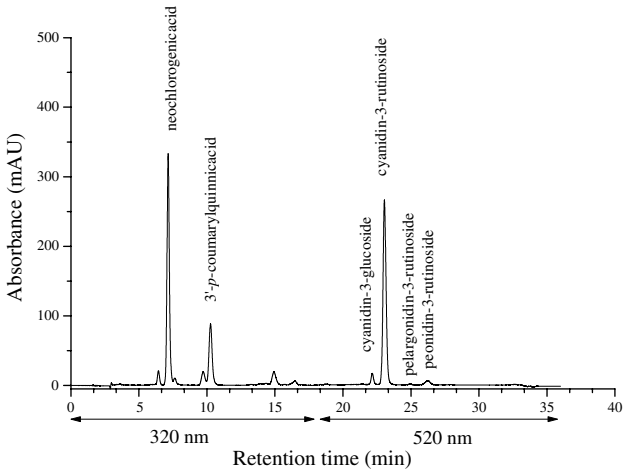

Fig. 1. HPLC separation of polyphenols from Lambert Compact cherry, detected at nm for hydroxycinnamic acids and at 520 nm for anthocyanins.

tor showed no change in the control fruit, and an average 9 % decrease from 576 to 525 mg of cy-3-rut per kg FW in 360 ppb 1-MCP treated fruit. In cherries treated with 180 ppb 1-MCP, total anthocyanins increased by 12 % to 645 mg of cy-3-rut per kg FW (Fig. 2). These increases were not significantly different at 95 % confidence level. The only significant difference at this confidence level was observed between the 180 and 360 ppb 1-MCP treated fruit.

The anthocyanin composition (as % of total anthocyanins) of Lambert Compact cherries, pre- and post-storage, is presented in Table 1. Neither the treatment nor storage in the refrigerator influenced the profile of anthocyanins significantly, in contrast to the study of Esti et al. (2001), who reported a change in the ratio of anthocyanins in cherries after 15 days of storage in air at 1 °C and 94 % relative humidity. In that study, cyanidin-3-glucoside decreased more than cyanidnin-3-rutinoside, which was explained by the higher antioxidant activity of the former. The anthocyanins of Lambert Compact cherries comprised 91.4 % cyanidin-3-rutinoside, 4.3 % cyanidin-3-glucoside, 3.8 % peonidin-3-rutinoside and 0.5 % pelargonidin-3-ruitnoside at the beginning of the experiment, and remained at this level after storage, with no significant differences between control and 1-MCP treated fruit.

HPLC quantification showed a decrease in total HCAs over 12 days of storage in all three groups (Fig. 2). The decrease was greatest (22 % on average) in 360 ppb 1-MCP treated fruit, from 427 to 334 mg of chlorogenic acid per kg FW and least in 180 ppb 1-MCP treated fruit (average 3 %) where total HCAs reached the value of 414 mg of chlorogenic acid per kg FW. The control fruit contained 372 mg of chlorogenic acid per kg FW (Fig. 2), which represented a 13 % decrease during storage. Those differences between the mean values were not significant ($P > 0.10$), compared either to the initial value or between the three groups.

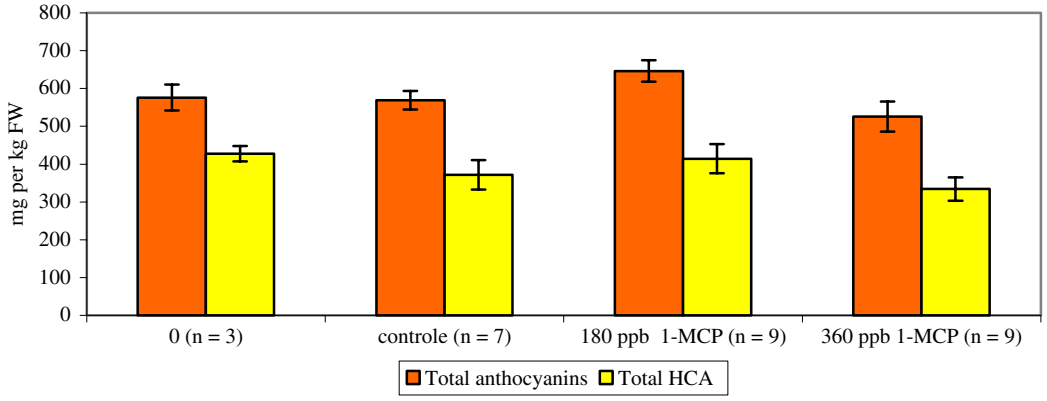

Fig. 2. Mean values with SE of total anthocyanin content (as mg of cyanidin-3-rutinoside per kg FW) and total HCA content (as mg of chlorogenic acid per kg FW) prior to treatment (day 0, $n = 3$) and 12 days after treatment (control, $n = 7$; 180 ppb MCP, $n = 9$; 360 ppb 1-MCP, $n = 9$).

Table 1
Anthocyanin composition (% of total anthocyanins) of Lambert Compact sweet cherries pre- and post storage at 2–4 °C

	Prior to treatment	12 days after treatment		
	($n = 3$)	Control ($n = 7$)	180 ppb 1-MCP ($n = 9$)	360 ppb 1-MCP ($n = 9$)
Cyanidin-3-glucoside	4.3	4.0	4.2	3.5
Cyanidin-3-rutinoside	91.4	91.8	91.8	91.4
Pelargonidin-3-rutinoside	0.5	0.4	0.4	0.4
Peonidin-3-rutinoside	3.8	3.8	3.6	4.6

Table 2
Hydroxycinnamic acid composition (% of total hydroxycinnamic acids) of Lambert Compact sweet cherries pre- and post storage at 2–4 °C

	Prior to treatment	12 days after treatment		
	($n = 3$)	Control ($n = 7$)	180 ppb 1-MCP ($n = 9$)	360 ppb 1-MCP ($n = 9$)
Neochlorogenic acid	76.3	72.4	76.0	72.6
3′-*p*-Coumarylquinic acid	23.7	27.6	24.0	27.4

The ratio of neochlorogenic acid/3′-*p*-coumarylquinic acid is quite characteristic for a sweet cherry cultivar (Gao & Mazza, 1995; Mozetič et al., 2002) and it can be expressed also through the hydroxycinnamic acid composition in % of total HCAs, as presented in the Table 2. The major HCA in Lambert Compact cherries was nechlorogenic acid which, in all groups, ranged from 72 % to 76 % of total HCAs. 3′-*p*-coumarylquinic acid was present in the range 24–27 %. The LSD Fishers test showed no significant difference between control, 1-MCP treated fruit and the cherries prior to the experiment.

This data show that 1-MCP had no influencing effect on polyphenol metabolism in sweet cherries post-harvest.

The highest drop of total HCAs on 12 days storage (22 %), the lowest anthocyanin content post-storage (12 % decrease) and the lowest proportion of rotten cherries (6 %) were observed in 360 ppb 1-MCP treated fruit. In the control fruit total anthocyanins scarcely changed, total HCAs decreased by 13 %, and 14 % of cherries were rotten post-storage. Only in cherries treated with 180 ppb 1-MCP did anthocyanins increase on storage (645 mg of cy-3-rut per kg FW), along with the highest percentage (20 %) of rotten cherries and the smallest decrease of total HCA (3 %). Comparing the mean values of total anthocyanins and percentage of rot in the three groups post-storage, the Fisher's LSD test showed significant differences of 180 ppb 1-MCP treated fruit to control and 360 ppb 1-MCP treated cherry fruit. The highest percentage of rotten cherries were accompanied by increased anthocyanin accumulation ($R = 0.62$, $P < 0.10$). The anthocyanin biosynthesis can be triggered by microbiological infection leading to the rot occurrence (Macheix et al., 1990). This implies that the rot observed to follow 180 ppb 1-MCP treatment is most probably coincidental and therefore not triggered by 1-MCP treatment, since 180 ppb 1-MCP treated fruit does not behave significantly differently from control fruit. 360 ppb 1-MCP resulted in the lowest rot percentage (6 %) on storage, with significant differences from control fruit (14 %), and the 180 ppb 1-MCP treated groups (20 %). We were able to retard the occurrence of rot of cherries during storage using 1-MCP for the first time. The extensiveness of our study has not provided what is the precise physiological way of observed 1-MCP beneficial effect on fruit quality. Since the biggest problem of cherry storage, the stem browning could not be stopped with our treatment (data not shown), the contribution of rot retardation might seem of less importance for commercial practise. The regulation of ripening processes in non-climacteric fruit is still under question and not so detailed compared to climacteric fruit. The role of ethylene, plant triggering growth hormone, in non-climacteric fruit is not very known (Hartmann, Drouet, & Morin, 1987). It has been already shown that cherries produce much lower amounts of ethylene compared to climacteric fruits (Hartmann, 1989). Hartmann (1992) proposed more indirect role of ethylene in ripening process of cherries, expressed through interactions with other plant hormones, like abscisic acid, specially for anthocyanin accumulation.

It was hypothesised by Sisler and Serek (1997) that 1-MCP occupies ethylene receptors in the way that ethylene cannot bind and elicit action. Many researchers in the last 7 years have shown a delay of fruit ripening and improved its postharvest quality with 1-MCP. Positive results have especially been obtained for climacteric fruits. Besides improving the postharvest quality of fruits, 1-MCP can be used for determination of ethylene involvement in different ripening processes. The good thing is that 1-MCP is very easy to use and positive at much lower concentration (15–2000 ppb) compared to other ethylene inhibitors and now already commercially available (Blakenship & Dole, 2003).

The visual colour, as seen by colour space CIE L^*, a^*, b^*, showed no statistically significant differences in the treated fruits, at all monitored phases. That confirmed previous reports that 1-MCP has no retarding effect on colour change during storage of sweet cherries (Gong et al., 2002). The a^* value, chroma value, hue angle and L^* value behaved similarly on storage, regardless of the treatment. All these parameters decreased, reflecting the lost of sweet cherry skin shiny red colour important for the consumers. Since the colour as seen by eye is the most approximated by *hue angle* parameter value of the CIE L^*, a^*, b^* colour space, we present this only in Fig. 3. Gong et al. (2002) concluded when following the unsuccessful treatment of cherries with 1-MCP that ethylene most probably does not regulate the colour change of cherries. We came to the same conclusions.

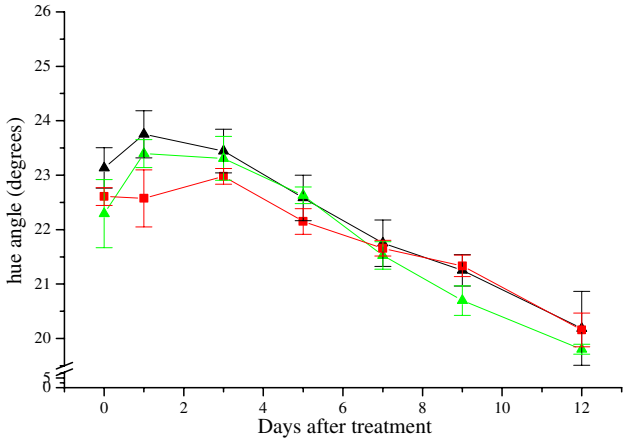

Fig. 3. Hue angle distribution of –▲– control, –▲– 180 ppb 1-MCP and –■– 360 ppb 1-MCP treated fruit during storage (mean values with SE, $n = 3$).

The diversity of the amounts of total anthocyanins and hydroxycinnamic acids within the treatment groups, together with the constancy of the ratio of these polyphenols, indicated that anthocyanins and hydroxycinnamic acids have no impact on cherry colour change during storage. The same observations were published previously (Esti et al., 2001; Bernalte et al., 2003). The post-harvest colour change of cherries is thus probably due to other physiological changes, for example total acidity and soluble solid content (SSC) % drop (Bernalte et al., 2003), or to the loss of cellular compartmentation (Zhang et al., 2000).

In the group of fruit, which was not treated with 1-MCP, no significant change of polyphenols during cold storage was observed at all. Polyphenols in fruits constantly go under metabolic reactions thus the polyphenol content is changing throughout the life of a fruit (Macheix et al., 1990). In the past it was mostly thought that post harvest changes of anthocyanins mainly involve degradation processes (Mazza & Miniatti, 1993). In effort to explain the post harvest polyphenol variations in our study, we leaned on Bernalte et al. (2003) study who got similar results after exposing cherries to the same temperature treatment post-harvest as we did. The cherries were kept after harvest at room temperature for 24 h. Than we treated them with 1-MCP and afterwards moved to the refrigerator (2–4 °C) where they stayed for the next 12 days. Bernalte et al. (2003) measured after 25 h post-harvest at 22 °C 5-fold anthocyanin content increase, followed by moderate 14% decline during the subsequent cold storage (1 °C). Post harvest increases in anthocyanin content have been previously reported for cherries as well as for other small red fruits like strawberries and raspberries. Increases are more intensive (5-fold) when higher storage temperatures (20 ± 5 °C) are used, but they can occur at lower temperatures (1–5 °C) as well (Goncalves et al., 2004; Kalt, Forney, Martin, & Prior, 1999; Wang & Stretch, 2001).

The *hue angle* value increase is a sign of anthocyanin accumulation in sweet cherries (Mozetič et al., 2004). As seen on Fig. 3, the *hue angle* value increased in the first three days after treatment (Mozetič et al., 2004). Considering that and the conclusions of Bernalte et al. (2003), the anthocyanin biosynthesis of Lambert Compact cherries resumed post-harvest as well as during cold storage. That is why only slight changes of anthocyanins were measured in control cherries during cold storage.

Our results confirm the facts obtained in the past few years (Esti et al., 2001; Bernalte et al., 2003) that metabolic changes of anthocyanins are not the reason for sweet cherry colour post-harvest changes. Making the conclusions on already known facts about 1-MCP blocking the elicit of growth hormone ethylene (Sisler & Serek, 1997; Blakenship & Dole, 2003) the post harvest metabolic changes of sweet cherry polyphenols are not regulated by ethylene. The same conclusions were made by Hartmann (1992) who tried to retard the ripening of cherries with silver thiosulfate (STS), an ethylene inhibitor, more used in the past (Sisler & Serek, 1997).

Goncalves et al. (2004) emphasised that cherry cultivar is important in post-harvest polyphenol changes. We present post harvest polyphenol changes Lambert Compact cherries for the first time. It is possible that this cultivar has a stable polyphenol post-harvest metabolism.

4. Conclusions

1-MCP showed non-retarding effects on colour stability of cherries, confirming the previous study on sweet cherries (Gong et al., 2002). All cherries became darker and less shiny post-storage, regardless of the treatment.

The changes in levels of total and individual anthocyanins and hydroxycinnamic acids had no influence on colour behaviour of cherries post-harvest. Other physiological changes during the senescence of cherries, such as pH or SSC change, must be major factors affecting the post harvest colour change of cherries.

1-MCP reduced sweet cherry rot at the highest concentration (360 nL/L) but not at 180 nL/L. The fact that the highest concentrations of anthocyanins were found in the groups of cherries containing the highest proportion of rotten cherries indicated that rot occurrence was not induced by PAL (key enzyme in anthocyanin biosynthesis) inhibition, as in the case of strawberries (Jiang et al., 2001). The accumulation of anthocyanin appeared to be connected with occurrence of rot, which agrees with the hypothesis that PAL is (or anthocyanin synthesis) induced by wounding or infecting the plant tissue (Liang, Dron, Cramer, Dixon, & Lamb, 1989; Macheix

et al., 1990). These results may seem of less economic importance, since the stem browning could not be stopped (data not shown). We should also use more 1-MCP concentrations. Our results are interesting from physiological point of view, because the main idea from literature is that ethylene has no role in ripening processes of sweet cherries at all (Gong et al., 2002; Hartmann, 1992).

In contrast to published data (Mazza & Miniatti, 1993; Esti et al., 2001; Bernalte et al., 2003) the profile of Lambert Compact sweet cherry individual anthocyanins and hydroxycinnamic acids was not affected by storage time either by 1-MCP treatment. This could be the result of a different cultivar examined but there is a great possibility that the main changes of polyphenols occurred in the first 24 h post-harvest, which were not measured during the experiment. Therefore we concluded that handling cherries post-harvest prior experiments should be carefully chosen.

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