Factors affecting the quality of fresh-cut sweet cherry

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Abstract

Sweet cherries are a very perishable commodity with a short shelf life in conventional cold storage. Sweet cherries are an important fruit in terms of production volumes for Italy. Their shelf life is shortened by loss of firmness, rot susceptibility, discoloration and desiccation of the stem. Postharvest treatments providing even a short extension of shelf-life would benefit the marketing of fresh cherries. Modified atmosphere packaging (MAP) has been successfully applied in order to prolong the shelf-life of sweet cherries. High CO_2 concentrations maintain fruit brightness, preserve acidity and firmness and extend storage life. For these reasons, the aim of this work was to determine the potential of packaging as a practical technique for ready to eat sweet cherry. Hand harvested 'Giulietta' was used to verify the possibility to employ cherries as a ready to eat product. Samples were stored for a short period (10 days), to simulate the shelf-life of ready to eat products. The followed parameters were evaluated: soluble solids content (°Brix), titratable acidity (meq L^{-1}), colour (CIELAB), texture (Durofel Index), total anthocyanin content (mg of cyanidin-3-glucoside 100 g^{-1} product) and antioxidant capacity (mmol Fe 2 kg^{-1} product). The results show that 'Giulietta' can be suitable for use as a ready to eat product because good firmness and titratable acidity was retained after 10 days of storage.

Keywords: 'Giulietta', MAP, ready to eat, shelf-life, storage period

INTRODUCTION

The fresh-cut fruit and vegetable industry is growing rapidly due to the popularity of convenience and healthy food choices. There have been a number of reports in regards to the fresh-cut quality in apple, pear, kiwifruit and mango (Dong et al., 2000; Poubol and Izumi, 2005; Aguayo et al., 2010; Antunes et al., 2010; Dea et al., 2010; Gomes et al., 2010; Abadias et al., 2011). However, there is only one report regarding the use of sweet cherries as a fresh-cut product (Toivonen et al., 2006). Since high quality sweet cherries are grown in Italy, their potential for use in a fresh-cut packaged product was considered to have commercial interest. Value-added products can help to maintain an industry, since they provide income in addition to the sale of the raw commodity.

Sweet cherry is considered one of the most appreciated fruit by consumers since it is an early season fruit and has an excellent quality. Sweet cherry fruits deteriorate rapidly after harvest. For this reason there are severe problems for commercialisation mainly due to incidence of decay and a fast loss of sensory quality for both fruit and stem. In some cases sweet cherries do not reach the consumer at optimal quality after transport and marketing. Special care is needed to control the decay, which is responsible for the high percentage of losses during postharvest storage. The main causes of cherry deterioration are weight loss, colour changes, softening, surface pitting, stem browning and loss of acidity, while low variations occur in TSS (Barrett and Gonzalez, 1994; Bernalte et al., 2003). A value-added fresh-cut sweet cherry product would offer an alternate market for fruits which are culled for defects such as loss of stems and this market could offer a better return for the cherry industry. Several pre- and postharvest technologies have been used to control decay, but the postharvest use of chemicals as fungicides is restricted in most countries. Thus, new preservation technologies are needed. Among these technologies, the use of modified atmosphere packaging for fresh-cut products has been reported to be effective in cherry storage.

Thus, the objective of this work was to evaluate whether sweet cherries could make an acceptable fresh-cut product and if modified atmosphere packaging is a valid practical technique for maintaining the cherry fruit quality during cold storage and extending its shelf life.

MATERIALS AND METHODS

Fruit handling, fresh-cut processing and packaging

Sweet cherries (*Prunus avium* L. 'Giulietta') were harvested from a commercial orchard. In the laboratory, fruits were selected to obtain homogeneous batches based on colour, size, absence of injuries and healthy green stems. Thirty cherries (average mass of 200 g) were packed in non-perforated polyethylene bags (20×30 cm). Plastic films had 90 μm thickness and a permeability at 1°C of 50 mL O_2 m^{-2} day^{-1} atm^{-1} and 150 mL CO_2 m^{-2} day^{-1} atm^{-1}.

All packages were stored at 1°C in the dark. The fruits were analysed at five time points: at harvest (day 0), and after 3, 6, 8 and 10 days of storage. For each sampling date, analytical determinations were performed.

Gas composition

The concentrations of oxygen and carbon dioxide inside the packages were monitored daily by sampling (0.5 mL) the headspace using a CANAL 121 (Vizag, Gas Analysis, France). A syringe was inserted into the package through a rubber seal placed on the film. Gases were analysed with an infrared sensor for CO_2 level and an electrochemical sensor for O_2 level. The instrument was calibrated with air. Results were expressed as % O_2 and % CO_2 inside the bags.

Colour

Colour was determined using the CieLab System and a Minolta colorimeter CR400™ model (Minolta Camera, Osaka, Japan). Following the record of individual L*, a* and b* parameters, colour was expressed as chroma $(a^2+b^2)^{1/2}$ index and Hue Angle and results are the means of two determinations for each cherry along the equatorial axis. Also the L* parameter was determined.

Texture

The textural measurements were carried out with a rapid non-destructive instrument: a penetrometer test by Durofel® (CTIFL Copa Technologie, France), a dynamometer with a bolt of 3 mm Ø (0.10 cm^2), on a scale of 1 (soft) to 60 (firm). Results were expressed as Durofel Index.

Total soluble solids content and titratable acidity determination

The total soluble solids content (TSS) was determined in the juice from 15 fruit with a digital refractometer Atago PR-101 (Atago, Japan) at 20°C and results expressed as °Brix. Titratable acidity (TA) was determined by titration with 0.1 N NaOH up to pH 8.1, using 10 mL of diluted juice in distilled H_2O and results were expressed as meq L^{-1}.

Anthocyanin contents and total antioxidant capacity

For determination of the anthocyanin contents and total antioxidant capacity, extracts were prepared by weighing 10 g of fresh cherries into a centrifuge tube, adding methanol (25 mL) and homogenising the sample for 1 min. Extractions were performed under reduced light conditions. Tubes were centrifuged (3000 rpm for 15 min) and the clear supernatant fluid was collected and stored at -26°C. For identification and quantification, the extraction was performed as three replicates.

The anthocyanin content was quantified according to the pH differential method by Cheng and Breen (1991). Anthocyanins were estimated by their difference of absorbance at 510 and at 700 nm in buffer at pH 1.0 and at pH 4.5, where $A = (A_{515}-A_{700})_{pH1.0} - (A_{515}-$

$A_{700})_{pH4.5}$. Results were expressed as mg of cyanidin-3-glucoside (C3G) 100 g^{-1} fresh berries.

The antioxidant activity was determined using ferric reducing antioxidant power (FRAP) assay, following the method by Pellegrini et al. (2003), with some modifications. The antioxidant capacity of dilute fruit extract is determined by its ability to reduce ferric iron to ferrous iron in a solution of TPTZ prepared in sodium acetate at pH 3.6. The results were expressed as mmol Fe^{2+} kg^{-1} fresh cherries.

Statistical analysis

Data for the physical and chemical sensory parameters were subjected to analysis of variance (ANOVA). Sources of variation were time of storage. Mean comparisons were performed using HSD the Tukey's test to examine if differences between storage time were significant at $P<0.05$. All analyses were performed with program package STATISTICA ver. 6.0 (Statsoft Inc., Tulsa, OK, USA).

RESULTS AND DISCUSSION

Gas composition

The changes in attributes of packaged cherries may be related to the changes in O_2 and CO_2 levels in the package. Cherries passively modified the internal atmosphere with reductions in O_2 and increases in CO_2. The concentration inside the packages reached very high levels of CO_2 (ca. 30% after 10 days of storage) and low levels of O_2 (ca. 2.5% after 10 days of storage). No high-CO_2 disorder was noted in the cherries packaged because cherries can tolerate high CO_2 levels during such a short storage period (Remón et al., 2003).

Colour

The skin colour is considered to be the most important index of cherry quality and maturity (Gao and Mazza, 1995). Chroma index value at harvest was 29.74 and this did not significantly change during the 10 days of cold storage, the values slightly increased until the end of the experiment (31.41) (Figure 1). The same behaviour was also observed in hue angle values.

The consumers demand cherry fruit with a bright red colour and green stems. In this work, an evaluation of colour based on lightness (L) evolution was a good indicator for cherry skin darkening during postharvest storage, since a significant reduction of lightness was obtained (Figure 1).

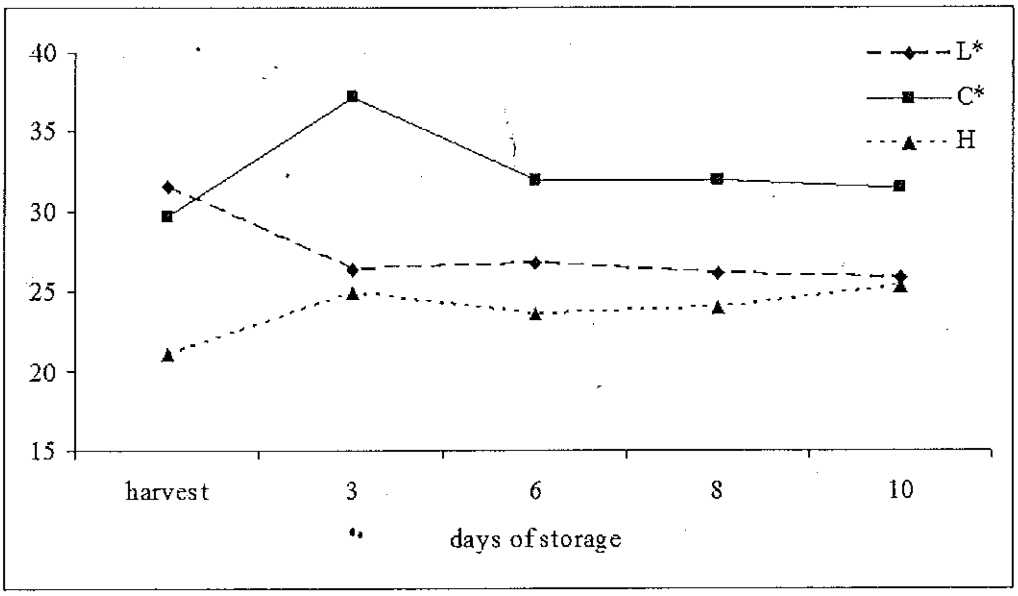

Figure 1. Lightness (L*), chroma index (C*) and Hue angle (H) evolution during cold storage.

Firmness

The firmness at harvest was 59.6 Durofel Index and during cold storage, a small reduction of this parameter was observed, 58.2 Durofel Index at the end of storage period (Table 1). In general, texture changes during the ripening and storage of fruit involves cell wall degradation, which occurs as a result of dissolution in the pectin-rich middle lamella region (Barrett and Gonzalez, 1994). However, Batisse et al. (1996) suggested that cherry fruit softening does not depend on pectin depolymerisation, but on changes in the degree of contact between the cell wall polymers.

Table 1. Durofel index (D.I.), titratable acidity (meq L^{-1}), total soluble solid (°Brix), anthocyanin contents (cyanidin-3-glucoside (C3G) 100 g^{-1} fresh fruit) and total antioxidant capacity (mmol Fe^{2+} kg^{-1} fresh fruit) evolution during cold storage.

	Durofel index	Titratable acidity	Total soluble solid	Anthocyanin contents	Total antioxidant capacity
Harvest	59.6	47.7	11.5	24	12
5 days	58.4	48.9	11.8	-	-
7 days	59	-	-	-	-
10 days	58.2	44.6	11.4	20	10

Total soluble solids content and titratable acidity

At harvest, the levels of TSS were 11.5 °Brix, and no significant modifications were observed during cold storage (Table 1). Many researchers reported that storage with high CO_2 and low O_2 atmospheres did not significantly influence TSS cherries (Neven and Drake, 2000; Remón et al., 2000).

The titratable acidity slightly decreased with storage time, but without significant differences between the harvest and the end of the storage period (Table 1). Accordingly, previous reports have shown that in cherry, the use of MAP has a slight or no effect on the evolution of these chemical parameters (Neven and Drake, 2000; Remón et al., 2000).

Anthocyanin contents and total antioxidant capacity

Anthocyanins are responsible for the red colour in cherries (Gardiner et al., 1993). Nevertheless, discrepancies exist in the changes in anthocyanins during postharvest cherry storage, since either increases or decreases have been reported in different cultivars (Esti et al., 2002; Bernalte et al., 2003; Mozetic et al., 2004).

In this work, anthocyanins significantly decrease during storage by 16% compared with the harvest values. Also the antioxidant capacity of 'Giulietta' decreased linearly during storage, the value at 10 days being 12% lower than that found at 0 days.

CONCLUSION

The results show that 'Giulietta' can used for ready to eat produce because it retains high texture and titratable acidity for 10 days of storage in MAP. The data presented demonstrate that a fresh-cut sweet cherry product is feasible. Delay of storage gives rise to some differences in physical and chemical parameters of cherry samples after storage. However, these changes are, in general, not large enough to prejudice the final cherry quality.

Literature cited

Abadias, M., Alegre, I., Usall, J., Torres, R., and Viñas, I. (2011). Evaluation of alternative sanitizers to chlorine disinfection for reducing foodborne pathogens in fresh-cut apple. Postharvest Biol. Technol. *59* (*3*), 289–297 https://doi.org/10.1016/j.postharvbio.2010.09.014.

Aguayo, E., Requejo-Jackman, C., Stanley, R., and Woolf, A. (2010). Effect of calcium ascorbate treatments and storage atmosphere on antioxidant activity and quality of fresh-cut apple slices. Postharvest Biol. Technol. *57* (*1*), 52–60 https://doi.org/10.1016/j.postharvbio.2010.03.001.

Antunes, M.D.C., Dandlen, S., Cavaco, A.M., and Miguel, G. (2010). Effects of postharvest application of 1-MCP and postcutting dip treatment on the quality and nutritional properties of fresh-cut kiwifruit. J. Agric. Food Chem. *58* (*10*), 6173–6181 https://doi.org/10.1021/jf904540m. PubMed

Barrett, D.M., and Gonzalez, C. (1994). Activity of softening enzymes during cherry maturation. J. Food Sci. *59* (*3*), 574–577 https://doi.org/10.1111/j.1365-2621.1994.tb05565.x.

Batisse, C., Buret, M., and Coulomb, P.J. (1996). Biochemical differences in cell wall of cherry fruit between soft and crisp fruit. J. Agric. Food Chem. *44* (*2*), 453–457 https://doi.org/10.1021/jf950227r.

Bernalte, M.J., Sabio, E., Hernandez, M.T., and Gervasini, C. (2003). Influence of storage delay on quality of Van sweet cherry. Postharvest Biol. Technol. *28* (*2*), 303–312 https://doi.org/10.1016/S0925-5214(02)00194-1.

Cheng, G.W., and Breen, P.J. (1991). Activity of phenylalanine ammonia-lyase (PAL) and concentrations of anthocyanins and phenolics in developing strawberry fruit. J. Am. Soc. Hortic. Sci. *116*, 865–869.

Dea, S., Brecht, J.K., Nunes, M.C.N., and Baldwin, E.A. (2010). Quality of fresh-cut 'Kent' mango slices prepared from hot water or non-hot water-treated fruit. Postharvest Biol. Technol. *56* (*2*), 171–180 https://doi.org/10.1016/j.postharvbio.2010.01.007.

Dong, X., Wrolstad, R.E., and Sugar, D. (2000). Extending shelf life of fresh-cut pears. J. Food Sci. *65* (*1*), 181–186 https://doi.org/10.1111/j.1365-2621.2000.tb15976.x.

Esti, M., Cinquanta, L., Sinesio, F., Moneta, E., and Di Matteo, M. (2002). Physicochemical and sensory fruit characteristic of two sweet cherry cultivars after cool storage. Food Chem. *76* (*4*), 399–405 https://doi.org/10.1016/S0308-8146(01)00231-X.

Gao, L., and Mazza, G. (1995). Characterization, quantitation, and distribution of anthocyanins and colorless phenolics in sweet cherries L. J. Agric. Food Chem. *43* (*2*), 343–346 https://doi.org/10.1021/jf00050a015.

Gardiner, M.A., Beyer, R., and Melton, A. (1993). Sugar and anthocyanidin content of two processing-grade sweet cherry cultivars and cherry products. N. Z. J. Crop Hortic. Sci. *21* (*3*), 213–218 https://doi.org/10.1080/01140671.1993.9513771.

Gomes, M.H., Fundo, J.F., Santos, S., Amaro, A.L., and Almeida, D.P.F. (2010). Hydrogen ion concentration affects quality retention and modifies the effect of calcium additives on fresh-cut 'Rocha' pear. Postharvest Biol. Technol. *58* (*3*), 239–246 https://doi.org/10.1016/j.postharvbio.2010.07.004.

Mozetic, B., Trebse, P., Simcic, M., and Hribar, J. (2004). Changes of anthocyanins and hydroxycinnamic acids affecting the skin colour during maturation of sweet cherries (*Prunus avium* L.). LWT *37*, 123–128.

Neven, L.G., and Drake, S.R. (2000). Comparison of alternative postharvest quarantine treatments for sweet cherries. Postharvest Biol. Technol. *20* (*2*), 107–114 https://doi.org/10.1016/S0925-5214(00)00110-1.

Pellegrini, N., Serafini, M., Colombi, B., Del Rio, D., Salvatore, S., Bianchi, M., and Brighenti, F. (2003). Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different in vitro assays. J. Nutr. *133* (*9*), 2812–2819 https://doi.org/10.1093/jn/133.9.2812. PubMed

Poubol, J., and Izumi, H. (2005). Shelf life and microbial quality of fresh-cut mango cubes stored in high CO_2 atmospheres. J. Food Sci. *70* (*1*), M69–M74 https://doi.org/10.1111/j.1365-2621.2005.tb09049.x.

Remón, S., Ferrer, A., Maquina, P., Burgos, J., and Oria, R. (2000). Use of modified atmospheres to prolong the postharvest life of Burlat cherries at two different degrees of ripeness. J. Asian Food Agric. *80*, 1545–1552 https://doi.org/10.1002/1097-0010(200008)80:10<1545:AID-JSFA680>3.0.CO;2-X.

Remón, S., Marquina, P., Peiró, J.M., and Oria, R. (2003). Storage potential of sweetheart cherry in controlled atmosphere. Acta Hortic. *600*, 763–769 https://doi.org/10.17660/ActaHortic.2003.600.117.

Toivonen, P.M.A., Kappel, F., Stan, S., McKenzie, D.-L., and Hocking, R. (2006). Factors affecting the quality of a novel fresh-cut sweet cherry product. LWT *39* (*3*), 240–246 https://doi.org/10.1016/j.lwt.2005.02.014.