Trends in Food Science & Technology 55 (2016) 72–83

Contents lists available at ScienceDirect

Trends in Food Science & Technology

journal homepage: http://www.journals.elsevier.com/trends-in-food-science-and-technology

Review

Sweet cherry: Composition, postharvest preservation, processing and trends for its future use

Suwimol Chockchaisawasdee [a,*], John B. Golding [a,b], Quan V. Vuong [a], Konstantinos Papoutsis [a], Costas E. Stathopoulos [c]

[a] School of Environmental and Life Sciences, The University of Newcastle, PO Box 127 Ourimbah, NSW 2258, Australia
[b] NSW Department of Primary Industries, Locked Bag 26, Gosford, NSW 2250, Australia
[c] School of Science, Engineering and Technology, University of Abertay, Dundee DD1 1HG, UK

ARTICLE INFO

Article history:
Received 16 October 2015
Received in revised form
21 June 2016
Accepted 1 July 2016
Available online 12 July 2016

Keywords:
Prunus avium
Postharvest technology
Sweet cherry products
Anthocyanins
Phenolic compounds
Value adding

ABSTRACT

Background: Sweet cherries (*Prunus avium* L.) are a nutritious fruit which are rich in polyphenols and have high antioxidant potential. Most sweet cherries are consumed fresh and a small proportion of the total sweet cherries production is value added to make processed food products. Sweet cherries are highly perishable fruit with a short harvest season, therefore extensive preservation and processing methods have been developed for the extension of their shelf-life and distribution of their products.
Scope and approach: In this review, the main physicochemical properties of sweet cherries, as well as bioactive components and their determination methods are described. The study emphasises the recent progress of postharvest technology, such as controlled/modified atmosphere storage, edible coatings, irradiation, and biological control agents, to maintain sweet cherries for the fresh market. Valorisations of second-grade sweet cherries, as well as trends for the diversification of cherry products for future studies are also discussed.
Key findings and conclusions: Sweet cherry fruit have a short harvest period and marketing window. The major loss in quality after harvest include moisture loss, softening, decay and stem browning. Without compromising their eating quality, the extension in fruit quality and shelf-life for sweet cherries is feasible by means of combination of good handling practice and applications of appropriate postharvest technology. With the drive of health-food sector, the potential of using second class cherries including cherry stems as a source of bioactive compound extraction is high, as cherry fruit is well-known for being rich in health-promoting components.

1. Introduction

Cherries are thought to be native to Europe and western Asia and are now grown widely around the world (Iezzoni, 2008; Webster & Looney, 1996). Cherries are within the Rosaceae family and belong to the genus *Prunus*, subspecies *Cerasus* and section *Eucerasus*. There are three main species of cherry fruits referenced in this section; sweet (*Prunus avium*), and tart or sour (*Prunus cerasus*), and ground (*Prunus fruticosa* Pall.) cherries. Among the three species, of global trading importance are sweet and tart cherries (Iezzoni, 2008). Commercial cultivation of sweet cherry is generally more difficult and expensive than tart cherry as high levels of care must be taken throughout the supply chain to achieve premium quality fruit for serving in the fresh market (Looney & Jackson, 2011; Sredojević, Milić, & Jeločnik, 2011).

The basic chromosome number of *Prunus* (section *Eucerasus*) is $x = 8$. Sweet cherry is diploid ($2n = 16$) while tart cherry is tetraploid ($2n = 32$) (Iezzoni, 2008). A botanical feature which differentiate sweet from sour cherries is the size distribution of subepidermal cells: in tart cherry are even, while those in sweet cherry are not. However, the main difference in physiochemical properties of sweet and tart cherry are fruit size, level of pectic substances, the ratio of soluble solids content (SSC, or total soluble solids (TSS)) to titratable acidity (TA), and the composition of anthocyanins. Unlike the tart cherry fruits, which have more sour taste due to higher levels of organic acids (8–20% SSC, 1.5–1.8% TA),

* Corresponding author.
E-mail addresses: Suwimol.Chockchaisawasdee@newcastle.edu.au (S. Chockchaisawasdee), John.Golding@dpi.nsw.gov.au (J.B. Golding), Vanquan.Vuong@newcastle.edu.au (Q.V. Vuong), Konstantinos.Papoutsis@uon.edu.au (K. Papoutsis), C.Stathopoulos@abertay.ac.uk (C.E. Stathopoulos).

http://dx.doi.org/10.1016/j.tifs.2016.07.002
0924-2244/

sweet cherries have higher levels of sugar and lower levels of TA (13–25% SSC, 0.4–1.5% TA) (Girard & Kopp, 1998; McLellan & Padilla-Zakour, 2004). The SSC/TA ratio has an impact on the perception of sweetness and flavour (Crisosto, Crisosto, & Metheney, 2003). Kappel, Fisher-Fleming, and Hogue (1996) reported that the SSC/TA ratio yielding the highest sensorial appreciation was between 1.5 and 2. The major anthocyanin compound found in sweet cherry is cyanidin 3-rutinoside whilst in tart cherry is cyanidin 3-glucosylrutinoside (Kim, Heo, Kim, Yang, & Lee, 2005). Tart cherries are generally smaller in size but contain higher amounts of pectic substances than those in sweet cherry (Cao et al., 2015). Tart cherries are generally grown exclusively for processing, while sweet cherries are mainly grown for the fresh market.

This review will focus on the use of fresh sweet cherry for fresh and processing markets. It provides comprehensive details on the important nutritional components and their analysis methods in sweet cherries, trends of postharvest research (such as controlled/modified atmosphere storage, edible coatings, irradiation, and biological control agents), processing of sweet cherries, as well as trends for the diversification of cherry products for future studies.

2. World production, cultivars, and eating quality attributes of sweet cherries

Sweet cherry is an important horticultural trading around the world (Webster & Looney, 1996). The quantity of global cherry exports increased from 145 thousand tons in 2000 to 376 thousand tons in 2011, with the USA, Turkey, Chile, and Spain as the main exporters (FAOSTAT, 2015). There are hundreds of commercial sweet cherry cultivars, but there are generally only a number of predominate cultivars in any given country or region. Cherries are harvested in the summer periods, where in general early-ripening cultivars predominate at lower latitudes, while late-maturing cultivars are grown in higher latitudes, such as western Canada and Norway (Looney & Jackson, 2011). Fresh sweet cherries are now routinely marketed across the world. Different cultivars meet the market demands in each overseas market. Important considerations of each export cultivar include harvest time, suitability for long-distant shipping, and fruit quality and eating attributes appropriate for each market. However, cultivars yielding high quality fruit which are less prone to fruit defects during growth and after harvest are always highly sought after. Current important cherry cultivars include 'Alex', 'Attika', 'Bing', 'Brooks', 'Burlat', 'Chelan', 'Hedelfingen', 'Kordia', 'Lambert', 'Lapins', 'Rainier', 'Regina', 'Skeena', 'Sonata', 'Staccato', 'Stella', 'Sweetheart', 'Techlovan', 'Tulare' and 'Van' (Schuster, 2012). However the breeding of new cherry cultivars with superior pre- and postharvest traits are being actively researched. Schuster (2012) summarised an update of the *S*-genotype of 734 sweet cherries, which included 51 new cultivars in addition to the previously published data.

The quality of sweet cherries in the market is usually determined by fruit size, skin colour, flavour, sweetness, sourness, firmness and stem colour, as these attributes have been found to be closely related to consumers' acceptability and market prices (Dever, MacDonald, Cliff, & Lane, 1996). Indeed many studies have confirmed correlations between physicochemical properties of sweet cherries (weight, appearances of skin and stem, SSC, TA, SSC/TA ratio, firmness) and cherry fruit acceptability by taste panellists and consumers (Crisosto et al., 2003; Dever et al., 1996; Kappel et al., 1996). In general, consumers are firstly attracted to the appearance of cherries; where fruit which have bright and shiny skin, absence of defects and flaws, intensity and homogeneity of skin colour, appearance of stem, and good fruit size are highly prized. Taste, texture and flavour are generally second decisive criteria in quality appreciation. Each market has its own preferences and opinions on what constitutes a high quality cherry. Crisosto et al. (2003) showed that for 'Brooks' and 'Bing' cherries, need to be a full bright red or dark mahogany skin colour, respectively with a minimum SSC of 16.0% Brix to satisfy the majority of American consumers.

3. Composition of sweet cherries

Botanically, cherry fruit are classified as a fleshy drupe with a central stony-hard seed surrounded with fleshy fruit, which contains most of the nutrients and bioactive components. Sweet cherry fruits have a glossy bright appearance with a thin skin and can either be described as dark red, red, blush, or white. The development of chromatic characteristics depends on the cultivars, growing conditions, ripeness stage, and storage conditions (Gonçalves et al., 2007). Sweet cherry fruits are considered highly nutritious fruits where they have significant levels of important nutrients and bioactive components, including glucose, fructose, vitamin C, anthocyanins, quercetin, flavan-3-ols, flavanols and hydroxycinnamate (Gao & Mazza, 1995). However numerous studies have demonstrated that the levels of these compounds vary depending on a range of preharvest and postharvest factors such as cultivar, stages of ripeness, growing conditions, pre- and postharvest treatments (Cao et al., 2015; Esti, Cinquanta, Sinesio, Moneta, & Di Matteo, 2002; Gonçalves et al., 2007; Serrano, Guillén, Martínez-Romero, Castillo, & Valero, 2005a; Usenik, Fabčič, & Štampar, 2008).

Sweet cherry fruits also contain relatively high levels of bioactive components. There have been numerous *in vitro* and *in vivo* studies which have linked these bioactive components in cherries with various health benefits (McCune, Kubota, Stendell-Hollis, & Thomson, 2011; Del Rio, Costa, Lean, & Crozier, 2010; Tomás-Barberán & Andrés-Lacueva, 2012; Wang & Stoner, 2008).

3.1. Nutrient components

Sweet cherry fruit are prized for their excellent taste and nutritious nature. A summary of the organoleptic attributes (SSC, TA, anthocyanin, total phenolic content (TPC)) in a range of sweet cherry cultivars is presented in Table 1 and demonstrates the range and diversity of cherry quality parameters in important cherry cultivars around the world.

3.1.1. Sugars

Sugars play an essential role in quality of sweet cherry fruits as they are balanced with acid in the fruit to contribute to flavour. In sweet cherries, the level of sugars can be as high as 25 g/100 g of fruit (Girard & Kopp, 1998). Five different types of sugars are normally found in sweet cherries, glucose, sucrose, fructose, maltose, and sorbitol. However the main sugars found in sweet cherries are glucose and fructose which account for approximately 90% of total sugars of the fruits (Usenik et al., 2008). The levels of these different sugars vary depend on the cultivar, agronomic factors, environmental conditions and the stage of development and ripening (Ballistreri et al. 2013; Serrano, Guillén, et al., 2005; Usenik et al., 2008; Usenik, Stampar, Petkovsek, & Kastelec, 2015). A study on the changes of sugar levels the cherry cultivar 'Marvin-Niram', during 14 different stages of maturity (in accordance with homogenous size and colour), showed that the levels of glucose and fructose steadily increased during growth and development (Serrano, Guillén, et al., 2005).

The levels of sugars in the fresh cherry fruit have been shown to have a strong relationship with the acceptability by customers (Crisosto et al., 2003). In processed cherry products, the levels of sugars in fruits also contribute to final product quality. For example