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Ready-to-eat sweet cherries: Study on different packaging systems

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ABSTRACT

In this study the influence of different packaging systems on quality loss of ready-to-use cherries was assessed. In particular, the fruits were packaged in oriented polypropylene-based bag and in a bio-based polymeric matrix under ordinary and modified atmosphere conditions (MAP). Cherries quality during storage was determined by monitoring headspace gas concentration, weight loss, titrable acidity, total soluble solids, maturity index, antocyanins level, pH, viable cell load of various microbial groups and sensory quality. Results suggest that under ordinary atmosphere conditions, OPP shows the best performances. Otherwise, under MAP, both investigated films exert similar effects on the portioned fruit.
Industrial relevance: Due to changes in consumer attitudes, ready-to-use fruit market has grown rapidly in recent years. At the same time there is a real need to prevent the environmental pollution provoked by packaging material. Therefore, the combination of a biodegradable film to modified atmosphere packaging could gain widespread acceptance by the industry. This paper, in fact, suggests effective packaging solution to delay the quality decay kinetic of ready-to-use cherries.

1. Introduction

Sweet cherries (*Prunus avium* L.) are one of the most popular temperate fruit. They are usually picked from June to mid-July at peak maturity for optimal taste and appearance (Vursavus, Kelebek, & Selli, 2006). The main characteristics often used for cherry quality assessment are colour, sweetness, sourness and firmness (Esti, Cinquanta, Sinesio, Moneta, & Di Matteo, 2002). The range of total soluble solids (TSS) accounts for 11–20 °Brix and the acidity for 0.4–1.5% (Serrano, Martínez-Romero, Castillo, Guillén, & Valero, 2005). The relationship between TSS, acidity and visual appearance plays an important role in determining consumer acceptance of this fruit (Crisosto, Crisosto, & Metheney, 2003). Due to considerable contents of phenolics and anthocyanins sweet cherries are characterized by a high antioxidant activity (Usenik, Fabcic, & Stampar, 2008; Vursavus et al., 2006). This fruit is by nature a highly perishable product. Postharvest quality loss is mainly due to bruising of the skin, softening, changes in the sugar–acid balance, desiccation and browning of the stem (Alique, Zamorano, Martínez, & Alonso, 2005; Bernalte, Sabio, Hernandez, & Gervasini, 2003; Petracek, Joles, Shirazi, & Cameron, 2002). Moreover, fungal spoilage of the genera *Penicillium, Botrytis* and *Monilia* can damage seriously sweet cherries, in particular for longer storage period (Chand-Goyal & Spotts, 1996). For the control of postharvest diseases numerous alternatives to synthetic fungicides have been applied to sweet cherries (Romanazzi, Nigro, & Ippolito, 2003, 2008; Romanazzi, Nigro, Ippolito, & Salerno, 2001). Martínez-Romero et al. (2006) studied the effects of a novel edible coating based on *Aloe vera* gel to maintain sweet cherry quality and safety during postharvest.

Evidences of health-promoting properties of fruit, combined to consumer demand for food with high convenience level, have boosted the interest in minimally processed products (Ragaert, Devlieghere, & Debevere, 2007). As a consequence, the exploration of new technologies to preserve the quality of fresh-cut and ready-to-eat commodities, considered as human-safe and environmentally friendly, is greatly desirable (McKellar et al., 2004; Rico, Martín-Diana, Barat, & Barry-Ryan, 2007). For sweet cherries cool storage appeared to be a reliable way to stop fruit deterioration (Bernalte et al., 2003). In addition, the use of modified atmosphere packaging (MAP) has been reported to be effective in delaying the physico-chemical changes related to quality loss (Meheriuk et al., 1995; Petracek et al., 2002; Remón, Ferre, Marquina, Burgos, & Oria, 2000; Spotts, Cervantes, & Facteau, 2002; Tian, Jiang, Xu, & Wang, 2004). Different O_2 and CO_2 concentrations have been reported to be optimal for different cherry cultivars. The combination of passive MAP with several essential oils has been also shown to improve the beneficial effects of the headspace gas composition on the quality of cherries (Serrano et al., 2005).

In the sector of ready-to-eat products the polymeric material used for packaging could be another aspect of industrial relevance. The extensive use of synthetic packaging films has led to serious ecological problems due to their total non-biodegradability. Their complete substitution with

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more eco-friendly polymers is difficult, however, the utilization of biodegradable systems in specific food packaging sector such as ready-to-eat food, could be possible (Siracusa, Rocculi, Romani, & Dalla Rosa, 2008). A few applications of bio-based films to ready-to-use fruit and vegetables have been reported in the literature; moreover, the different characteristics of every product need to tailor a specific packaging for each of them (Conte, Scrocco, Brescia, & Del Nobile, 2009; Del Nobile, Baiano, Benedetto, & Massignan, 2006; Del Nobile, Conte, Cannarsi, & Sinigaglia, 2008; Del Nobile, Licciardello, Scrocco, Muratore, & Zappa, 2007; Del Nobile, Sinigaglia et al., 2008; Del Nobile et al., 2009). For this reason, the potential application of a bio-polymeric film, compared to traditional oriented polypropylene, was investigated on ready-to-eat sweet cherries packaged under ordinary and modified atmosphere conditions.

2. Materials and methods

2.1. Sample preparation

Two batches of cherries (*Prunus avium* L., cv Ferrovia) were harvested from a commercial agricultural farm, Gigante Giacomo (Conversano, Italy) at a week of distance. The harvests were named BatchI and BatchII, depending on the harvesting time. Each of them was directly transported from the field to the laboratory of the University of Foggia, and selected for size, absence of injuries and greenish stems. The cherries were washed in tap water, treated for 1 min with cold chlorinated water ($0.25\ g \cdot L^{-1}$) and rinsed by immersion in tap water at room temperature for another minute. The excess water was removed by using a manual salad spinner. Amounts of 250 g of cherries were packaged in two different bags having a surface area of about 875 cm^2. These films were made up of oriented polypropylene (OPP, 20 μm), kindly provided by Metalvuoto (Roncello, Mi, Italy) and by biodegradable co-extruded polyesters (COEX, 35 μm) kindly provided by Novamont (Novara, Italy). The bags were hermetically sealed. The cherries belonged to the BatchI were sealed under ordinary atmosphere, whereas the fruit belonged to the BatchII were packaged under modified atmosphere conditions (MAP) (10% O_2, 4% CO_2 and 86% N_2) by means of a thermal sealer (Gandus sealers, Milan, Italy). All bags were stored at 0 °C. Samples of cherries from each Batch stored without packaging served as the control (CNT).

2.2. Headspace gas composition

O_2 and CO_2 headspace concentrations of all packages were measured using a gas-metre (PBI Dansensor, Checkmate 9900, Ringsted, Denmark). The volume taken from the package headspace for gas analysis was about 10 cm^3. To avoid modifications in the headspace gas composition due to gas sampling, each package was used only for a single measurement. At each sampling time three samples per treatment were used.

2.3. Microbiological analyses

For the microbiological analyses, about 10 g of product from each bag were homogenised with 90 ml of sterile saline solution (0.9%) mixed in a sterilmixer (International PBI, Milan, Italy) for 2 min at room temperature. Afterwards, serial dilutions (1:10) were performed and microbiological counts of total mesophilic and psychrotrophic bacteria, total coliforms, yeasts and moulds were determined. The media and the conditions used were the following: (1) Plate Count Agar (PCA, Oxoid, Milan, Italy), incubated at 30 °C for 48 h for total mesophilic bacteria (ICMSF, 1978) and at 7 °C for 10 days for total psychrotrophic bacteria (ICMSF, 1978); (2) Violet Red Bile Agar (VRBA, Oxoid), incubated at 37 °C for 24 h for total coliforms (ICMSF, 1978); (3) Sabouraud Dextrose Agar (Oxoid), supplemented with chloramphenicol ($0.1\ g\ L^{-1}$) (C. Erba, Milan, Italy) incubated at 25 °C for 48 h for yeasts and for 5 days for moulds (ICMSF, 1978). The analyses were carried out twice.

2.4. Chemical analyses

The pH was evaluated on the homogenised cherries by a pH-metre (Crison Instruments, Barcelona, Spain). The titrable acidity (TA) was determined by potentiometric titration with 0.1 N NaOH up to pH 8.1, using 25 ml of diluted juice in 200 ml distilled water, according to the method proposed by Remón, Venturini, Lopez-Buesa, and Oria (2003). Results were expressed as g of malic acid equivalents per 100 ml juice. Total soluble solids content (TSS) was measured from the juice cherries by a digital refractometre (Atago Co., Ltd. Japan) at 20 °C. Results were expressed as °Brix. Maturity index was expressed as the ratio between TSS and TA. Anthocyanins were determined using 5 g of fruit tissue homogenised in 10 ml of methanol, by reading the absorbance at 530 nm, according to the method proposed by Serrano et al. (2005). Results were expressed as $mg100\ g^{-1}$. All chemical analyses were carried out twice.

2.5. Weight loss

The percentage weight loss was calculated by weighting samples with a digital precision balance (±0.1 g) (Gibertini Europe, Italy). At each sampling time the weight was measured twice.

2.6. Permeation tests

The Water Vapour Transmission Rate (WVTR) of the selected films was determined by means of a water vapour permeability analyser (Lyssy, Model 80-5000, Dansensor, Ringsted, Denmark). The films (surface area of 5 cm^2) were tested at 23 °C and 85% of relative humidity (RH) gradient. A flow rate of 100 ml/min of nitrogen was used. The measurements were curried out twice.

The Oxygen Transmission Rate (OTR) was determined by means of an Ox-Tran (Mocon, Model 2/20). The films (surface area of 5 cm^2) were tested at 23 °C and 0% RH at the upstream and the downstream side of the sample. The measurements were curried out twice.

2.7. Sensory analysis

The sensory quality of the investigated ready-to-eat cherries packaged under ordinary and modified atmosphere conditions was evaluated by using a panel of 7 untrained judges (Del Nobile et al., 2009), researches of the Department of Food Science (Agricultural Faculty) of the University of Foggia. In particular, odour, colour, taste, texture and visible moulds were selected as quality attributes. The panellists were also asked to give their opinion about the *overall quality* of the product, taking into account the judgement assigned to each above-mentioned attribute. To this aim, a scale ranging from 1 to 5 (1 = extremely unacceptable and 5 = extremely acceptable) was used, according to the procedure reported by Giménez et al. (2003). A score equal to 3 was used as the threshold for produce acceptability. The analyses were performed in isolated booths in a standard taste panel kitchen by presenting samples with 3 digit codes. The panelists drunk water between the samples. During the test sessions, the sample presentation order was randomized.

2.8. Sensory acceptability limit calculation

In order to determine the sensory acceptability limit of the differently packaged cherries the following first order kinetic type equation was fitted to the experimental data:

$$Attr(t) = \frac{Attr_{min} - Attr_0 \cdot exp(-k \cdot SAL)}{1 - exp(-k \cdot SAL)} + \left(Attr_0 - \frac{Attr_{min} - Attr_0 \cdot exp(-k \cdot SAL)}{1 - exp(-k \cdot SAL)}\right) \cdot exp(-k \cdot t) \quad (1)$$