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The use of natural antifungal compounds improves the beneficial effect of MAP in sweet cherry storage

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Abstract

Sweet cherry shows severe problems for commercialisation mainly due to incidence of decay and a fast loss of sensory quality, both for fruit and stem. A package has been developed based on the addition of eugenol, thymol, menthol or eucalyptol (pure essential oils) separately to trays sealed with polypropylene bags to generate a modified atmosphere (MAP). In addition, cherries in MAP (without essential oils) were selected and served as controls. All cherries were stored during 16 days at 1 °C and 90% RH. Steady-state atmosphere was reached after 9 days of cold storage with 2–3% of CO_2 and 11–12% of O_2 with no significant differences between treated and control, with the exception of eucalyptol, in which significant increases in CO_2 and decreases of O_2 were obtained. When fruit quality parameters were determined, those treated with eugenol, thymol or menthol showed benefits in terms of reduced weight loss, delayed colour changes and maintenance of fruit firmness compared with control. Stem remained green in treated cherries while they became brown in control. However, cherries packaged with eucalyptol behaved even worst than control cherries, with generation of off-flavours, loss of quality and stem browning. Finally, the microbial analysis showed that all essential oils reduced moulds and yeasts and total aerobic mesophilic colonies by 4- and 2-log CFU compared with control, respectively. In conclusion, the use of MAP in combination with eugenol, thymol or menthol is an effective tool on maintaining cherry fruit quality and reducing the occurrence of decay.

Keywords: *Prunus avium* L.; Essential oils; Fruit quality; Decay; Ripening; MAP

Industrial relevance: The data presented in this work suggest that the use of pure essential oils (eugenol, thymol or menthol) in combination with modified atmosphere packaging (MAP) is an innovative and useful tool as alternative to the use of synthetic fungicides in fruits and vegetables, especially for those which are highly perishable and have a short shelf-life, as cherries. These compounds have been included in the list of generally recognized as safe (GRAS) compounds by FDA. As far as we know, this is the first paper dealing on the use of natural antifungal compounds and MAP and that these combined technologies confer benefits in fruit storage and retailing, with reduction in spoilage microorganisms, maintenance of cherry quality attributes and extension of shelf-life. The effects of these natural compounds on individual microorganisms, both responsible for spoilage and food-borne pathogens, as well as the minimum concentration to gain effectiveness deserve further research.

1. Introduction

Spain is one of the main cherry producers in Europe, with production of 115 000 metric tonnes in 2003, which represents a 20% of the total in the European Union (MAPYA, 2003). Sweet cherry is considered one of the most appreciated fruit by consumers since it is an early season fruit and has an excellent quality. The main sensory attributes are: colour, sweetness, sourness and firmness. Skin colour is considered one of the main quality indexes and is related to fruit ripening and affected by anthocyanin concentration (Gao & Mazza, 1995). Sweetness is mainly due to glucose and fructose

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and lower presence of sucrose and sorbitol, with a range of total soluble solids (TSS) of 11–20 °Brix, depending on cultivar. Acidity (TA) depends also on cultivar, with levels of 0.4–1.5%, the main organic acid being malic acid (Bernalte, Hernández, Vidal-Aragón, & Sabio, 1999; Bernalte, Sabio, Hernández, & Gervasini, 2003; Esti, Cinquanta, Sinesio, Moneta, & Di Matteo, 2002). Fruit firmness is also an important quality attribute and is directly related to enhance the storability potential and to induce greater resistance to decay and mechanical damage (Barret & González, 1994). In addition, the TSS/TA ratio at harvest has been shown to be a predominant parameter for consumer acceptance together with the absence of stem browning (Crisosto, Crisosto, & Metheny, 2003).

Sweet cherry fruits deteriorate rapidly after harvest with a reduced shelf life and in some cases do not reach the consumer at optimal quality after transport and marketing. 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 (Barret & González, 1994; Batisse, Buret, & Coulomb, 1996; Bernalte et al., 2003). Finally, special care is needed with the occurrence of decay, which is responsible for the high percentage of losses during postharvest storage. In cherry, the fungal spoilage is mainly due to species of genera *Penicillium*, *Botrytis* and *Monilia*, which are responsible for blue rot, gray mold and brown rot, respectively (Venturini, Oria, & Blanco, 2002). The development of these fungi during postharvest storage can cause great economic losses, and thereafter a fermentative metabolism with generation of "off-flavours" due to ethanol and acetaldehyde (Esti et al., 2002). The occurrence of rots and their influence on cherry quality have been reported to be dependent on cultivar (Kappel, Toivonen, McKenzie, & Stam, 2002) and ripening stage at harvest (Drake & Elfving, 2002). Several pre- and postharvest technologies have been used to control decay, but the postharvest use of chemicals as fungicides is restricted in most countries. Besides, consumers demand agricultural commodities without pesticide residues. Thus, new preservation technologies are needed, which have to be considered as human-safe and environmentally friendly.

Among these technologies, the use of modified atmosphere packaging (MAP) has been reported to be effective in cherry storage. MAP induces a delay in the physicochemical changes related to fruit quality loss by increasing the level of CO_2 and decreasing the O_2 content. However, different O_2 (2–10%) and CO_2 (5–20%) concentrations have been reported to be optimal for different cherry cultivars (Kupferman & Sanderson, 2001; Meheriuk et al., 1997; Remón, Ferrer, Maquina, Burgos, & Oria, 2000; Remón, Venturini, López-Buesa, & Oria, 2003; Spotts, Cervantes, & Facteau, 2002; Tian, Fan, Xu, Wang, & Jiang, 2001). These discrepancies could be related to cultivar itself or ripening stage at harvest. Thus, for each cultivar the optimum atmospheric composition should be carefully evaluated.

In recent years, there is an increasing interest in the possible use of natural compounds to prevent microbial growth in the food items, thus answering to consumer's pressure to reduce chemical additives in foods. Plants have an almost limitless ability to synthesise aromatic substances, most of which are phenols or derivatives. Many compounds are responsible for plant flavour, and some of the herbs and spices used by human to season food yield useful medicinal compounds (Cowan, 1999). Among these natural compounds, the antifungal activity of several essential oils belonging to genus *Thymus*, *Syzygium*, *Mentha* and *Eucalyptus*, is well documented (see review of Appendini & Hotchkiss, 2002). In food products, these essential oils have been used in bakery (Nielsen & Ríos, 2000), cheese (Vázquez, Fente, Franco, Vázquez, & Cepeda, 2001), meat (Quintavalla & Vicini, 2002) and fruit (Lanciotti et al., 2004), among others. The advantage of essential oils is their bioactivity in the vapour phase, a characteristic that makes them useful as possible fumigants for stored commodity protection. In this sense, fumigation of sweet cherry with thymol (the main active ingredient of thyme) was effective controlling gray mold and brown rot caused by previous inoculation with spores of *B. cinerea* (Chu, Liu, Zhou, & Tsao, 1999).

There are evidences that some of these compounds have been added to polymeric films in their structure (Appendini & Hotchkiss, 2002). However, no data are available of these essential oils inside the packages and their role on controlling cherry quality and spoilage. Thus, the aim of this paper was to develop a package using some natural antifungal compounds to improve the beneficial effect of MAP on maintaining cherry fruit quality during cold storage and extending its shelf life. The natural antifungal compounds used were eugenol, thymol, menthol and eucalyptol.

2. Material and methods

2.1. Plant material and experimental design

Sweet cherries (*Prunus avium* L. cv. 'StarKing') were harvested from a commercial farm belonging to Denominación Específica "Cerezas de la Montaña de Alicante" (Alicante, Spain). At laboratory, fruit were selected to obtain homogeneous batches based on colour, size, absence of injuries and healthy greenish stems. Twenty cherries (average mass of 135.91±0.23 g) were packed in polypropylene trays. Five sets of 30 trays were introduced in non-perforated oriented polypropylene (N-OPP) bags (20×15 cm) for the natural antifungal treatments: eugenol, thymol, menthol or eucalyptol (99.5% purity and purchased from Sigma, Sigma-Aldrich, Madrid, Spain). Sweet cherries packed in the same conditions but without essential oils