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The addition of rosehip oil improves the beneficial effect of *Aloe vera* gel on delaying ripening and maintaining postharvest quality of several stonefruit

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ABSTRACT

In this work *Aloe vera* gel (AV) alone or with the addition of 10 or 2% rosehip oil was used as fruit edible coatings in a wide range of *Prunus* species and cultivars: peaches ('Roma' and 'B-424-16' flat type), plums ('Red Beauty' and 'Songria'), nectarine ('Garofa') and sweet cherry ('Brooks'). Following treatments, fruit were stored at 20 °C for 6 days and analysed for the effect of treatments on fruit ripening and quality parameters compared with uncoated fruit (control). The addition of the rosehip oil to AV gel reduced respiration rate in all fruit, and ethylene production in the climacteric ones (peaches, plums and nectarine). In addition, all the parameters related with fruit ripening and quality, such as weight loss, softening, colour change and ripening index, were also delayed in treated compared with control fruit, the effect being generally higher when rosehip oil was added to AV, and especially in those fruit that exhibited the highest ethylene production rates ('Roma' and flat type peaches). Although the highest effect was obtained with AV + rosehip oil at 10%, the sensory panel detected an excess of gloss and oiliness on the fruit surface, which was considered as a negative attribute. Thus, 2% rosehip oil added to AV could be used as an innovative postharvest tool to increase the beneficial effect of AV as an edible coating, especially in climacteric fruit showing high ethylene production rates.

1. Introduction

Stonefruit including peach, nectarine, plum and sweet cherry are very appreciated by consumers due to their organoleptic and nutritive properties as well as their content of bioactive compounds with antioxidant activity (Díaz-Mula et al., 2008; Serrano et al., 2009, 2011; Legua et al., 2011). However, stonefruit deteriorate rapidly after harvest and lose their quality in a short period of time ranging from several days to 1–2 weeks, depending on plant species and cultivar (Valero and Serrano, 2010).

Low temperature storage is generally used to delay the postharvest deterioration process, although in some cases this treatment is not enough to maintain fruit quality during handling, transport and commercialization. In this sense, additional postharvest tools together with cold storage are necessary. In recent years, the use of *Aloe vera* gel (AV) has been used as an edible coating for raw produce such as mangoes (Dang et al., 2008), nectarines (Ahmed et al., 2009; Navarro et al., 2011), apples (Ergun and Satici, 2012), papaya (Marpudi et al., 2011), table grapes (Valverde et al., 2005), sweet cherries (Martínez-Romero et al., 2006), figs (Marpudi et al., 2013), strawberries (Singh et al., 2011), tomatoes (Chauhan et al., 2013), peaches and plums (Guillén et al., 2013). In all these fruit commodities, the AV treatment preserved physico-chemical parameters such as colour, firmness, total acidity (TA), and reduced respiration rates, ethylene production (in those climacteric fruit) and weight loss, leading to maintenance of the quality characteristics and extension of the shelf-life.

The gel of AV and other *Aloe* spp. is mainly composed of polysaccharides and soluble sugars followed by proteins, vitamins and minerals (Eshun and He, 2004), but are very low in lipid content, ranging from 0.07 to 0.42% depending on the *Aloe* spp. and climatic conditions during the growth cycle (Zapata et al., 2013). Thus, the gas barrier and hydrophobic properties of AV-based edible coatings could be improved with the addition of lipids, since the increase of lipid content in the composition of edible coatings leads to higher hydrophobic properties and barrier efficacy (Morillon et al., 2002). In this sense, rosehip seed is an inexpensive source of unsaturated fatty acids rich oil and is becoming very popular in cosmetic and other high valuable applications such as in the pharmaceutic industry, due to its antioxidant properties (Franco et al., 2007;

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Table 1
Fatty acid composition and relative concentration of rosehip oil ($n = 3$).

Fatty acid	Chemical name	Concentration (%)
Myristic acid	C14:0	2.26 ± 0.15
Palmitic acid	C16:0	6.70 ± 0.34
Palmitoleic acid	C16:1	2.32 ± 0.09
Stearic acid	C18:0	2.78 ± 0.11
Oleic acid	C18:1	16.04 ± 1.12
Linoleic acid	C18:2	43.47 ± 2.45
Linolenic acid	C18:3	23.77 ± 1.06
Arachidic acid	C20:0	2.65 ± 0.23

Machmudah et al., 2007). However, there is no evidence of the use of rosehip oil in the agro-food industry. Thus, the objective of this research was to analyse the beneficial effect of the addition of rosehip oil to AV gel on delaying the ripening process and maintaining quality in a wide range of *Prunus* species and cultivars. As far as we know, this is the first time in which rosehip oil is being used as postharvest fruit treatment.

2. Materials and methods

2.1. Experimental design

Several stonefruit were manually harvested from commercial orchards in Southern Spain on year 2012 at the commercial ripening stage. The fruit were: peach (*Prunus persica* [L.] Batsch cv. Roma), flat peach (*Prunus persica* [L.] Batsch cv. B-424-16), nectarine (*Prunus persica* [L.] Batsch cv. Garofa), plums (*Prunus salicina* Lindl. cv. Red Beauty and Songria) and sweet cherry (*Prunus avium* L. cv. Brooks). For peach and plum species, 15 lots of 5 fruit each homogeneous in colour and size were selected, while for cherries the lots were composed of 20 fruit. Three lots were used to determine the fruit properties at harvest and the remained 12 for the following treatments in triplicate: control (distilled water), *Aloe vera* gel at 100% (AV), *Aloe vera* gel at 100% + rosehip oil 2% (AVR2), and *Aloe vera* gel + rosehip oil 10% (AVR10). The AV gel was obtained according to previous reports (Navarro et al., 2011; Zapata et al., 2013). Briefly, freshly AV leaves (harvested 3 h after sunrise) were transferred to the laboratory and then the parenchymatous tissue was manually removed to obtain the gel from each leaf, which was filtered to discard fibrous tissue. Rosehip oil (*Rosa rubiginosa* L. or its synonymous *Rosa eglanteria*) was purchased from Guinama, Valencia, Spain). Chemical composition of free fatty acids from rosehip oils is shown in Table 1. AVR2 and AVR10 were prepared by dissolving the corresponding concentration of rosehip oil (2 or 10%) to Tween-80 and then added to AV gel by vigorous shaking. Treatments were performed by dipping the fruit in the corresponding solution for 10 min. After treatments, fruit were left to dry at room temperature and stored in a controlled-chamber at 20 °C and 85% of relative humidity (RH) for 6 days. For analytical determinations, ethylene production and respiration rate were measured individually on a daily basis (with the exception of sweet cherry for which 20 cherries were used), while quality parameters, weight loss, colour, fruit firmness, total soluble solids (TSS) and total acidity (TA) were measured at day 0 and after 6 days of storage.

2.2. Analytical determinations

Weight loss of individual fruit was calculated as % with respect to the weight on day 0. Ethylene production and respiration rate were measured by placing each fruit in a 0.5 L glass jar hermetically sealed with a rubber stopper, for 30 min. Ethylene was quantified using a Shimadzu™ GC-2010 gas chromatograph (Kyoto, Japan), equipped with a flame ionisation detector (FID) and CO_2 using Shimadzu™ GC-2010 with thermal conductivity detector (TCD). Results are the mean ± SE and expressed as nL g^{-1} h^{-1} and mg CO_2 kg^{-1} h^{-1} for ethylene and respiration rate, respectively.

Colour parameters (L^*, a^* and b^*) were determined individually on each fruit using the CIE Lab System in a Minolta colorimeter CR200 model (Minolta Camera Co., Japan). Two determinations were performed on opposite side of each fruit, the Hue angle index (arctan = (b^*/a^*) was calculated and results are the mean ± SE. Fruit firmness was measured on the fruit shoulder using a flat steel plate coupled with a texturometer (TX-XT2i Texture Analyzer, Stable Microsystems, UK) interfaced to a personal computer. A bevelled holder prevented bruising of the opposite side. For each fruit, the diameter was measured and then a force that achieved a 3% deformation of the fruit diameter was applied. Results are expressed as the force-deformation (N mm^{-1}) and are the mean ± SE. After firmness determination, fruit from each treatment and replicate were manually peeled to separate the peel from the flesh. The flesh tissue from each lot was cut into small pieces and used to determine total soluble solids concentration (TSS) and titratable acidity (TA) in duplicate. TSS were measured with a digital refractometer Atago PR-101 (Atago Co. Ltd., Tokyo, Japan) at 20 °C and expressed as % (g 100 g^{-1}). Total acidity (TA) was determined by automatic titration (785 DMP Titrino, Metrohm) with 0.1 N NaOH up to pH 8.1, using 1 mL of diluted juice in 25 mL of distilled H_2O, and results expressed as g malic acid equivalent per 100 g^{-1} fresh weight. The ripening index (ratio between TSS and TA) was calculated and results are expressed as the mean ± SE.

2.3. Fatty acid composition of rosehip oil

Rosehip oil (2 mL) was submitted to methylation of fatty acids by adding 1 mL boron trifluoride/methanol at boiling temperature for 10 min. Methylated fatty acids were extracted with hexane, taken to dryness and redissolved in 200 μL chloroform before injection. Fatty acids were separated and quantified by gas chromatography (GC, Hewlett-Packard model 6890) equipped with flame ionisation detector (FID). Five microliters in split mode was injected into a capillary column (HP-Innowax Polyethylene glycol, 30 m × 250 μm × 25 μm). A gradient of temperature was used for fatty acid separation: initial temperature 120 °C for 2 min and then a rate at 4 °C/min to 190 °C which was held 5 min, and final rate at 4 °C/min to 242 °C. Identification of fatty acids was performed by comparing retention times with authentic standards (purchase from Sigma, Sigma–Aldrich, Madrid, Spain). The results of fatty acid composition are shown in Table 1.

2.4. Sensory evaluation

Sensory analyses to compare the external visual aspect of treated and control stonefruit after 6 days of storage at 20 °C were carried out by 10 trained adults, aged 25–50 years (5 female and 5 male). The panel was trained in a pre-test for evaluating the colour of these fruit. A laboratory of sensory analyses with an individual booth for each panellist was used. Each judge evaluated 1 sample for each treatment. Samples were blind labelled with random three digit codes, and the sample order was randomised. The rating for external visual aspect was based on a five-point scale (5 to 1) with 5 = like extremely (very characteristic of the fruit), 4 = like moderately, 3 = neither like nor dislike like (limit of acceptance for consumers), 2 = dislike moderately and 1 = dislike extremely (non-characteristic of the product).

2.5. Statistical analysis

Experimental data were subjected to ANOVA analysis. Sources of variation were treatment and storage. The overall least significant differences (Fisher's LSD procedure, $P < 0.05$) were calculated and