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Effects of 1-methylcyclopropene in combination with chitosan oligosaccharides on post-harvest quality of aprium fruits

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ABSTRACT

Aprium (*Prunus armeniaca* × *salicina* L. cv. Xingmei) fruits were treated with 1.0 μL/L 1-methylcyclopropene (1-MCP) for 12 h at 20 °C or dipped for 2 min into 0.5% (w/v) chitosan oligosaccharides (COS) solution, or treated with the combination of the both, then stored at 2 °C for up to 30 days. Aprium fruits exhibited a typical climacteric pattern in ethylene production and respiration rate. Treatment with 1-MCP or COS could retard the decline in firmness, titratable acidity and total soluble solids of aprium fruits during storage, as well as reduce ethylene production and respiration rate. In addition, COS treatment also had a pronounced effect on reduction of decay rate.

1. Introduction

Apriums or pluots (*Prunus armeniaca* × *salicina* L. cv. Xingmei) are later-generations of hybrids between a plum (*Prunus salicina*) and an apricot (*Prunus armeniaca*). Apriums look like apricots, and noted for their sweet taste, which due to high content of fructose and other complex sugars. Apriums have been known for hundred years from regions where grow both plums and apricots, which production increase rapidly in the world. Generally, apriums are perishable, which have a very short storage life; rapid softening and susceptibility to physical damage and disease. So far there is little information on how to control postharvest quality of aprium fruits.

It is known that most of *Prunus* fruits are climacteric and their ripening process are regulated by ethylene, therefore, controlling ethylene biosynthesis or action is important to control postharvest quality of the fruit. 1-Methylcyclopropene (1-MCP) is an extensively studied novel ethylene action inhibitor which is a non-toxic and odorless gas. Ripening of apricots and plums can be delayed by 1-MCP (Cao et al., 2009; Dong et al., 2002).

Chitosan coating has been used on many kinds of fresh fruits to reduce moisture transfer, oxidation and respiration rate, which is important to prolong the shelf-life of fruits (Debeaufort et al., 1998). However, chitosan coating has several drawbacks to be utilized in fruits, such as sticky, not easy to wash and led to anaerobic respiration. Chitosan oligosaccharides (partially hydrolyzed chitosan, COS) which have a low molecular weight (about 1000–1500), so that it can get inside cells easily, recently have been applied to fruits as pre-harvest treatments, with beneficial effects on control postharvest gray mold of tomato fruit (Mohamed and Badawy Entsar, 2009).

The objective of this work was to evaluate effects of 1-MCP, as well as its combing with chitosan oligosaccharides on postharvest quality of aprium fruit.

Our result show that both of 1-MCP and COS can improve the post-harvest quality of aprium fruits. Some additional effects on keeping quality of the fruit were observed by the treatment of 1-MCP combing with COS.

2. Materials and methods

2.1. Plant material

Aprium fruits (*Prunus armeniaca* L. cv. Xingmei) were harvested at commercial maturity, obtained from a wholesale market in Beijing (China), selected for uniformity in shape, colour, and size, and then were used for the experiments.

Abbreviations: 1-MCP, 1-methylcyclopropene; COS, chitosan oligosaccharides.

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2.2. Treatments

Aprium fruits were randomly distributed into four groups prior to treatments, and then treated as follows: (1) immediate storage (control); (2) fumigation with 1.0 μL/L 1-MCP for 12 h at 20 °C before storage; (3)dip for 2 min in 1000 mL 1.0%(w/v) chitosan oligosaccharides solution by the way of negative pressure(−0.02 MPa) infiltration, and then let dry naturally; and (4) dip for 2 min in 1000 mL 1.0%(w/v) chitosan oligosaccharides solution by the way of negative pressure(−0.02 MPa) infiltration followed by fumigation with 1.0 μL/L 1-MCP for 12 h at 20 °C.

Apriums were stored at 2 ± 0.5 °C and 80% ± 2% relative humidity for 30 days following treatment.

For the stock solution (1%, w/v) of chitosan oligosaccharides, was prepared by dissolving purified chitosan (low molecular weight, about 1000–1500, purchased from Sigma Chemical Co.) in distilled water.

2.3. Measurements

2.3.1. Decay rate

Decay rate was reported as a percentage (%) of infected fruit. The test group consisted of three replicates (15 fruits per replicate). Fruit were placed in plastic trays and wrapped in polyethylene bags. Each 10 days, the percentage of infected fruit was determined. When the visible rot zone outside the wounded area on fruit was more than 1 mm wide, it was counted as decayed fruit. All experiments were performed twice.

2.3.2. Weight loss

Apriums (5 fruits × 2 replicates) were weighed at the beginning of the experiment just after treatment and air drying, and then every five days interval during the storage period. Weight loss was expressed as the percentage loss of the initial total weight.

2.3.3. Ethylene and respiration rate determination

Three fruits for each replicate (each treatment with 3 replicates) taken at random from each treatment at the time as indicated in results were conditioned for 2 h at 20 °C, then sealed in a airtight jar (710 mL) for 1 h at 20 °C. Thereafter, 1 mL of the gas sample was withdrawn from the jar, and was quantified for ethylene using a GC-7890F gas chromatograph (Tianmei, Shanghai) equipped with a FID detector, or quantified for CO_2 with a TCD detector.

2.3.4. Fruit quality measurements

Quality measurements were carried out at harvest and for each 5 days during storage time.

Fruit firmness was measured on two pared surfaces with a universal GY-3 texture analyzer (Zhejiang Tuopu Instrument Co., Ltd) with a 0.79-cm tip. Titratable acidity (TA) was measured as reported earlier (Terada et al., 1978). Total soluble solids (TSS) was determined by extracting and mixing one drop of juice from each fruit by a digital refractometer (Jenway – 6405 UV/V) at 20 °C.

Total phenolics content (TPC) was determined by the Folin-Cicalteau method as described by Singleton et al. (1999), with minor modifications, based on colorimetric oxidation/reduction reaction of phenols. Polyphenols extraction was carried out by adding 10 mL methanol (85%) to 1 g fine grind of aprium tissue. 250 μL of sterile distilled water was added to 250 μL of extract, and then 2.5 mL of diluted Folin-Cicalteau reagent (10%) and 2 mL of 7.5% sodium carbonate were added. The samples were shaken for 1.5–2 h. The absorbance of samples was measured at 765 nm by a PG Instruments Ltd. T80+ UV/VIS spectrophotometer. Gallic acid was used for calibration curve. Results were expressed as μg/g.

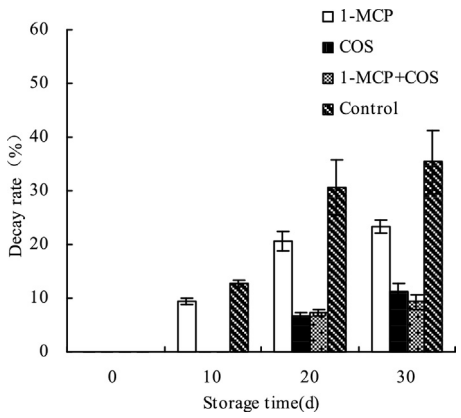

Fig. 1. Effects of the treatments on decay rate of aprium fruit during storage at 2 °C. Each data point is the average of three replicates (15 fruits per replication). Vertical bars represent standard error of the mean.

2.4. Statistical analysis

Data were analyzed by analysis of variance (ANOVA) with SPSS 11.0 statistical software (SPSS Inc., Chicago, IL, USA). Significant differences were performed by Duncan's new multiple range tests. Differences at $P \leq 0.05$ were considered as significant.

3. Results and discussion

3.1. Decay rate

Decay rate of aprium fruits increased during the storage time (Fig. 1). Compared with control group, decay rate in 1-MCP, COS, or 1-MCP + COS treated fruits decreased by 33%, 67% and 74%, respectively. However, no obviously difference on decay rate between the COS and 1-MCP + COS treated fruits ($P < 0.05$).

The major postharvest losses of stone fruits are due to fungal infection, physiological disorders, and physical injuries (El Ghaouth et al., 1991, 1992). In present research, we observed that COS had remarkable effect on the inhibition of the aprium decay rate. This result is consistent with studies on some other fruits (Meng et al., 2010; Yang et al., 2012; Ma et al., 2013; Gianfranco et al., 2013; Erica et al., 2013).

This effect of chitosan on decreasing fruit decay has been attributed to the fact that COS may enhance activity of some defense enzymes, such as chitinase and β-1,3-glucanase, elicit production of hydrogen peroxide (Li et al., 2009; Lin et al., 2005), and upregulate expression of the defense genes (Lin et al., 2005).

3.2. Weight loss

Treatment with 1-MCP, COS or 1-MCP + COS significantly prevented weight loss of aprium fruit, comparing with control fruit in the early stage of storage at 2 °C; however, no remarkable effect on weight loss of treated fruits could be observed after fruits stored 2 °C for 15 days (Fig. 2).

Fruit weight loss is mainly associated with respiration and moisture evaporation through the skin. The rate of water lost depends on the water pressure gradient between the fruit tissue, the surrounding atmosphere, and also the storage temperature. This study indicated that weight loss of the aprium during the storage was unconspicuous, which was similar to other research on apricots (Fan et al., 2000).