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Research Note

Effects of exogenous oxalic acid on ripening and decay incidence in mango fruit during storage at room temperature

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Abstract

Mango fruit (*Mangifera indica* L. cv. Zill) were dipped in 5 mM oxalic acid solution for 10 min at 25 °C to investigate effects on ripening and decay incidence during storage at room temperature (25 °C). The results showed that oxalic acid treatment delayed fruit ripening and reduced fruit decay incidence compared to the control. It was suggested that the physiological effect of oxalic acid in decreasing ethylene production was an important contributor to delaying the ripening process. Oxalic acid treatment might be a promising method for postharvest storage of mango fruit.

Keywords: Decay incidence; Mango fruit; Oxalic acid; Postharvest storage; Ripening

1. Introduction

Rapid ripening processes and infection by microorganisms are serious causes of postharvest losses in mango fruit (*Mangifera indica* L.) and limit transport of fresh fruit from the site of harvest (Mitra and Baldwin, 1997). There are many reports in the literature showing that postharvest application of chemicals such as pesticides/fungicides (Johnson et al., 1994), calcium infiltration (Mootoo, 1991), phosphonate (Zainuri et al., 2001), salicylic acid (Zainuri et al., 2001; Zeng et al., 2006), gibberellic acid (Khader et al., 1988), and 2,4-dichlorophenoxyacetic acid (Kobiler et al., 2001) can retard ripening of mango fruit and/or control their diseases. To date, alternative chemical treatments with no side-effects, attractive cost–benefit ratios, and easy manipulation are still needed.

Oxalic acid is an organic acid ubiquitously occurring in plants, fungi, and animals, and seems to play different roles in different living organisms (Libert and Franceschi, 1987; Shimada et al., 1997). Recently, oxalic acid application for food preservation has received much attention, as it has been shown not only to be an anti-browning agent for harvested vegetables (Castañer et al., 1997), banana slices (Yoruk et al., 2002), and litchi fruit (Zheng and Tian, 2006), but also to be available as a natural antioxidant in the natural and artificial preservation of oxidized materials (Kayashima and Katayama, 2002). Our previous work has reported that a pre-storage oxalic acid treatment (5 mM dip for 10 min) in combination with controlled atmosphere (6% CO_2 + 2% O_2, 14 ± 1 °C) extends the storage time and decreases the incidence of mango fruit decay (Zheng et al., 2005). To better understand the role of oxalic acid in improving the limited storage life of mango fruit, and to develop an oxalic acid treatment which could be put into practice, the effects of oxalic acid on ripening and decay incidence in mango fruit during storage at room temperature were investigated.

2. Materials and methods

Mango fruit (*M. indica* cv. Zill) at about the 80% maturity stage, were harvested from a commercial orchard in Panzhihua city, China. Harvested fruit were selected for uniformity of size and appearance. After the selected fruit were cooled for about 2 h at about 25 °C near the orchard, they were dipped in water (control) or 5 mM oxalic acid for 10 min at 25 °C, air-dried and then each of about 15 kg fruit of control and treated fruit were placed in separate cartons. Transit time at a temperature of about 25 °C from harvest to arrival at the Beijing laboratory

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was approximately 30 h. Upon arrival at the laboratory, each 30 fruit without injury for control and treatment were placed inside a clean plastic box with fruit touching. Each box was wrapped in a 0.02 mm polyethylene bag, and then held at 25 ± 1 °C. Analysis in triplicate of 6 fruit each from six plastic boxes was used to measure parameters at 3-day intervals, and 108 fruit in total for the controls and treatments were used. Another 60 fruit of each treatment were observed to evaluate the firmness index, disease index and marketability.

Fruit firmness was assessed by squeezing by hand and a firmness index scale from extremely firm (9) to soft ripe (1). The firmness index was calculated using the formula: $\sum$(firmness scale × percentage of fruit within each firmness class). The disease index was assessed by assessing the extent of total decayed area on each fruit surface using the following scale (Zheng et al., 2005): 0 = no visible decay; 1 = < 1% decay spots; 2 = 1–20% decay; 3 = 20–50% decay; and 4 = > 50% decay. The disease index was calculated using the formula: $\sum$(disease scale × number of fruit in each class)/(number of total fruit × highest disease scale) × 100. Fruit with scores of 0 and 1 had commercial value. The total percentage of fruit with these scores was defined as marketable fruit.

Juice samples were obtained from 12 discs of flesh (taken about 5 mm deep under the peel, 10 mm thickness × 13 mm diameter, 2 discs per fruit on opposite regions) from 6 fruit on the longer transverse axis, and soluble solids contents (SSC) of the fruit juice were determined using a refractometer (10481 S/N, USA). Ten grams of flesh tissue (about 5 mm deep under the peel) from six fruit on the longer transverse axis (each fruit on opposite regions) was homogenized with 25 mL distilled water and filtered, and then titratable acids (TA) of the solution were determined by titration to pH 8.1 with 0.1 M NaOH. TA is expressed as the percentage of citric acid per 100 g fresh mass. Ethylene production was assessed on 6 fruit for each treatment that were sealed in 5 L gas-tight jars for 3 h at 25 °C prior to gas sampling. Ethylene was monitored with a Shimadzu G-14a gas chromatograph with an activated Poropak 80/100 column and a flame ionization detector at 2-day intervals. Fruit were stored in open jars between the sampling periods and three replicates were used.

The experiment was carried out in three consecutive growing years (2003–2005) and results obtained in different years were similar. Data represent the means of replicates. They were also analyzed by one way analysis of variance (ANOVA) using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA). Differences between means were tested using Duncan's multiple comparison procedure at the 5% level.

3. Results and discussion

Fruit firmness and TA decreased, while SSC increased in mango fruit during storage. However, oxalic acid treatment not only resulted in a significantly higher fruit firmness index after storage of at least 6 days (Fig. 1A), but also retarded significantly the increase in SSC and decrease in TA compared to the controls, particularly from 9 to 15 days after harvest (Fig. 1B and C). Parameters useful for determining maturity and ripen-

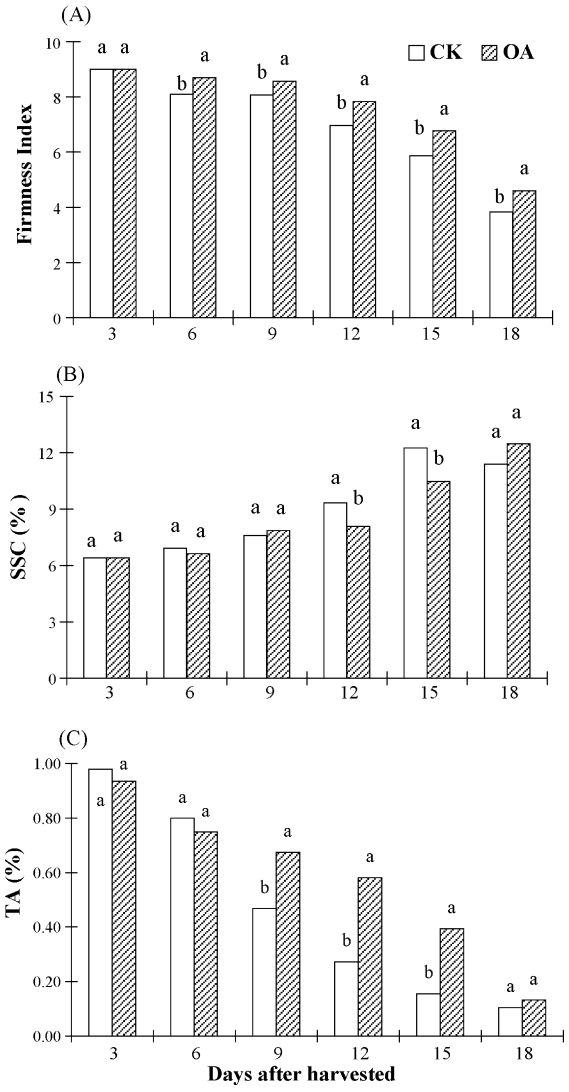

Fig. 1. Changes in fruit firmness index (A), SSC (B) and TA (C) in flesh juice of control and oxalic acid treated mango fruit during storage at room temperature in 2005. Data of firmness index are means of two replicates (60 fruit), and the others are means of three replicates. Different letters indicate significant differences between treatments according to Duncan's multiple range tests ($p < 0.05$).

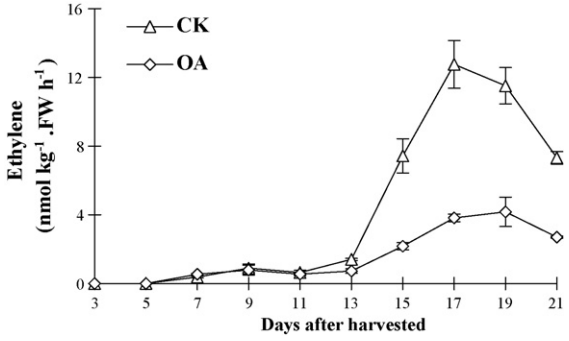

Fig. 2. Changes in ethylene production in control and oxalic acid treated mango fruit during storage at room temperature in 2005. Data are means of three replicates ± S.E.