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Quality and biochemical changes of 'Hindi-Besennara' mangoes during shelf life as affected by chitosan, *trans*-resveratrol and glycine betaine postharvest dipping

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ABSTRACT

Effects of chitosan (1%), *trans*-resveratrol (resveratrol) (1.6×10^{-5} M, 1.6×10^{-4} M and 1.6×10^{-3} M) and glycine betaine (GB) (10, 15 and 20 mM) dipping on quality and biochemical changes of 'Hindi-Besennara' mangoes during ripening at shelf life (SL) (18 ± 2 °C, 60–70% RH) were studied. Resveratrol, especially at low rate followed by GB, especially at high rate, decreased decay percentage after one and two weeks of SL compared to other treatments. Both compounds at all rates retained higher fruit firmness during SL and higher titratable acidity (TA) (only after one week of SL). Both GB and resveratrol at all rates retained higher vitamin C level than control with no effect on total soluble solids (TSS) after two weeks of SL. These compounds had no effect on weight loss after one week, but increased it after two weeks of SL compared to control. Chitosan showed higher weight loss during SL but, retained higher TA and vitamin C, and lower pH with no significant impact on firmness, TSS and decay compared to control. Chitosan, low and medium resveratrol rates, and low and high GB rates maintained higher membrane stability of peel after two weeks of SL compared to control. All treatments showed lower α-amylase but, higher peroxidase (POD) activities in peel than control after two weeks of SL. High resveratrol rate retained higher total phenols level than control, in contrast to chitosan after two weeks of SL while, total flavonoids was not affected. Compared to initial, peel free radical scavenging capacity (FRSC) decreased after one week followed by a sharp increase after two weeks of SL. Chitosan, medium and high resveratrol rates, and medium GB rate showed higher FRSC than control after one week of SL but, with no differences after two weeks of SL. In conclusion, both *trans*-resveratrol and GB treatments retained quality of 'Hindi-Besennara' mangoes during SL and being suggested as natural alternatives to synthetic chemicals.

1. Introduction

As climacteric fruit, mangoes (*Mangifera indica* L.) possess a relatively short shelf life at ambient conditions due to rapid softening and the development of several physiological and pathological disorders (Sivakumar et al., 2011; López-Mora et al., 2013). Also, mangoes are highly sensitive to chilling injuries when stored at a temperature below 13 °C (Sivakumar et al., 2011). Synthetic chemical preservatives application at pre or postharvest stages is restricted due to rising consumers concerns on both human health and the environment. Thus, alternative tools to maintain mangoes quality during shelf life are critically required. Chitosan, a bioactive natural edible coat, is widely considered as a promising alternative to chemical preservatives (Romanazzi et al., 2013; Al-Qurashi and Awad, 2015). Postharvest dipping of 'Tainong' mangoes in 2% chitosan decreased respiration rate, and the loss of firmness, color change, acidity, ascorbic acid and fruit weight as well as inhibited diseases progress during storage at 15 °C (Zhu et al., 2008). Also dipping 'Nam Dok Mai' mangoes, previously inoculated with *C. gloeosporioides*, in chitosan (from 0.5 to 2.0%) delayed ripening and reduced respiration rate, ethylene production, and

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weight loss, ascorbic acid, and acidity and reduced diseases progression (Jitareerat et al., 2007). However, 'Tommy Atkins' mangoes dipped in 1% chitosan had no effects on fruit ripening, weight loss and black spot incidence, but inhibited the extension of this disease during storage at 12 °C and 25 °C (López-Mora et al., 2013). Resveratrol, its 3-glucopyranoside piceid, and their *cis* isomers are natural antioxidant plant phenolics, representing the major active compound of stilbene phytoalexins that mainly occur in grapes, berries, and other dietary constituents and are presumed to be involved in defense system against plant pathogens and metabolic diseases in human (Adrian et al., 1997; Gonzalez Urena et al., 2003; Jimenez et al., 2005; Gülçin, 2010; Chen et al., 2016). Postharvest dipping in *trans*-resveratrol at 1.6×10^{-4} M maintained firmness, sensory and nutritional value and reduced water loss during storage of apples, grapes and tomatoes compared to control (Jimenez et al., 2005). Cherukuri (2007) reported that exogenous *trans*-resveratrol treatment at 1.6×10^{-3} M, 1.6×10^{-4} M and 1.6×10^{-5} M increased total phenolics, vitamin C and total carotenoids concentration and antioxidant capacity of Satsuma mandarins. Postharvest *trans*-resveratrol dipping at 1.6×10^{-5} M, 1.6×10^{-4} M and 1.6×10^{-3} M reduced decay, increased antioxidant compounds, POD and polyphenoloxidase (PPO) and decreased polygalacturonase activities of 'El-Bayadi' table grapes after cold storage and shelf life (Awad et al., 2015). Glycine betaine (GB) is a naturally occurring compatible solute that function as an effective osmotic stress protectant and stabilizing photosynthetic pigments and cell membranes in plants (Robinson and Jones, 1986; Genard et al., 1991; Ashraf and Foolad, 2007; Mansour, 2000; Yang et al., 2003; Chen and Murata, 2011). Foliar application of GB at 50 and 100 mM/L increased antioxidant enzymes activities and enhanced photosynthesis of maize under salinity stress (Nawaz and Ashraf, 2009). Postharvest GB dipping of Shredded Iceberg lettuce, at especially 0.2 mM, maintained sensory quality during cold storage (Hurme et al., 1999). Also, dipping of 'Zhongnong 8' cucumbers in GB at 5, 10, and 15 mM decreased lipoxygenase (LOX) activity but increased POD and catalase (CAT), restrained malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) accumulations, especially at 10 mM during cold storage (Fu-gui et al., 2013). Postharvest GB dipping at 10, 15 and 20 mM increased antioxidant compounds, POD and PPO activities of 'El-Bayadi' table grapes after cold storage and shelf life (Awad et al., 2015). This study aim to evaluate the response of 'Hindi-Besennara' mangoes to postharvest dipping in chitosan, resveratrol and GB treatment as an attempt to maintain quality during SL.

2. Materials and methods

2.1. Plant materials and experimental procedure

This experiment was performed on mature hard-green 'Hindi-Besennara' mangoes collected from a commercial orchard located in Jizan region (17.4751°N, 42.7076°E), Kingdom of Saudi Arabia. Fruit were packed in perforated cardbox (12 fruit of each box, about 3.0–3.5 kg) and transported to the postharvest laboratory at King Abdulaziz University in Jeddah within about 8 h at 15 °C. Fruit of uniform size, weight (250–300 g/fruit) and appearance and free of visual defects were selected for this experiment.

2.2. Fruit treatment

A completely randomized experimental design with three replicates (20 fruit of each) was established. Fruit of each treatment/replicate were soaked either into water (control), 1% acetic acid, 1% chitosan (100,000–300,000 MW) (Acros Organic, New Jersey, USA) dissolved in 1% acetic acid, *trans*-resveratrol (Baoji Guokang Bio-Technology Co., Ltd., China) solution (1.6×10^{-5} M, 1.6×10^{-4} M and 1.6×10^{-3} M; referring to 0.00365, 0.0365 and 0.365 g/L, respectively) or glycine betaine (Danisco, Finland) solution (10, 15, 20 mM; refereeing to 1.172, 1.757 and 2.343 g/L, respectively) for 1 min. A surfactant (Tween 20 at 0.5 mL/L) was added to all treatments. Following air draying of about 1 h, all treatments/replicates were weighted and stored at 18 ± 2 °C and 60–70% (RH) in perforated cardboard cartons for 2 weeks. Before applying the treatments, additional three samples (5 fruit of each) were randomly collected for initial quality and biochemical analyses as described below. After one and two weeks of shelf life, weight loss and decay incidence were recorded for each treatment/replicate as described below. Also, samples (5 fruit of each) from each treatment/replicate were randomly collected for quality and biochemical analyses. Then, these fruit samples were peeled and the peel tissue was sliced and mixed. Random part of this peel was used for electrolyte leakage measurement and the remaining peel was kept at −80 °C for later total phenols, flavonoids, enzymes and antioxidant activity analysis. Pulp firmness was measured in each sample directly following peeling then, the pulp tissue was sliced and mixed. Random portion of this pulp tissue was directly used for TSS, TA, pH, and vitamin C determinations.

2.3. Weight loss determination

The total fruit weight loss was calculated on initial weight basis and expressed in percentage.

2.4. Decay incidence

Decay incidence, due to skin browning, shriveling and diseases, was recorded and calculated on initial fruit number basis for each samples and expressed in percentage.

2.5. Firmness, TSS, TA, pH and vitamin C measurements in fruit pulp

Fruit pulp firmness was measured independently in 5 fruit (two opposite measurements in the middle of each fruit) per replicate by a digital basic force gauge, model BFG 50N (Mecmesin, Sterling, VA, USA) supplemented with a probe of 11 mm diameter and the results were expressed as Newton. A homogeneous sample was prepared from these 5 fruit per replicate for measuring TSS content, TA, pH and vitamin C concentration. TSS content was measured in fruit pulp juice with a digital refractometer (Pocket Refractometer PAL 3, ATAGO, Japan) and expressed in percentage. TA was determined in distilled water diluted fruit juice (1:2) by titrating with 0.1N sodium hydroxide up to pH 8.2, using automatic titrator (HI 902, HANNA Instrument, USA) and the results expressed as a percentage of citric acid. Fruit juice pH was measured by a pH meter (WTW 82382, Weilheim, Germany). Vitamin C was measured by the oxidation of ascorbic acid with 2,6-dichlorophenol endophenol dye and the results expressed as g kg^{-1} on a fresh weight (FW) basis (Ranganna, 1979).

2.6. Leakage of ions from fruit peel

Leakage of ions was measured in peel disks according to Sairam et al. (1997) with some modifications and was expressed as membrane stability index percentage (MSI %). Three grams of peel disks per replicate/treatment was randomly taken and placed in 30 ml of deionized water at ambient temperature for 4 h in a shaker. Conductivity before boiling (C1) was measured with an electrical conductivity digital meter (Orion 150A+, Thermo Electron Corporation, USA). The same disks were kept in a boiling water bath (100 °C)