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Effect of Salicylic Acid and Essential Oils Treatments on Quality Characteristics of Apple (*Malus domestica* Var. Granny Smith) Fruits During Storage

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ABSTRACT

Apple texture can deteriorate during cold storage, resulting in softness and mealiness. The experiment was started in season 2010-2011. In order to study the effectiveness of salicylic acid, calcium nitrate and essential oils treatments on postharvest quality and storage behavior of "Granny Smith" cultivar of apple. Fruit weight losses, fruit firmness, total soluble solids, pH; titratable acidity, total soluble solids/titratable acidity ratio and ethylene production were measured at 20, 80 and 140th days of postharvest life. Apples were dipped in concentrations, 2.5 mM salicylic acid (1%) of calcium nitrate and mentha essential oils solutions (150 ppm) 10 min and stored 0-2°C in a cold store for 20 weeks period. One percent Calcium nitrate and 2.5 mM salicylic acid did affect quality parameters of the fruit compared to control treatment ($p = 0.05$). Mentha essential oils solutions (150 ppm) did not affect quality parameters of the fruit compared to control treatment ($p = 0.05$). Results indicated the potential improvement of shelf life of apple by salicylic acid and calcium nitrate pre-treatment of the fruit, did further improve product quality.

Key words: Apple, salicylic acid, calcium nitrate, essential oils

INTRODUCTION

Postharvest life of some fruits such as apples is limited by physiological disorders. During the process of ripening, ethylene increasing physiological disorders (Cano *et al*., 1995; Wolfe *et al*., 2003). The rate of physiological decay of fruit is directly related to the respiration rate (Kader *et al*., 1989). Pre-harvest with essential oils have been shown effective in reducing the physiological disorders in fruits (Ismail *et al*., 2011; Ahmad *et al*., 2005; Ganjewala and Luthra, 2007a, b; Reza and Abbas, 2007; Swamy and Rao, 2008; Soltan *et al*., 2009; Fortes *et al*., 2011; Louis *et al*., 2011; Patra, 2011; Upadhyay and Patra, 2011). Postharvest application of calcium may delay senescence in fruits, applied calcium stabilizes the plant cell wall and protects it from cell wall degrading enzymes (White and Broadley, 2003). Senescence often depends on the calcium and by increasing calcium levels, various parameters of senescence are altered (Shirzadeh and Kazemi, 2011). Postharvest salicylic acid application has been reported to decrease respiration rate and fruit weight losses by closing stoma (Zheng and Zhang, 2004). The purpose of this study was to investigate using essential oils, salicylic acid and calcium postharvest application on weight Losses, Fruit Firmness, Total soluble solids, pH; Titratable acidity, Total soluble solids/Titratable acidity ratio and ethylene production which considered in this study after 20, 80 and 140th days storage.

MATERIALS AND METHODS

Plant material: 'Granny Smith' apple fruits were harvested manually at the optimal date for commercial harvesting located in an experiment orchard at the apple Research Institute of Iran (Zanjan, Iran) in 2010-2011. Apples uniform in shape and size and free of fungal infection were selected. Fruits were subsequently transferred to laboratory and sorted based on size and the absence of physical injuries or infections. The study was arranged as factorial experiment based on a completely randomized design with three replications. The first factor was included immersion fruits at different levels of calcium (1%), Mentha essential oils solutions (150 ppm) 2.5 mM salicylic acid and fruits immersed in distilled water as control for 10 min. Fruits were then dried for about 24 h and then stored at 0-2°C and 85-90% relative humidity for 140 days. After 20, 80 and 140 days storage, 12 fruits per treatment were taken from cool storage for fruit quality assessment. Oil was extracted from Mentha fresh leaves flowers via hydro distillation. The method started with 300 g of fresh leaves cut into small pieces with 700 mL of water in a 2 L round flask placed on electrical mantel. The steam and extracted essential oil pass through a water condenser, allowing the volatile oil fraction to float on top of the water. The oil was collected by drawing out the water.

Fruit quality evaluation: Physical and chemical quality factors were measured periodically after treatment and every 40 day of storage at 0±2°C plus 2 day at 25°C in 12-apple samples per treatment (4 apples replicate-1). Fruit weight losses, fruit firmness, total soluble solids, titratable acidity, TSS/TA, pH and ethylene production were measured at 140 days of postharvest life.

Fruit firmness: Firmness was measured on two opposite peeled sides using a pressure meter (OSK 10576 CO., Japan) fitted with an 8 mm diameter flat tip. The firmness considered as an average peak force of 10 fruits and expressed as kg.

Total soluble solid: TSS in the juice was determined with a hand-refractometer (NC-1, Atago Co., Japan) at room temperature and expressed as a percentage.

Titratable acidity: TA was determined by titration an aliquot (20 mL) of the juice to pH 8.2 with 0.1 N NaOH and the result was expressed as a percentage of malic acid.

TSS/TA ratio: The maturity index was evaluated as the TSS/TA ratio (i.e., ratio increasing with maturity) (Schirra *et al.*, 2004).

pH: pH of the juice were measured using a pH meter (Jenway, 3020).

Thiault index: The Thiault index was calculated as follows: index = [10×acidity (g L^{-1})+sugar content (g L^{-1})] (Harker *et al.*, 2002).

Perlim index: Perlim index was evaluated as follows: PI = [Kg cm^{-2}×0.5+Brix×6.7+malic acid (g L^{-1})×0.67] (Lafer, 1999).

Ethylene determination: Three fruits were enclosed in 3 L airtight jars for 1 h at 20°C. Ethylene measurements were performed by withdrawing 1 mL headspace gas sample from the jars with a syringe and injecting it into a Varian 3300 gas chromatograph, equipped with a stainless steel column filled with Porapak, length 100 cm, diameter 0.32 cm, at 50°C and a flame-ionisation detector at 120°C. The carrier gas was nitrogen at a flow rate of 20 mL min^{-1}.

Experimental design and statistical analysis: A completely randomized factorial design with three replications was used. An analysis of variance was used to analyze difference between means and the Duncan test was applied for mean separation at $p \leq 0.05$. All analyses were done with MSTAT-C statistical software.

RESULTS AND DISCUSSION

Results showed that Dipped fruits in Ca^{2+}, salicylic acid and Mentha essential oil solution at different concentration prevented weight loss in comparison with control ($p \leq 0.05$). The results in Table 1 show that the Mentha essential oil, salicylic acid and calcium had effect on fruit firmness after 140 days storage ($p \leq 0.05$). Conway *et al.* (1987) and Rabiei *et al.* (2011) reported that use of essential oils and calcium increased fruit firmness. Mahajan and Dhatt (2004) reported that pear fruit treated with Ca proved to be most effective in reducing weight loss compared to non treated fruit during a 75 days storage period. Calcium dips have been used as firming agents to extend postharvest shelf life in apples (Sams *et al.*, 1993), strawberries (Garcia *et al.*, 1996) and zucchini slices (Izumi and Watada, 1995) and to improve postprocessing quality in blueberries (Camire *et al.*, 1994). Fattahi *et al.* (2010) reported that Dipped fruits in SA solution at different concentration increased kiwifruit Firmness percentages. After 140 days storage, Mentha essential oil and calcium treatment had no a significant effect on apple TSS/TA ratio, titratable acids and total soluble solids ($p \leq 0.05$). Our result showed that salicylic acid had a significant effect on apple TSS/TA ratio, titratable acids and total soluble solids ($p \leq 0.05$). This result was in agreement with the report of Manganaris *et al.* (2005) that suggested postharvest application of apple by Ca dips did not effect of TA%. This result was in agreement with the report of Anthony *et al.* (2003) that reported spraying essential oils *Cymbopogon nardus*, *Cymbopogon flexuosus* and *Ocimum basilicum,* no effect had on the TSS after ripening during storage. Mentha essential oil and calcium immersion had no effect on pH of 'Granny smith' apples after 140 days storage (Table 1). The results indicate that after 140 days storage, Mentha essential oil had a slight significant effect on

Table 1: Mean comparison of fruit weight loss, firmness, ethylene, TSS, TA, TSS/TA, pH in different Mentha essential oil, salicylic acid and calcium nitrate treatments during 140 days storage at 0-2°C

Time storage	Treatment	Weight loss (%)	Firmness (kg)	Ethylene (μL kg^{-1} h^{-1})	Total soluble solids	Titratable acids	TSS/TA ratio	pH
20	0	0.040^a	2.03^b	1.40^a	11.00^b	88.10^b	0.12^b	3.25^b
	1% calcium	0.029^b	2.36^a	1.30^b	10.80^b	88.70^b	0.12^b	3.20^b
	150 ppm Mentha	0.028^b	2.35^a	1.39^a	10.78^b	89.70^b	0.12^b	3.15^b
	2.5 mM SA	0.038^b	2.32^a	1.12^b	11.52^a	90.40^a	0.15^a	3.35^a
80	0	1.200^a	2.12^b	2.84^a	12.01^b	75.03^c	0.16^b	3.40^b
	1% calcium	1.150^b	2.40^a	2.05^b	11.20^b	84.70^b	0.13^b	3.34^b
	150 ppm Mentha	1.100^b	2.48^a	2.80^a	11.10^b	82.07^b	0.13^b	3.30^b
	2.5 mM SA	1.110^b	2.20^b	2.00^b	14.06^a	86.02^a	0.20^a	3.53^a
140	0	2.450^a	1.95^b	3.66^a	12.60^b	65.03^c	0.19^a	3.76^b
	1% calcium	2.300^b	2.00^a	3.00^b	11.80^b	78.07^b	0.15^b	3.75^b
	150 ppm Mentha	2.201^b	2.06^a	3.60^a	11.80^b	75.03^b	0.15^b	3.70^b
	2.5 mM SA	2.200^b	2.10^a	2.92^b	14.75^a	80.60^a	0.22^a	3.88^a

Means in each column followed by similar letters are not significantly different at 5% level (Duncan test) decreased ethylene production (Table 1) but the results indicate that ethylene production significantly decreased with calcium and salicylic acid concentration in the storage duration ($p \leq 0.05$). Ca^{2+} increasing stabilization of membrane systems (Jackman and Stanley, 1995; Mignani *et al.*, 1995). Endogenous and added Ca^{2+} can firm plant tissue by complexing with the pectic carboxyl groups that have been generated through the action of PE (Stanley *et al.*, 1995). Ca^{2+} appears to be necessary because it induces the cross-linking of polygalacturonan chains into a structure that can be recognized by its isoperoxidase (Penel *et al.*, 1999). Zhang *et al.* (2003) reported, application of SA on kiwifruits increased superoxide free radical and Lipoxygenase (LOX) activity. In that case, climacteric rise in ethylene production was retarded. So, fruit ripening, REC, BI and senescence were delayed (Zhang *et al.*, 2003). Ethylene possesses an important role in integrating developmental signals and responses to abiotic stresses, like cold storage and it has been suggested that calcium delays the onset of the ethylene climacteric period and climacteric peak (Ben-Arie *et al.*, 1995). High calcium concentrations result in decreased ethylene production, electrolyte leakage and flesh browning symptoms which are directly associated with calcium content in fruits (Hewajulige *et al.*, 2003). This result was in agreement with the report of Mortazavi *et al.* (2007) that suggested postharvest application of apple by Ca, decreased electrolyte leakage and increased the cell wall integrity and stability. Essential oils and calcium dips retarded metabolism as indicated by the lower respiration rates of essential oils and calcium treated samples. Essential oils and calcium dips improved the firmness of apple, essential oils and calcium concentration of treated samples was significantly greater ($p \leq 0.05$) than the control. Further studies are necessary to determine the sensory profile and the microbiological stability.

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