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Effect of Essential Oils Treatments on Quality Characteristics of Apple (*Malus domestica* var. Gala) During Storage

[1]E. Shirzadeh and [2]M. Kazemi
[1]Young Researchers Club, Khorramabad Branch, Islamic Azad University, Khorramabad, Iran
[2]Young Researchers Club, Karaj Branch, Islamic Azad University, Karaj, Iran

Corresponding Author: M. Kazemi, Young Researchers Club, Karaj Branch, Islamic Azad University, Karaj, Iran

ABSTRACT

Apple texture can deteriorate during cold storage, resulting in softness and mealiness. The experiment was started in season 2010-2011 and 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 140 the days of postharvest life. The fruits were immersed in distilled water, calcium (1%) or at essential oils thyme (300 ppm) and lavender (500 ppm). Results showed that fruit weight loss significantly decreased in essential oils and calcium treatments in comparison to control. Also, results showed that essential oils and calcium treatments increase fruit firmness, TA while decreasing of ethylene production during cold storage at 0-2°C for 140 days ($p = 0.05$). The results showed that essential oils and calcium treatments application was influenced on ethylene in comparison to control. In general, this experiment showed that post-harvest essential oils and calcium treatments prevented fruit softening and decreased weight losses.

Key words: Essential oils treatment, calcium, apple, quality improvement, cold storage

INTRODUCTION

Malus domestica is a climacteric fruit and is belongs to the Rosaceae family, ethylene affecting apple fruit quality and can decreased Fruit quality during cold storage that resulting it is in softness and mealiness. (Kader, 1985; Shirzadeh and Kazemi, 2011). Shirzadeh and Kazemi (2011) reported that exogenously applied calcium stabilizes the plant cell wall, maintains cell turgor, membrane integrity and increase calcium content considerably compared to control. The effects of ethylene reduced by anti-ethylenes. The essential oils medicinal and aromatic plants have shown pharmaceutical, antibacterial properties (Ismail *et al*., 2011; Ahmad *et al*., 2005; Ganjewala and Luthra, 2007a, b; Reza and Abbas, 2007; Swamy and Rao, 2008; Upadhyay and Patra, 2011). Soltan *et al*. (2009), Fortes *et al*. (2011), Louis *et al*. (2011) and Patra (2011) reported that essential oils obtained from aerial parts and seeds of aromatic plants have antifungal and antibacterial properties. Rabiei *et al*. (2011) reported, application of essential oil on apple decreased Ethylene production. preharvest calcium treatment may increase fruit postharvest life (Crisosto *et al*., 2000). Calcium application decrease ion leakage and delays senescence in horticultural, extending storage life of fresh fruits (Picchioni *et al*., 1998). 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 storage period. Misra and Gupta (2006) and Singh *et al*. (2006) reported that calcium stabilizing cellular membranes and delaying senescence in horticultural and agronomy crops.

The objectives of this study were to determine the effect of postharvest fruit immersion in different calcium nitrate, thyme and lavender essential oils and the effect of calcium concentrations on apple fruit tissue during storage.

MATERIALS AND METHODS

Plant material: 'Gala' 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.

Thyme and lavender essential oils treatment and storage: 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%), thyme essential oils solutions (300 ppm) and second was lavender essential oils solutions (500 ppm) 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 140th day of storage, 12 fruits per treatment were taken from cool storage for fruit quality assessment.

Oil extraction: Oil was extracted from thyme fresh leaves and lavender 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 days of storage at 0±2°C plus 2 days 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.

Thiault index: The Thiault index was calculated as follows:

$$\text{Index} = [10\times\text{acidity (g L}^{-1})+\text{sugar content (g L}^{-1})]$$

(Harker *et al*., 2002).

Perlim index: Perlim index was evaluated as follows:

$$PI = [\text{Kg cm}^{-2}\times 0.5+\text{Brix}\times 6.7+\text{malic acid (g L}^{-1})\times 0.67]$$

(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. Analysis of variance was used to analyze difference between means and the Duncan test was applied for mean separation at p = 0.05. All analyses were done with MSTAT-C statistical software.

RESULTS AND DISCUSSION

Results showed that fruit weight loss significantly decreased in essential oils and calcium treatments in comparison to control (Table 1) (p = 0.05). Fruit firmness increased during storage (p = 0.05). The results shows that the thyme essential oil and lavender essential oil and lavender essential oil had no effect on fruit firmness after 160 days storage (Table 1) (p = 0.05).

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

Time storage (days)	Treatment	Weight loss (%)	Firmness (kg)	Ethylene (µL kg h^{-1})	Total soluble solids (TSS) (mg L^{-1})	Titratable acids (TA) (g L^{-1})	TSS/TA ratio	pH
20	0	0.040^{a}	2.00^{a}	1.52^{a}	13.37^{a}	49.38^{a}	0.27^{a}	3.58^{a}
	1% nitrate	0.039^{a}	2.00^{a}	1.50^{a}	13.34^{a}	53.55^{a}	0.24^{a}	3.48^{a}
	300 ppm thyme	0.037^{a}	2.05^{a}	1.48^{b}	13.20^{a}	53.55^{a}	0.24^{a}	3.45^{a}
	500 ppm lavender	0.040^{a}	2.03^{a}	1.51^{a}	13.36^{a}	49.38^{a}	0.27^{a}	3.53^{a}
80	0	1.53^{a}	1.61^{b}	3.00^{a}	13.80^{a}	33.05^{b}	0.41^{a}	4.00^{a}
	1% nitrate	1.42^{b}	1.65^{a}	2.40^{b}	13.38^{b}	44.88^{a}	0.30^{b}	3.98^{a}
	300 ppm thyme	1.40^{b}	1.70^{a}	2.35^{c}	13.30^{b}	49.30^{a}	0.27^{b}	3.95^{a}
	500 ppm lavender	1.52^{a}	1.62^{b}	2.98^{a}	13.74^{a}	33.95^{b}	0.40^{a}	4.01^{a}
140	0	2.86^{a}	1.40^{b}	3.90^{a}	14.60^{a}	30.05^{b}	0.48^{a}	4.10^{a}
	1% nitrate	2.55^{b}	1.53^{a}	3.05^{b}	13.69^{b}	36.80^{a}	0.37^{b}	4.01^{a}
	300 ppm thyme	2.50^{b}	1.58^{a}	2.98^{c}	13.52^{b}	36.18^{a}	0.37^{b}	4.00^{a}
	500 ppm lavender	2.83^{a}	1.43^{b}	3.85^{a}	14.50^{a}	30.95^{b}	0.47^{a}	4.08^{a}

Means in each column followed by similar letters are not significantly different at 5% level

At the end of storage (160 days) apples calcium was significantly firmer than apples from the other treatments or the control (Table 1) ($p = 0.05$). The results of this study were in agreement with those of previous studies which showed that of essential oil had positive effect on firmness and quality of fruits. The increase in cell wall-bound calcium of calcium-treated peaches was related to both calcium concentration and time of storage. Similar results after postharvest calcium application have been reported for apple fruits by Chardonnet *et al.* (2003) and Saftner *et al.* (1998) who suggested that soluble calcium was mobilized and integrated into the cell wall. After 160 days storage, lavender essential oil had no a significant effect on apple titratable acids and total soluble solids, but thyme essential oil and calcium nitrate had a significant effect on apple titratable acids total soluble solids, after 160 days storage (Table 1) ($p = 0.05$). Saftner *et al.* (1998) have reported that water-soluble pectin calcium does not affect flesh firmness. Furthermore, Chardonnet *et al.* (2003) in postharvest dips of apple fruits in concentrations up to 4% calcium chloride found that immersions in 2% calcium chloride was enough for maximum calcium accumulation in the cell wall, avoiding at the same time possible surface damage. Calcium accumulation in the cell wall facilitates cross-linking of pectic polymers leading to a cell wall network that increases wall strength and cell cohesion (White and Broadley, 2003) with unbound calcium ions to have little or no direct effect on tissue strength (Saftner *et al.*, 1998). Consequently, cell wall calcium cannot be used as indicator of peach fruit quality. On the contrary, the calcium bound in the water-insoluble pectin fraction can be used as quality indicator. This result was in agreement with Anthony *et al.* (2003) who reported that spraying of essential oils *Cymbopogon nardus*, *Cymbopogon flexuosus* and *Ocimum basilicum* had no effect had on the TSS after ripening during storage. Calcium salts can suspend or even accelerate the senescing-related processes, depending on calcium concentration (Conway *et al.*, 1994; Saftner *et al.*, 1998). In 'Gala' apples, after 160 days, there were not significant differences in pH fruit treatments with thyme essential oil, lavender essential oil, calcium and control (Table 1) ($p = 0.05$). These results are in line with those reported by Wang (2003) that treated raspberries with natural volatile compounds increase the acidity during storage. Calcium, thyme essential oil and lavender essential oil immersion had no effect on TSS/TA ratio of 'Gala' apples after 160 days storage (Table 1) ($p = 0.05$). The results indicate that after 160 days storage, lavender essential oil had a slight significant effect on decreased ethylene production (Table 1) ($p = 0.05$) but the results indicate that ethylene production significantly decreased with increasing calcium concentrations in the storage duration (Table 1) ($p = 0.05$). The high calcium concentrations resulted in decreased flesh browning symptoms. These symptoms have been directly associated with calcium content in other fresh fruits (Hewajulige *et al.*, 2003). Therefore, calcium dips raise the possibility of producing fruits less susceptible to flesh browning symptoms. Physiological disorders that are caused by low storage temperatures probably are related to calcium content (Hewajulige *et al.*, 2003). The same action of calcium salts has also been reported for fresh-cut fruits (Gorny *et al.*, 2002; Luna-Guzam and Barrett, 2000) where the enzymatic browning of flesh is a result of different metabolic pathways. As Rabiei *et al.* (2011) reported, application of essential oil on apple decreased ethylene production. However, further studies should be conducted, including sensory evaluation, in order to assure that such treatments do not lead to bitter, salty or other off-flavour developments. In addition, it must be elucidated whether such calcium salts are corrosive to metal processing equipment used in processing factories for fruit sanitation and sorting.

CONCLUSION

In this study, Essential oils and calcium had positive effect in postharvest and quality properties of 'Gala' apples which our speculated that this efficacy of essential oils may be related to its potential to initiation of defense responses in the fruits.

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