Journal of Medicinal Plants Research Vol. 5(23), pp. 5522-5527, 23 October, 2011
Available online at http://www.academicjournals.org/JMPR
ISSN 1996-0875 ©2011 Academic Journals

Full Length Research Paper

Effect of thyme and lavender essential oils on the qualitative and quantitative traits and storage life of apple ‘Jonagold’ cultivar

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Accepted 22 August, 2011

An experiment was conducted in order to evaluate the effect of the thyme and lavender essential oils on some qualitative and quantitative traits and storage life of 'Jonagold' apple. The study was arranged as factorial experiment based on a completely randomized design with three replications. The first factor included different levels of thyme essential oils solutions (0, 25, 100 and 200 ppb) and the second was lavender essential oils solutions (0, 25 and 100 ppb). Treated fruits were stored 160 days in a cold storage with 0 to 2°C and 85 to 90% relative humidity. Traits in the experiment includes: Fruit firmness, titrable acidity (TA), total soluble solids (TSS), acidity (pH), ethylene production, fruit flavor index (TSS/TA), percentage of weight loss, Perlim and Thiault indexes. Results showed that the treatments which received 100 ppb thyme essential oil solutions increased titrable acidity and prelim index. Also, it decreased TSS, TSS/TA ratio and weight loss percentage, but the other traits was not affected with thyme essential oil treatment. Lavender essential oil solutions were not affected except the percentage of weight loss. Treatments that had received both factors were maintained fruit firmness and Perlim and Thiault indexes but ethylene production and percentage of weight loss had as significant reduction. Interaction between thyme and lavender essential oils had no significant effect on other traits.

Key words: Apple, essential oil, thyme, lavender, storage life, ‘Jonagold’.

INTRODUCTION

Fruits are among the most important foods of mankind as they are nutritive and indispensable for the maintenance of health. They are also high-value commodities, offering good economic return even on small area of land. One of the research priority areas in Iran for enhanced fruit production was identified as reducing post harvest losses.

Apple (*Malus domestica* Borkh.) fruits are commonly stored for long periods at low temperatures under controlled atmosphere. Quality and fruit nutritional value decrease during storage time. A number of techniques such as pre-storage heat treatment (Klein and Lurie, 1992), treatment with chemicals (Leverentz et al., 2003) and modified atmosphere (Hertog et al., 2001) have been used. However, some chemicals pose serious health hazard and environmental risks. Additionally, consumers increasingly prefer agricultural products without chemicals residues and, hence, alternative methods to control postharvest disease and to extend fruit shelf life are required (Hemmaty et al., 2007). Application of plant extracts and essential oils have been extensively evaulated for postharvest application on fruits (Dudareva et al., 2004; Tripathi and Dubey, 2004). Saks and Barkai-Golan (1995) reported that application of *Aloe vera* L. Webb and Berth gel on wounded grapefruit reduced green mould decay by 75%, six days after inoculation with *Penicillium digitatum*.

The essential oil cumin from *Cuminum cyminum* L. Cumin has also been reported to protect citrus fruit from *P. digitatum* (Yigit et al., 2000). Thyme (*Thymus vulgaris* L.), a member of the Labiateae family, is an aromatic and medicinal plant of increasing importance in horticulture. Further essential oils derived from many aromatic plants are known to possess insecticidal (Konstantopoulou et al., 1992) and antimicrobial activities (Janssen et al.,

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1987), among them, thyme essential phenolic oil has been reported to have antibacterial, antimycotic, antioxidative and food preservative properties (Deans, and Ritchie, 1987; Deans et al., 1993).

Essential oil, as secondary metabolites, is made up of different volatile compounds, which are almost entirely classified as terpines and phenylpropenes. The role of essential oil has been discussed in terms of antibiotic activity, allelopathy, attractants, feeding deterrents and phytoalexin. Many researches point out that essential oil from different herbal plants demonstrates antifungal activity against a wide range of postharvest pathogen (Wilson et al., 1987; Dube et al., 1989; Deans, 1991; Jobling, 2001; Duamkhanmanee, 2002; Mahanta et al., 2007).

The aim of this work was to assess the impacts of thyme and lavender essential oils on postharvest quality parameters and shelf-life of 'Jonagold' apples.

MATERIALS AND METHODS

Plant material

'Jonagold' 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 to 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 includes immersion fruits at different levels of thyme essential oils solutions (25, 100 and 200 ppb) and the second was lavender essential oils solutions (25 and 100 ppb) and fruits immersed in distilled water as control for 10 min. Fruits were then dried for about 24 h and then stored at 0 to 2°C and 85 to 90% relative humidity for 5 months. After 20, 80, 120 and 160 days 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 day after storage in 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 (TSS), titratable acidity (TA), fruit flavor index (TSS/TA), acidity (pH), ethylene production, Thiault index, Perlim index were measured at 5 month of postharvest life.

Weight loss

Weight loss was determined by using Tefera et al. (2007) method.

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 is considered as an average peak force of 10 fruits and expressed in kilogram (kg).

Total soluble solid (TSS)

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)

TA was determined by titrating 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 (that is, ratio increasing with maturity) (Schirra et al., 2004).

pH

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

Thiault index

The Thiault index was calculated as follows:

Index = [10 × acidity (g/L) + sugar content (g/L)] (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) × 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.

Experimental design and statistical analysis

A completely randomized factorial design with three replications

Table 1. Mean comparison of fruit weight loss, firmness, ethylene, TSS, TA, TSS/TA, pH, Thiault and Perlim indexes in different thyme essential oil concentrations during 160 days storage at 0 to 2°C.

Thyme essential oil treatment (ppb)	Firmness (kg)	TA	TSS	pH	Ethylene (µl kgh^{-1})	TSS/TA ratio	Weight loss (%)	Thiault index	Perlim index
0	1.43^{a}	40.41^{b}	13.18^{a}	4.13^{a}	3.23^{b}	0.34^{a}	3.20^{b}	159.51^{a}	92.65^{a}
25	1.41^{a}	38.51^{b}	12.85^{ab}	4.15^{a}	3.37^{a}	0.36^{a}	3.16^{b}	154.12^{a}	89.81^{b}
100	1.45^{a}	40.78^{b}	13.07^{ab}	4.12^{a}	3.10^{bc}	0.33^{ab}	2.66^{c}	158.72^{a}	92.50^{a}
200	1.42^{a}	45.25^{a}	12.57^{b}	4.11^{a}	2.98^{c}	0.31^{b}	4.35^{a}	157.89^{a}	93.11^{a}
F-Value	1.174	6.039	4.00	0.350	5.80	6.043	7.63	1.23	6.03

Means in each column followed by similar letters are not significantly different at 5% level (P≤0.05).

Table 2. Mean comparison of fruit weight loss, firmness, ethylene, TSS, TA, TSS/TA, pH, Thiault and Perlim indexes in different lavender essential oil concentrations during 160 days storage at 0 to 2°C.

Lavender essential oil treatment (ppb)	Firmness (kg)	TA	TSS	pH	Ethylene (µl kgh^{-1})	TSS/TA	Weight loss (%)	Thiault index	Perlim index
0	1.43^{a}	41.50^{a}	12.98^{a}	4.17^{a}	3.42^{a}	0.34^{a}	3.60^{a}	158.48^{a}	89.28^{a}
25	1.42^{a}	41.19^{a}	13.05^{a}	4.11^{a}	3.29^{a}	0.34^{a}	3.14^{c}	158.92^{a}	89.39^{a}
100	1.43^{a}	41.01^{a}	12.70^{a}	4.10^{a}	2.97^{b}	0.33^{a}	3.28^{b}	155.03^{a}	87.69^{a}
F-Value	0.262	0.060	0.096	3.22	7.875	1.485	7.53	1. 26	0.652

Means in each column followed by similar letters are not significantly different at 5% level (P≤0.05).

was used. An 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

Fruit firmness

Thyme essential oil and lavender essential oil treatments had no effect on fruit firmness after 5 months storage (Tables 1 and 2). The interaction thyme essential oil × lavender essential oil had a significant effect on apple firmness. Fruit firmness of apples was not affected by lavender essential oil. At the end of storage apples immersed at 100 ppb thyme × 100 ppb lavender essential oils and 200 ppb thyme without lavender essential oil were significantly firmer than apples from the other treatments or the control (Table 3). The obtained results could be explained by the statement of Serrano et al. (2005) which showed that use of natural antifungal compounds on sweet cherry storage increased fruit firmness. The loss of firmness due to cell wall carbohydrate metabolism during storage has been associated with increased susceptibility to infection by fungal pathogens (Conway et al., 1987). Thymol has been determined to be an effective antifungal essential oil with potential application for the control of plant diseases, particularly on fruits (Chu et al., 2001; Tsao and Zhou, 2000).

Titratable acids and pH

After storage, lavender essential oil immersion had no effect on the TA and pH of apples (Table 2). There was significant difference in apple TA when immersed at 200 ppb thyme essential oil (Table 1) but, thyme essential oil treatment had a significant effect on the pH of apples. Apples immersed at 200 ppb thyme essential oil had significantly higher TA than other treated or control apples (Table 1). The interaction thyme essential oil × lavender essential oil treatments had no effect on fruit titratable acids and pH after 160 days storage (Table 3). The study by Gnsalez-Aguilar et al. (2003), metyl jasmonate increased postharvest quality and organic acids of papaya. These results are in line with those reported by Wang (2003) that treated raspberries with natural volatile compounds increase the acidity during storage.

Total soluble solids and TSS/TA ratio

Immersion in thyme essential oil had a significant effect on the TSS and TSS/TA ratio in apples at the end of storage. Treated apples had a lower TSS and TSS/TA ratio than control apples (Table 1). TSS and TSS/TA ratio were not influenced by the postharvest lavender essential oil and the interaction thyme essential oil × lavender essential oil and slight differences existed. The results of Anthony et al. (2003) study on banana fruit indicated that

Table 3. Mean comparison of fruit weight loss, firmness, ethylene, TSS, TA, TSS/TA, pH, Thiault and Perlim indexes in different thyme and lavender essential oils concentrations during 160 days storage at 0 to 2°C

Thyme essential oil treatment (ppb)	Lavender essential oil treatment (ppb)	Firmness (kg)	TA	TSS	pH	Ethylene (µl kgh^{-1})	TSS/TA	Weight loss (%)	Thiault index	Perlim index
0	0	1.39^{ab}	36.82^{a}	13.16^{a}	4.19^{a}	3.23^{bc}	0.38^{a}	2.32^{i}	155.71^{bc}	86.86^{cd}
	25	1.47^{ab}	42.69^{a}	13.24^{a}	4.08^{a}	3.26^{bcd}	0.33^{a}	3.43^{d}	162.43^{b}	91.33^{b}
	100	1.42^{abc}	41.71^{a}	13.14^{a}	4.11^{a}	3.10^{bcd}	0.33^{a}	3.85^{b}	160.39^{bc}	90.11^{bc}
25	0	1.40^{bc}	38.36^{a}	13.07^{a}	4.21^{a}	3.01^{bcde}	0.36^{a}	2.95^{fg}	156.30^{bc}	87.51^{cd}
	25	1.39^{bc}	37.39^{a}	12.70^{a}	4.11^{a}	3.88^{a}	0.37^{a}	3.65^{c}	151.41^{d}	85.18^{d}
	100	1.45^{abc}	39.76^{a}	12.77^{a}	4.12^{a}	3.22b^{cd}	0.34^{a}	2.87^{g}	154.52c^{d}	87.21^{cd}
100	0	1.43^{abc}	41.57^{a}	12.84^{a}	4.18^{a}	3.24^{bcd}	0.33^{a}	3.00^{f}	157.07^{b}	88.70^{c}
	25	1.43a^{bc}	41.85^{a}	13.58^{a}	4.10^{a}	3.14^{bcd}	0.33^{a}	2.23^{i}	165.19^{a}	92.20^{ab}
	100	1.48^{a}	38.92^{a}	12.77^{a}	4.08^{a}	2.92^{cde}	0.34^{a}	2.74^{h}	153.68^{cd}	86.72^{cd}
200	0	1.50^{a}	49.25^{a}	12.87^{a}	4.10^{a}	3.39^{b}	0.30^{a}	6.14^{a}	165.07^{a}	94.13^{a}
	25	1.40^{bc}	42.82^{a}	12.70^{a}	4.14^{a}	2.89^{de}	0.32^{a}	3.24^{e}	156.84^{bc}	88.84^{c}
	100	1.38^{c}	43.67^{a}	12.14^{a}	4.10^{a}	2.66^{e}	0.30^{a}	3.68^{c}	151.75^{dc}	86.85^{cd}
F-Value		4.790	2.129	1.559	0.898	6.167	1.562	8.33	7.15	6.85

Means in each column followed by similar letters are not significantly different at 5% level (P≤0.05).

spraying essential oils *Cymbopagon nardus*, *Cymbopagon flexuosus* and *Ocimum basilicum,* no effect had on the TSS after ripening during storage.

Ethylene production

The interaction thyme essential oil × lavender essential oil immersion for the ethylene production was significant. However by the end of the storage period treated apples with 200 ppb thyme essential oil × 100 ppb lavender essential oil had a lower ethylene than other treatment apples (Table 3). Apple fruits dipped in 25 ppb thyme essential oil × 25 ppb lavender essential oil produced significantly higher levels of ethylene compared to the other treatments. Postharvest thyme and lavender essential oils treatments affected ethylene levels of apples and apples which had been immersed in 200 ppb thyme and 100 lavender essential oils had lower ethylene levels than other treatments and control apples (Tables 1 and 2). Babalar et al. (2007) showed that SA significantly affected strawberry (*Fragaria ananassa* cv. Selva) fruit postharvest ethylene production. The most effective SA concentration was 2 mmol.L^{-1}, which led to more than 30% reduction in fruit ethylene production in comparison to the control fruit, while 4 mmol.L^{-1} was less effective than 1 and 2 mmol.L^{-1}. Zhang et al. (2003) reported that postharvest treatment of kiwifruit with ASA (a synthetic analogue of SA) results in lower ACC oxidase and ACC synthase activity and decreases ethylene production during the early stages of fruit ripening. Thyme and lavender essential oils treatment effectively controlled fruit fungal decay and decreased ethylene production leading to absence of any decay on fruit and noticeable decrease in metabolic activity almost including respiration. It is well known that any factor increasing ethylene production or activity leads to increase in respiration rate and any factor increasing respiration rate leads to increase in ethylene production and activity (Wills et al., 1998).

Weight loss

The lowest significant values of weight losses percentages were recorded by the treatment of 100 ppb thyme and 25 ppb lavender essential oils (2.66 and 3.14%, respectively) after storage. The highest values of weight losses (%) were noticed by the 200 pbb thyme and 0 pbb (control) lavender essential oils treatments (Tables 1 and 2). Weight losses percentages was significantly increased in 200 ppb thyme essential oil × 0 ppb lavender essential oil apple fruits, compared to the control fruits and the other treatments (Table 3), whereas differences were observed among the different essential oils sources. Decrease in fruit metabolic activities results in a decrease in fruit water loss and carbohydrate depletion rate and consequently, effectively delays fruit senescence process (Wills et al., 1998).

Prelim and Thiault indexes

The interaction thyme essential oil × lavender essential oil had a significantly influence in increasing the Perlim and Thiault indexes in fruits compared to control in the end storage ($p \leq 0.05$). The results indicate that maximum Thiault and Perlim indexes were recorded in 200 ppb thyme essential oil × 0 ppb lavender essential oil and 100 ppb thyme essential oil × 25 ppb lavender essential oil treatments as compared to other treatment. Immersion in thyme essential oil had a significant effect on the prelim index in apples at the end of storage. Treated apples with 25 ppb thyme essential oil had a lower Perlim value than other treatments and control apples (Table 1). Lavender essential oil immersion had no effect on the Thiault and Perlim indexes of apples (Table 2). Growers use the Thiault index as an indicator of optimum ripeness for harvesting and consumption. Thiault values over 170 are considered acceptable for some apple varieties (Porro et al., 2002).

Conclusion

Conclusively, from the results obtained in this work, immersing ‘Jonagold’ apples at the combined treatment of 100 ppb thyme followed by 25 ppb lavender essential oils and treatment of 100 ppb thyme essential oil are suggested to be a good recommendation for improving the fresh quality assessments after 5 months of cold storage at 0 to 2℃, RH 85 to 90%.

ACKNOWLEDGMENT

Authors would like to thank the research section of Agriculture Faculty of University of Zanjan for their cooperation.

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