Application of *Ocimum basilicum* Essential Oil as Vapor on Postharvest Storage of Plum Fruit cv. ‘Golden Drop’

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**Abstract**

Increased interest in the use of natural compounds instead of chemicals is due to concerns about the effect of synthetic ingredients on humans’ health and over environment. Therefore, in this study essential oil from *Ocimum basilicum* as a natural and safe compound, was applied at three levels (100, 200 and 300 μl/l) as vapor and its effects on postharvest quality and storage life of ‘Golden Drop’ plums was evaluated. After application of treatments, the fruits were stored at +1 °C and 80-85% relative humidity for 42 days. During the storage period, samplings were carried out every week and to simulate market condition, they were kept at room temperate for 24 h. Then some of the qualitative and quantitative traits, such as total soluble solids (TSS), titrable acidity (TA), TSS/TA ratio, weight loss, firmness, ascorbic acid, total antioxidants, as well as color (L*, hue angle) were measured. Results showed that the basil essential oil contributed to a better maintenance of TSS, TA, TSS/TA ratio, firmness, ascorbic acid, antioxidant and delayed weight loss and color changes compared to control. However, the fruit treated with 300 μl/l concentration had essence flavor compared to control. In conclusion, the use of basil essential oil is an effective tool on maintaining postharvest quality and storage life of plum fruits.

**Keywords:** antioxidant, color, firmness, natural compounds, weight loss

**Introduction**

Ripening is the process by which fruits attain their desirable quality, flavor, color, palatable nature and other textural properties. Ripening is associated with changes in composition i.e. conversion of starch to sugar. On the basis of ripening behavior, fruits are classified as climacteric and non-climacteric fruits. Ripening of climacteric fruits, of which plums are included, is handled by ethylene which causes morphological, physiological and biochemical changes regarding ripening process, such as skin color, sugar and organic acid metabolism and fruit softening (Valero et al., 2005). During fruit ripening and softening, storage and shelf life of plum fruits decreases. Plum is a highly perishable fruit and will soon deteriorate after ripening. Its storage life is also limited even at low temperatures.

In recent years, consumer demands for food products that are free of synthetic chemicals residues, or products that are grown and supplied in an organic way, are significantly increasing. By using natural compounds such as plant essential oils, as non-destructive method, controlling decays and increasing storage life of plums is possible. Numerous papers have been published which report the use of natural compounds instead of chemicals, which in most cases have been associated with good results.

Essential oils are secondary metabolites that are produced in various parts of aromatic plants. They are volatile compounds that are called volatile oils or essential oils due to evaporation at normal temperatures. They are colorless compounds that get a dark color over time due to oxidation. Lipophilic characteristic of the essential oils is very important in inhibiting the growth of pathogens (Lanciotti et al., 2004). Antioxidant characteristic of essential oils causes the reduction of enzymatic browning and increase storage life of fruits and vegetables, without loss of quality (Lanciotti et al., 2004; Ponce et al., 2004).

Combination of mentol, eugenol or thymol with modified atmosphere packaging (MAP) maintained the quality of table grape during storage, since reduced caused weight loss and color change, delayed the increase in TSS/TA ratio and reduced fruit softening (Valverde et al., 2005). These treatments caused reduction of rachises and berries decay rate. Also, yeasts and fungi were significantly reduced in packages containing grape and natural antimicrobial compounds. The results contributed to maintenance of table grape quality and safety for longer storage period. Also, the use of methyl jasmonate treatment prevented fungal growth in grapefruit (Droby et al., 1999), reduced decay and maintained the postharvest quality of papaya (Gonzalez-Aguilar et al., 2003) and prevented microbial contamination of fresh-cut celery and peppers (Buta and Moline, 1998).

Thus, based on the above mentioned points, the aim of this study was to assay a potential use of basil essential oil as vapor on maintaining qualitative and quantitative characters and storage life of ‘Golden Drop’ plums.

**Materials and methods**

Plum fruits (*Prunus salicina* Lindl. var. ‘Golden Drop’) were harvested at commercial maturity from horticulture research center of the University of Tehran, located at Karaj,
Iran. Plum fruits of uniform size and free from visual symptoms of disease or blemishes were used for the experiment. The fruits were transported to the laboratory immediately after harvest and were randomly selected for different treatments. In the laboratory, 6 plums (average mass of approximately 270 g) were placed in separate plastic bags. *Ocimum basilicum* essential oil (purchased from commercial company) at concentrations of 100, 200 and 300 µl/l was applied on filter papers and placed in each plastic bag for expose plums to vapor (without any direct contact between plums and filter paper). Control samples were handled similarly with the exception of the volatile treatment. Treated and untreated fruits were stored at +1 °C and 80-85% relative humidity for 6 weeks. During the storage period, 12 sampling bags were carried out every week to simulate market conditions, being kept at room temperate for 24 h.

Gas Chromatography-Mass Spectrometry analysis of the essence

The analysis of the volatile constituents of the essential oil were run on a Hewlett-Packard GC/MS system (GC: 6890; MS: 5973). The fused-silica hp INNOWAX capillary column (30 m x 0.25 mm ID, film thickness of 0.32 µm) was directly coupled to the MS. The carrier gas was helium, with a flow rate of 1 mm/min. Oven temperature was programmed (60 °C for 3 min, then 60-220 °C at 5 °C/min) and subsequently, held isothermal for 2 min. Injector temperature: 250 °C, detector temperature: 300 °C. Split ratio 1:20.

Volume injected was 0.1 µl of 1% solution (diluted in hexane). The mass spectrometer was hp recording at 70 eV; scan time 1.5 sec; mass range 40-300 amu. The components of the oil were identified by comparison of their mass spectra with those of a computer library (Wiley 275 library). Retention indices were calculated using retention times of n-alkanes that have been injected to the same instrument (Adams, 1995; Shibamoto, 1987).

Total soluble solids content, acidity and TSS/TA ratio determination

The soluble solids content (TSS) of juice was determined using a digital refractometer and was expressed as percent soluble solids content. Titratable acidity (TA) was determined by titration against 0.1N NaOH up to pH 8.2 by using 5 ml of juice diluted to 50 ml with distilled H₂O.

The results were expressed as g of malic acid per 100 g fresh weight. The TSS/TA ratio was calculated by dividing TSS with the corresponding TA value.

Weight loss and fruit firmness

Weight loss percent was determined by the following formula: (A – B)/A x 100, in which A is the fruit weight just before storage and B is the fruit weight after storage period. Fruit firmness was determined by using a penetrometer fitted with a 5 mm tip. A small slice of fruit skin was removed from each side of a fruit, three fruits from each replicate were used for firmness measurements and results were expressed as Newton (N).

Fruit color

The changes in fruit color parameters including *L*, *a* and *b* were recorded at opposite sides of skin surface using three fruits from each replicate with a Minolta Chromameter CR400 then expressed as L*, hue angle (*b*° = 180 + tan⁻¹ *b*/*a*, if *a* < 0) (Pek et al., 2010; Fernando et al., 2007).

Ascorbic acid

The level of ascorbic acid was determined using 2,6-dichloro phenol indophenol method as described by A.O.A.C. (1994).

Total antioxidant activity

Total antioxidants in fruits’ pulp tissue were estimated by using the method of Faniadis et al. (2010) with some modifications. One gram of fruit pulp which had already been lyophilized with liquid nitrogen and stored at -80 °C was homogenized in a glass pestle and mortar, using 8 ml of 80% methanol. Then the mixture was shaken slowly for 10 min in the cold chamber and centrifuged for 15 min at 12000 rpm in 4 °C. Thereafter the supernatant was filtered through filter paper at cold chamber. Stock solution of 2,2-diphenyl-1-picrylhydrazyl (DPPH) 100 µM was made by dissolving 0.00394 g DPPH in 100 ml of methanol. In the dark room and inside the glass cuvette, 1700 µl of DPPH solution, 1000 µl of distilled water and 100 µl of methanol extract were combined and put in the darkness for 2 h. Then the absorbance was measured at 520 nm against methanol (as blank). Different concentrations of ascorbic acid (as standards) were used for determining the antioxidant capacity of samples.

Ascorbic acid stock solution (1 mM, 0.0176 g ascorbic acid in 100 ml 80% methanol) was prepared and from this stock other concentrations (0.125 mM, 0.25 mM and 0.5 mM) were produced to determine a standard curve. The absorbance was measured at 520 nm by using a spectrophotometer. According to standard curve and based on absorbance of the samples, the antioxidant capacity was determined and expressed as mg of ascorbic acid equiv. 100/g FW (A.O.A.C. 1994).

Statistical analysis

Statistical analysis of the data obtained in the present study was carried out using split factorial method in a completely randomized design layout, with two factors, including basil concentrations and storage period. All treatments were replicated for three times.

Means comparison was performed using Duncan’s multiple range test to examine if differences between treatments and storage time were significant at p < 0.05. All analyses were performed with SAS software package 9.1 for Windows.

Results and discussion

Results obtained by GC-MS analysis of the essential oil of *O. basilicum* are presented in Tab. 1. Eighteen compounds were identified in the essential oil of *O. basilicum*. As a result of GC-MS analysis, *O. basilicum* contained estragol (71.85%) as the major compound.

TSS, *pH*, TA and TSS/TA

During the storage, amount of TSS decreased gradually (Tab. 2). Using basil oil had a significant effect on TSS, so that the TSS was lower in treated fruits than in control fruits.
Tab. 1. Chemical composition of the *O. basilicum* essential oil

| No. | Chemical composition | Percentages of compounds |
|-----|----------------------|--------------------------|
| 1   | Estragol (Methyl Chavicol) | 71.85                    |
| 2   | Linalool              | 22.24                    |
| 3   | Eugenol               | 1                        |
| 4   | α-Thuijene            | 0.11                     |
| 5   | Myrcene               | 0.7                      |
| 6   | β-Piene               | 0.6                      |
| 7   | Methyl Eugenol        | 0.6                      |
| 8   | Cis-Bergamotene       | 0.40                     |
| 9   | Caryophyllene oxide   | 0.40                     |
| 10  | Linalool oxide        | 0.24                     |
| 11  | L. Cineol             | 0.21                     |
| 12  | α-Piene               | 0.2                      |
| 13  | Citronellol           | 0.20                     |
| 14  | Dihydro Linalool      | 0.18                     |
| 15  | α- Terpine 1          | 0.1                      |
| 16  | β-Cymene              | 0.1                      |
| 17  | γ-Terpineen           | 0.1                      |
| 18  | β-Gurgenene           | 0.08                     |

The ability of antioxidants to scavenge reactive oxygen species (ROS) is important to protect tissues from light-induced oxidative damage. The content of ascorbic acid and TAA decreased during storage (Tab. 2). Fruits treated with basil essence better maintained the ascorbic acid content compared to control (Fig. 6). Ascorbic acid is an antioxidant and there is positive correlation between its amount and the level of TAA, which was better maintained in treated fruits than control (Fig. 7).

Fruit firmness decreased over time (Tab. 2). Changes in firmness are due to changes in the chemical structure of the cell wall, because during the ripening process polygalacturonase and pectin methyl esterase enzymes cause dimethylation of galacturonic acid from cell wall pectin and Ca²⁺ gets released in the polymer chains, resulting in the softening of the cell walls (Perasanna *et al.*, 2007; Wei *et al.*, 2010). Fruit firmness in treated fruits was better maintained during storage compared to control fruits (Fig. 5).

Softening contributes to quality loss by reducing shelf life, but the addition of basil essential oil resulted in higher flesh firmness during cold storage. Similar effect has been reported for sweet cherry (Serrano *et al.*, 2005) and table grape (Valverde *et al.*, 2005; Valero *et al.*, 2006) which might be due to lower respiration rate.

**Color changes**

Color is a very important indicator of the quality of fresh fruit. It also serves for estimating the stage of maturity of fruits. Among plant pigments responsible for the color of fruits are anthocyanins. L shows the darkness or brightness of the fruit color, in a way that reduced L coincides with the darkening of fruits (James *et al.*, 2002). L decreased with the time and the fruits get darker during the ripening process in the storage (Tab. 2). L in treated fruits was higher than control during the storage and there was no significant difference in L between different basil concentrations (Fig. 8). Although the essential oil mechanism in maintaining L is unknown (Serrano *et al.*, 2005), however retarding of ripening might be the main factor. Maintenance of L in treated fruits can also be related to reduction of weight loss (Valverde *et al.*, 2005). Different pattern of surface discoloration of fruits (such as strawberries) is due to differences in the concentration and ratio of various phenolic compounds (Zhang *et al.*, 2008).

The hue gradually decreased during storage (Tab. 2). Fruits treated with essential oil had the highest hue angle and were greener than control fruits and with increasing the concentration, fruit color change occurred slower (Fig. 9). This has also been reported in other fruits, such as table grape (Martinez-Romero *et al.*, 2003), loquat (Amorós *et al.*, 2008) under MAP conditions and sweet cherry with essential oils (Serrano *et al.*, 2005).
Tab. 1. Chemical composition of the *O. basilicum* essential oil

| Treatment | Mean of Parameter | Mean of Parameter |
|-----------|------------------|------------------|
|           | Storage period (week) | TSS (%) | TA (%) | TSS/TA ratio | Weight loss (%) | Firmness (N) | Ascorbic acid (mg/100g) | Antioxidant activity (mg/100g) | L’ | Hue angle |
| 0         | 8.00g | 2.42a | 3.31g | 0.00g | 3.73a | 7.93a | 49.86a | 67.86a | 110.17a |
| 1         | 8.30f | 2.24b | 3.71f | 0.70f | 3.54a | 7.50b | 47.31b | 65.01b | 108.44b |
| 2         | 8.43e | 2.08c | 4.08e | 1.03e | 2.59b | 7.17c | 45.67c | 63.61c | 107.02c |
| 3         | 8.56d | 1.94d | 4.48d | 1.25d | 2.48bc | 6.86d | 43.79d | 62.40d | 105.60d |
| 4         | 8.73c | 1.81e | 4.93e | 1.44e | 2.39bc | 6.60e | 42.65e | 60.19e | 103.65e |
| 5         | 8.87b | 1.62f | 5.60b | 1.62f | 2.20cd | 6.24f | 39.75f | 58.26f | 102.66e |
| 6         | 9.05a | 1.43g | 6.41a | 1.81a | 2.05d | 5.93g | 38.09g | 55.70g | 100.91f |

Note: Means of treated and untreated fruits at columns with at least one common letter did not show significant difference at 5% level, using Duncan test.

Fig. 1. The effect of basil essential oil treatment on TSS of ‘Golden Drop’ plums

Fig. 2. The effect of basil essential oil treatment on TA of ‘Golden Drop’ plums

Fig. 3. The effect of basil essential oil treatment on TSS/TA of ‘Golden Drop’ plums

Fig. 4. The effect of basil essential oil treatment on weight loss of ‘Golden Drop’ plums

Fig. 5. The effect of basil essential oil treatment on firmness of ‘Golden Drop’ plums

Fig. 6. The effect of basil essential oil treatment on ascorbic acid of ‘Golden Drop’ plums

Note: All data in figures are the mean of all the measurements per factor in all sampling dates.
Fig. 7. The effect of basil essential oil treatment on TAA of 'Golden Drop' plum

Fig. 8. The effect of basil essential oil treatment on L*$ of 'Golden Drop' plum

Note: All data in figures are the mean of all the measurements per factor in all sampling dates.

Conclusions

Many efforts in the storage, distribution and sale of horticultural products have led to the global supply of high-quality fresh products to consumers, to respond to the consumers’ demands for healthy products, avoiding the application of chemicals as a mean of preservation. In this study, basil essential oil was used as a safe and natural compound for increasing the storage life and maintaining the qualitative and quantitative characteristics of Prunus salicina var. 'Golden Drop'. Treatments with 100, 200 and 300 µl/l of basil essence resulted in improved quality of the plum fruits during storage. However, the fruit treated with 300 µl/l concentration had essence flavor compared to control. Further studies are needed for a better understanding of the essential oils mechanism on physiology of the fruits and their ripening process.

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