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The Effect of Plant Essential Oils on Some Physiochemical Traits and Enzymatic Activity of Cherry (Prunus Avium L. CV Takdaneh mashhad) in Postharvest Conditions

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ABSTRACT: Maintenance and quality of fresh cherry fruit during storage is important therefor the aim of present study is to estimate the effects of post-harvest thyme, basil and mint (TEO, BEO and MEO) essential oils (EOs) on the biochemical traits and shelf life of cherry fruit during storage at 1±0.5 ℃ and 90 to 95% humidity. Fruit were dipped in deionized water (control), (EOs) at 250 and 500 µl l^{-1} concentrations for 5 min and evaluation of traits were performed on 0, 5, 10 and 15 days after harvest. All treatments had a significant effect on the measured variables. Firmness, anthocyanins and superoxide dismutase activity were improved with 500 µl l^{-1} MEO treatment. Fruit treated with 500 µl l^{-1} TEO exhibited the highest cell membrane stability index, phenol, vitamin C, catalase, polyphenol oxidase activity during the storage period. The maximum TSS and pH was observed at 500 µl l^{-1} BEO. At the end of the storage period, the lowest fresh weight loss and relative fresh weight were observed in the 500 µl/l TEO and Total acidity was in 250 µl l^{-1} MEO treatment, respectively. Over the cold storage, 500 µl l^{-1} TEO was found to be the best treatment to maintain fruit quality in terms of postharvest life with 21 days. This experiment revealed that post-harvest treatment with 500 µl l^{-1} thyme, basil and mint essential oil prolonged the storage-life and preserved the valuable marketing characteristics of cherry fruit.

Keywords: Basil, Cherry, Essential Oil, Mint, Shelf Life, Thyme.

Introduction

Cherry belongs to Rosaceae family and the genus *Prunus*, a non-climacteric fleshy drupe cultured in the temperate zones within the world. Sweet variant (*P. avium*) is one of the three major cultivars of cherry fruits (Iezzoni, 2008). Various species are demanded in overseas market namely Takdaneh Mashhad which is the most popular for export. The fruit is rich in health-promoting components such as vitamins B1, B2, A, D, potassium, magnesium, calcium and organic acid, anthocyanin, total phenolic content and antioxidants. The sweets varity contain higher rates of sugar and lower amount of TA (13-25% SSC, 0.4-1.5% TA) that affect the sweetness and flavor. Five kinds of sugars are generally present in sweet cherries; glucose, sucrose, fructose, maltose, and sorbitol (Usenik *et al.*, 2008). Although, they are extremely decayable

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and very problematic to employ after harvest. Cherries are sensitive to water loss, softening, rottenness and stem browning. They are also susceptible to different physiological and microbial disorders. Various postharvest methods have been expanded to increment the shelf life and market cost of cherries such as controlled and modified atmosphere storage (MAP), irradiation, edible coatings and some chemical materials. Other methods and technologies for processed cherry productions such as dehydration, freezing and canning have also been assumed for preservation of cherries (Shah *et al*., 2018).

Essential oils include complex, volatile and natural materials that are produced by different parts of plants as a secondary metabolite and have various assignment. In most situation, it has antimicrobial, allelopathic, antioxidant and bioregulatory attributes. Numerous studies displayed that factors associate with postharvest ripening, like color and firmness were remarkably postponed in treated cherries with combination of essential oils, plus respiration level and moisture loss (Zapata *et al.*, 2017). In this aspect, the conducted works have reported the positive effect of plant essential oils on improving the quality of fruits on postharvest conditions for example the positive effect of using *Thymus vulgaris*, *Foeniculum vulgare* and *Satureja hortensis* oils on *Vitis vinifera* (L.) cv. Tabarzeh and *Thymus vulgaris* and *Lavandula angustifolia* oils on apple Jonagold cultivar reported by *Abdolahi et al.* (2010) and *Rabiei et al*. (2011), and also Mohamed and El-Badawy (2013) and Salimi *et al.* (2013) reported the effect of *Thymus vulgaris* and *Syzygium aromaticum* oils and *Ocimum basilicum*, *Mentha longifolia* and *Carum copticum* oils on the quality of washington navel orange and *Vitis vinifera* fruits, respectively. Therefore, due to the risk of unsuitable applications of chemicals and the health of consumers application of natural products namely essential oils to improve the quality and extend of shelf life is pre to need.

Materials and Methods

- Plant material and treatment

Uniform commercial cherry was purchased according to commercial harvest and fruit color change without mechanical and pest or diseases damage. Pure essential oils of mint (*Mentha piperita*) (MEO), basil (*Ocimum basilicum*) (BEO) and thyme (*Thymus vulgaris*) (TEO) were provided from the Essential Oil Company (Portland, OR, USA). Post-harvest EOs treatments were applied with three replications. Fruit were dipped for 5 min in 250 and 500 $\mu l\ l^{-1}$ mint (MEO), basil (BEO), thyme (TEO) and distilled water (control). All fruits were kept in the storage with 1±0.5°C and 90-95% humidity. Samples traits were measured in 0, 5, 10 and 15 days after storage.

- Assessed traits

Fresh weight of nectarine fruits were recorded in the first, 5, 10 and 15 days using a digital scale with an accuracy of 0.01%. Weight loss was estimated in each replication and was noted initially and 5, 10 and 15-days during storage (Danaee and Abdossi, 2015).

In orders to determined cell membrane stability index, the samples were placed at Benmarry Jar in 30 °C for 60 min, then the EC_1 level was recorded by EC meter. The Falcons were then transferred in an autoclave at 120 ° C for 20 min at 1.2 atm. After cooling, the EC_2 was recorded. Finally, cell membrane stability index was expressed as a percentage (Dareini *et al*.,

2014). Fruit firmness was monitored using penetrometer (TA-XTPlus, Stable microsystem Co. Ltd., UK) with an 8 mm diameter flat probe. Total Acidity (TA) values of solutions were measured with titration method using 0.1 M NaOH to the endpoint pH: 8.3 and the results were expressed as percentage of citric acid. Total Soluble Solids (TSS) were demonstrated using a digital refractometer (Atago Co., Tokyo, Japan) and pH of juice squeezed from fruit was determined in 50 ml samples of pulp with a digital pH meter; CP - 505 Clmeriron (Imani and Danaee, 2023). In order to the anthocyanin content of nectarine fruits, a certain amount of fruit was ground with methanol extraction solution and hydrochloric acid. The samples were poured into a test tube and exposed to 4ºC for 24 h and centrifuged for 5 min at 5000 rpm. The adsorption rate of the extract was read using spectrophotometer at 530 and 657 nm (Meng and Wang, 2004). Vitamin C content was measured by two-steps oxidation-reduction titration. The content of Vitamin C was measured by titrimetric method and calculated in mg (ascorbic acid) $100g^{-1}$ FW (Hosseinzadeh Rostam Kalaei *et al*., 2022). In order to measure the amount of phenol, 0.5-1 g of sample was used, which was ground in 80% ethanol and centrifuged at 10000 rmp for 20 minutes. The absorbance of the samples at 650 nm was determined by the control reagent (Malik *et al*., 1980).

The superoxide dismutase activity was measured by NBT method, as explained by Soroori *et al*. (2021). Activity of catalase was expressed in the method of *Bailly et al.* (2004) and polyphenol oxidase was assayed following the procedure outlined by *Polle et al*. (1994).

In order to measure the shelf life, the fruits were kept at 0.5±1°C and 85-90 % relative humidity. Symptoms such as placed, spoilage and mold contamination were noted in relation to the shelf life parameters.

- Statistical Analysis

The factorial experiment was performed in a completely randomized design with 3 replications. The data were analyzed using SPSS software. Data values were compared using LSD test at 1 and 5% levels.

Results and Discussion

The result of analysis of variance shows that the effect of treatment and days was significant on relative fresh weight, fruit weight loss, cell membrane stability index, tissue firmness, total soluble solids, titratable acidity, anthocyanin content, vitamin C, antioxidant activities at 1% level and phenols at 5% level. The effect of treatment on postharvest life at different concentrations of treatment was significant at the level of 1% (Table 1).

- Morphological traits

The results of the experiment indicated relative fresh weight, fruit weight loss, cell membrane stability index and tissue firmness decreased in all treatments during storage but declining trend in control treatment was more than others. Relative fresh weight was decreased after harvesting and during storage period but it was highest to 63.73% with 500 µl l^{-1} TEO (Figure 1). Fruit weight loss increased during fruit storage; but minimum level was achieved to 11.41 % in treated fruit with 500 µl l^{-1} TEO (Figure 2).

Weight loss of fruits is due to the incline of water vapor pressure among the fruit and the circumambient air, which is normally decreased by both epidermal cell layer and cuticle. Therefore, edible coating proceed as a surplus tissue which also cover the stomata conduce a reduction in

transpiration and in turn, to a decrease in weight loss. This leads to the principal useful impact of edible coatings, which has been illustrated in an immense area of fruits such as *Prunus armeniaca*, *Capsicum annuum*, Prunus persica, sweet cherry and *Persea americana*, among others (Maftoonazad and Ramaswamy, 2005; Maftoonazad *et al*., 2008). These obstacle characters also decrease the selective penetrance to O_2 and CO_2 of the fruit surface being a gain in CO_2 levels in the fruit layers and a decline in O_2 concentration, which might be accountable for the minimize respiration level in the alginate coated fruits. 500 µl l^{-1} MEO were more effective than other sources and decreased softening rate, the difference was observed by the 15_{th} day with 13.27 N m^{-2} (Figure 3). Essential oils increased the amount of cell membrane stability index in all applied treatments and the highest level (63.73%) was observed in 500 µl l^{-1} TEO (Figure 4).

The preservation of firmness in covered fruits might be demonstrated by delayed decay of cell wall membrane, mostly water in soluble and NaOH insoluble pectin, because of the impact of the internal fruit atmosphere with supreme CO_2 and minimum O_2 on subtractive the activity of the cell wall hydrolases responsible for fruit softening (Valero and Serrano, 2010). Hence, the overall consequence displays a delay in the postharvest ripening/maturation process in alginate-coated cherries, leading to retention of organoleptic and nutritive quality factors, purposefully with the addition of essentials oils.

Loss of firmness might be expected with increased activity of cell wall degrading enzymes such as polygalacturonate and pectin methyl esterase. On the other hand, reducing the amount of fruit juice during storage increases the pressure of cellular turgor and reduces the firmness of fruit tissue. The use of compounds in the essential oils of medicinal plants such as carvacrol, siamic acid and anethole by increasing the antioxidant activity and strengthening the host's defense system reduces the rate of aging, softening and increasing tissue resistance to disease. As a result, relative fresh weight, cell membrane stability index and fruit tissue firmness, preservation and fruit weight loss percentage are also lower than the control treatment (Banani *et al*., 2018).

It is widely accepted that the most important quality parameters determining sweet cherry acceptability by consumers are red color, firmness and flavor which is mainly related to the ratio between TSS and TA, and they show important differences among cultivars and maturity stages (Díaz-Mula *et al*., 2009).

- Biochemical traits

Our finding indicated that total soluble solids, anthocyanin content, titratable acidity, antioxidant capacity, vitamin C and phenol declined in all treatments during storage time but decreasing style in control treatment is more than others except titratable acidity. Total soluble solids in 500 µl l^{-1} BEO treated fruit with 13.93 ºBrix was highest at the 15_{th} day. Total acidity with 0.95% was highest in 250 µl l^{-1} BEO treatment after 15_{th}. Anthocyanin content was significantly greater in 500 µl l^{-1} MEO treatment than the other treatments with 9.35 mg g^{-1} FW after 15_{th} day. Treatment of 500 µl l^{-1} TEO with 3.21 mg 100 g^{-1} FW, demonstrated maximum vitamin C content after 15_{th} day. Phenol content were influenced by 500 µl l^{-1} TEO treatment since its value obtained 31.72 mg 100 g^{-1} DW during fruit storage (Table 2). *Thymus capitates* L oil has been applied as barrier for plant diseases of

some fruits (Tzortzakis and Economakis, 2007; Abd-AllA *et al.,* 2011; Hyun *et al*., 2015) and considerably maintained the vitamin C content and quality of the orange fruit (Fatemi *et al.,* 2011). *Mentha piperita* L. oil employed to decrease decay levels and greatly implemented vitamin C, raised acidity and preserved quality of the orange fruit (Fatemi *et al.,* 2011) and illustrated positive impacts on TA, TSS, weight loss percentage, increased shelf life of plum fruits (Aminifard and Mohammad, 2013). The enhancement level of total soluble solids in this study was up to fifth day. Based on the results of other investigations the impact of essential oils on total soluble solids can be derived from features of essential oil have do not a positive efficacy on total soluble solids during storage (Maqbool *et al*., 2010). According to our data, the optimum concentration of essential oils is capable to protect the total acidity rate to the end of the storage period. This result is similar to those of (Yousuf and Srivastava, 2017). Various concentrations of essential oils during the keeping period show significant impact on pH changes. According to the previous results, it is not possible to establish a straight correlation between pH and total acidity due to the changes in the buffering capacity of organic acids, the application of organic acids in the reaction leads to lower enzymatic levels of respiration (Bico *et al*., 2009). Phenolic compounds are one of the important plant metabolites that are synthesized by the schemic acid pathway and play an important role in neutralizing the excess of free radicals. The essential oils stimulate induction resistances and as a result phenolic compounds are reduced at a slower rate than the control. According to similar research results, it can be noted that most of the antimicrobial activity of the essential oils is directly associated with the prevention of the production of phenolic compounds, which makes it possible to use plant essential oils to reduce phenolic compounds and reduced the effect of free oxygen (Tzortzakis, 2007).

As a result, reducing the amount of phenol will hamper ruinous effects and lower quality. Regarding the results of the experiment concerned with the total anthocyanin content, it should be mentioned, that by applying the essential oil treatment, total anthocyanin has increased. Essential oils with high antioxidant properties probably preserves and stabilizes the color markers (anthocyanin content) which is the main pigment in cherries, and prevents its decomposition. Similar results were observed by Oz and ulukanli, (2012).

Catalase activity of cherry fruits at 15th day after harvest with 8.85 unit enzyme g^{-1} FW was highest at 500 µl l^{-1} TEO treatment. 500 µl l^{-1} TEO treatment with 9.13 unit enzyme g^{-1} FW increased POD at 15th day after harvest and the highest SOD was at 500 µl l^{-1} MEO treatment after 15 day harvested (Table 3). Antioxidants delay the oxidation of biomolecules such as lipids, proteins, carbohydrates, and deoxyribonucleic acid by inhibiting the release of electrons into free radicals. The antioxidant capacity of fruits is related to enzymatic compounds (superoxide dismutase, catalase, peroxidase, glutathione reductase, etc.) and non-enzymatic (carotenoids, ascorbic acids, phenols, flavonoids, etc.) depending on plant growth conditions, including environmental conditions, harvest time which may affect the antioxidant capacity. Plant essential oils improve the activity of antioxidant enzymes (Dar *et al.,* 2015). It has been reported that bioactive compounds and antioxidant activity show changes during cold storage of sweet

cherry cultivars (Serrano *et al.*, 2009).

During postharvest storage, 500 µl l^{-1} TEO was found to be the best treatment to maintain fruit quality in terms postharvest life with 21 days (Figure 6). The results of the study is consisting with the findings of Hosseini *et al.* (2015) on the effect of essential oil of marjoram on (*Prunus avium* L. cv Takdaneh Mashhad). Kamyab and Mahidashti *et al.* (2018) effect of peppermint extract on banana, Saedi and Asgharzadeh (2017) effect of thyme and Clov on Prunus Avium L. CV Takdaneh mashhad. Also the result of Şerban *et al.* (2011) showed that *Lavandula hybrida* oil, *Anethum graveolens* L. oil and *Coriandrum sativum* L. oil indicated antibacterial and high antifungal activity against different bacteria and fungi species. Our experience is in line with recent studies on treatment with essential oil compound that have proven to induce the inductive-defensive system and increase the shelf life of fruits and vegetables (Bill *et al.*, 2017; Vithana *et al.*, 2019).

Table 1. Analysis variance of application of MEO, BEO, TEO on some physicochemical attributes of *Prunus avium* L. cv Takdaneh Mashhad

		Mean Square												
	DF	**Relative fresh weight**	**Weight lose**	**Cell membrane stability index**	**Firmness**	**TSS**	**TA**	**pH**	**Anthocyanin**	**Vitamin C**	**Phenol**	**Catalase**	**Superoxide desmutase**	**peroxidase**	**Shelf life**
Essential oils	6	147.215**	15.716**	117.318**	21.116*	18.217**	3.261*	9.045**	16.385**	6.526*	56.762**	14.196*	8.417**	18.056*	25.216**
Days	3	98.216**	6.312**	87.043**	9.710**	7.439**	1.012**	4.119*	7.520*	1.974*	37.912**	5.412**	3.762*	9.184**	-
Essential oils *Days	18	115.315**	11418**	104.216**	17.212**	12.093**	1.917**	6.171**	11.095**	4.219**	44.285*	8.087**	6.073**	14.458**	-
Error	42	4.51	3.12	5.18	2.03	4.51	3.85	4.12	6.81	3.65	4.12	5.04	6.01	4.65	3.28
CV (%)	-	9.54	`12.25	10.43	11.52	12.25	9.54	9.27	11.26	8.75	11.26	10.22	11.53	12.25	9.76

ns, * and ** indicates non-significant, significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

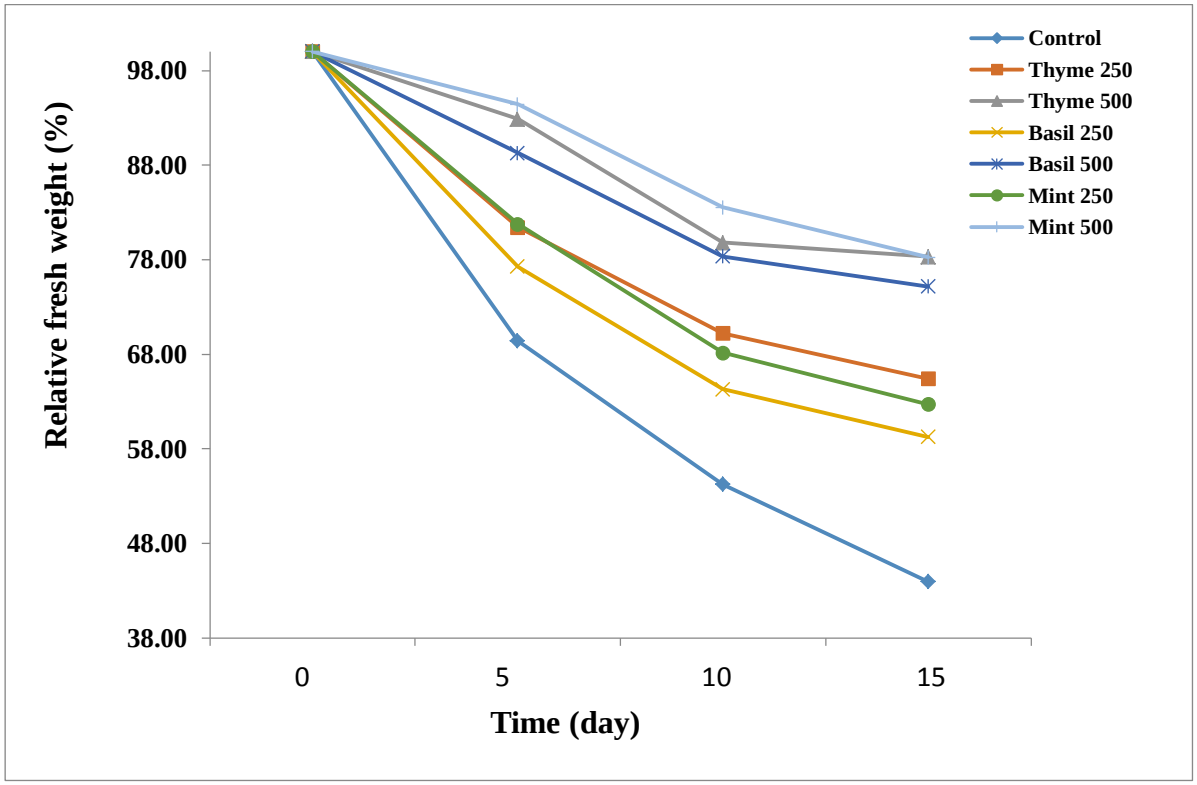

Fig. 1. Effect of application of MEO, BEO, TEO on relative fresh weight of *Prunus avium* L. cv Takdaneh Mashhad.

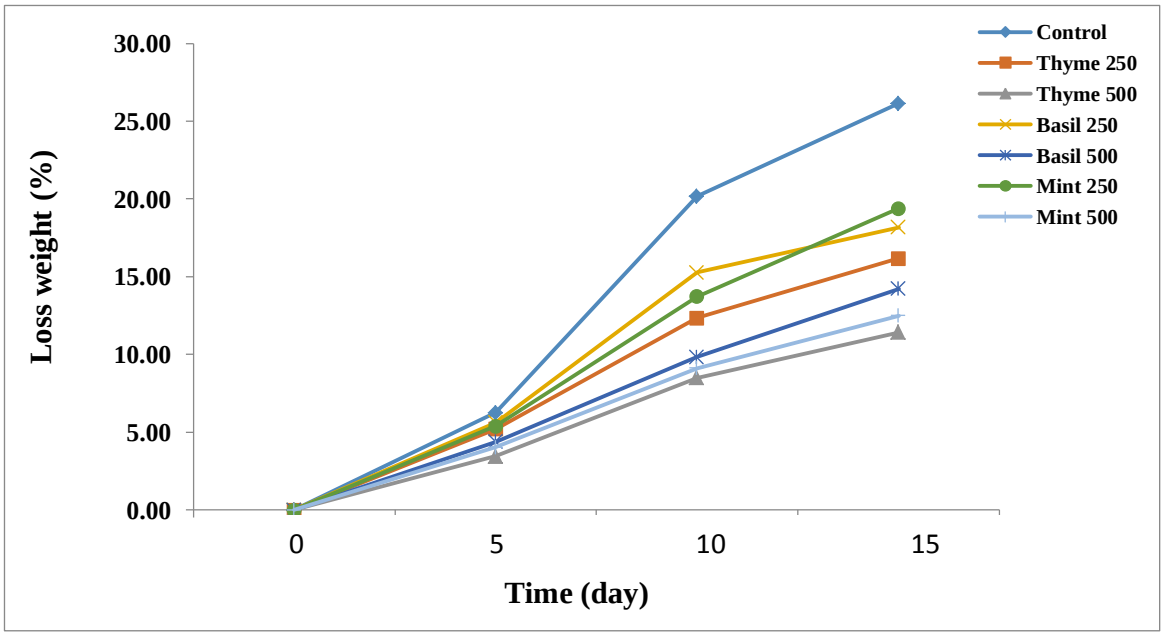

Fig. 2. Effect of application of MEO, BEO, TEO on loss weight of *Prunus avium* L. cv Takdaneh Mashhad.

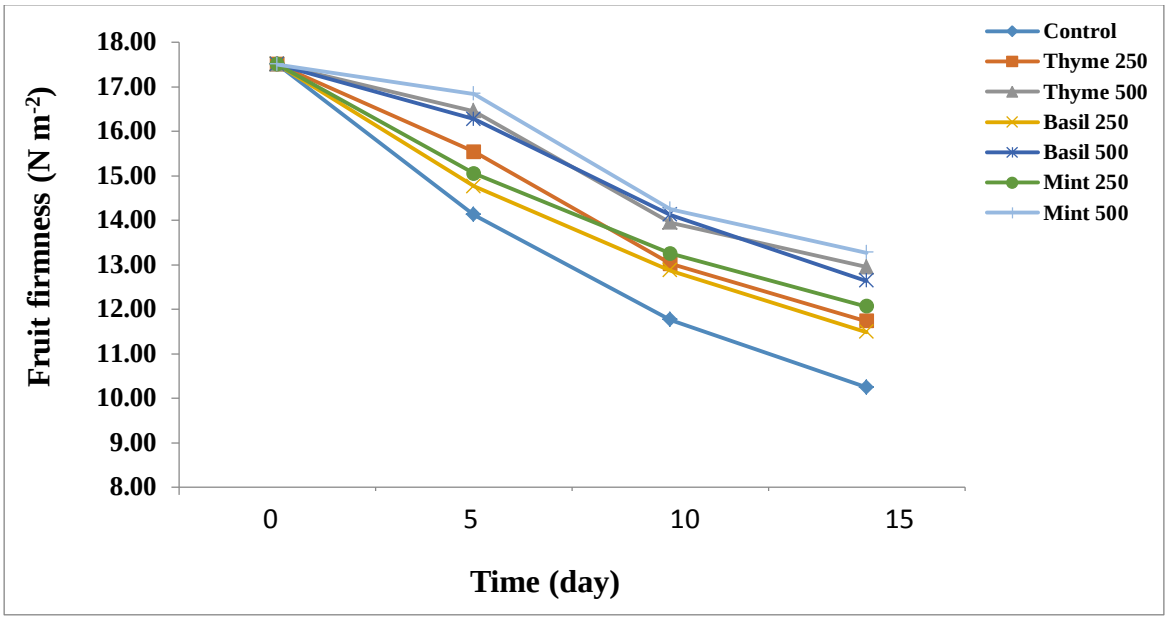

Fig. 3. Effect of application of MEO, BEO, TEO on furit firmness of *Prunus avium* L. cv Takdaneh Mashhad.

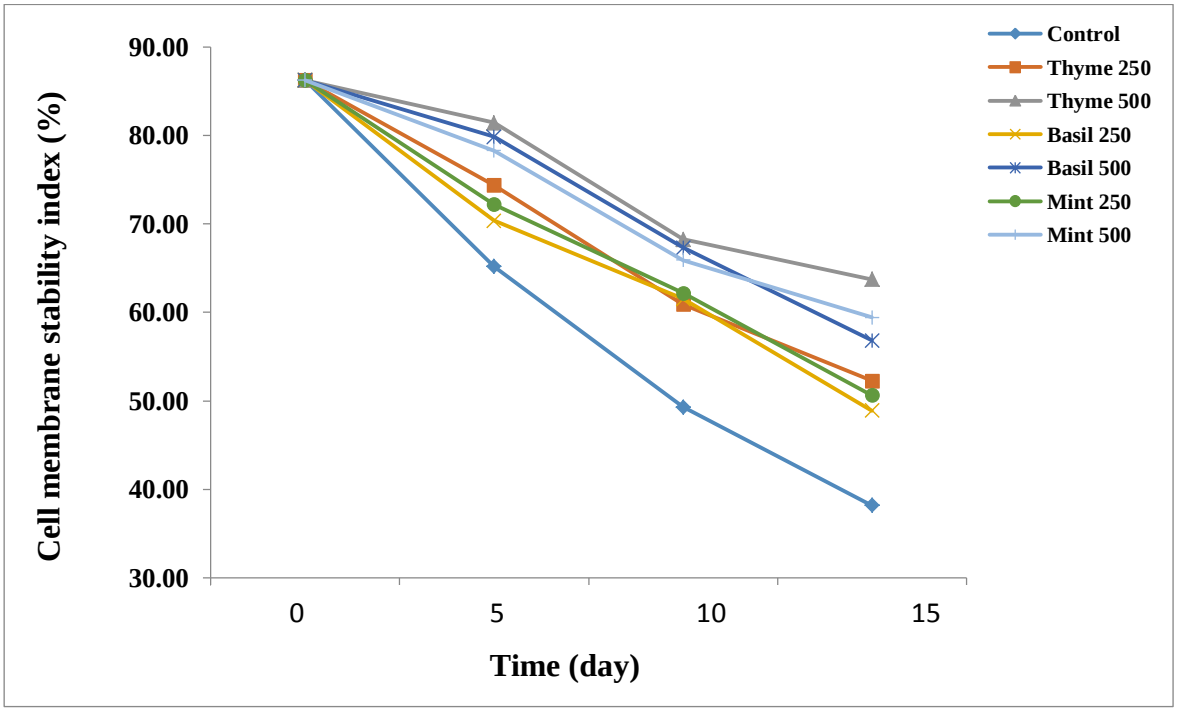

Fig. 4. Effect of application of MEO, BEO, TEO on cell membrane stability index of *Prunus avium* L. cv Takdaneh Mashhad.

Table 2. Effect of application of MEO, BEO, TEO on some physicochemical attributes of *Prunus avium* L. cv Takdaneh Mashhad

Storage time (day)	Treatment (µl l^{-1})	TA (mg 100 ml^{-1})	TSS (°Brix)	pH	Vitamin C (mg $100g^{-1}$ FW)	Anthocyanin (mg g^{-1} FW)	Phenol (mg g^{-1} DW)
At harvest	Control (distilled water)	1.45±0.33	15.66±0.18	4.76±0.14	4.27±5.89	12.45±3.43	42.17±0.43
	Thyme 250	1.45±0.28	15.66±0.14	4.76±0.09	4.27±2.18	12.45±4.34	42.17±0.30
	Thyme 500	1.45±0.10	15.66±0.20	4.76±0.09	4.27±3.34	12.45±12.01	42.17±0.24
	Basil 250	1.45±0.10	15.66±0.24	4.76±0.03	4.27±9.20	12.45±2.23	42.17±0.24
	Basil 500	1.45±0.08	15.66±0.14	4.76±0.06	4.27±19.05	12.45±5.09	42.17±0.17
	Mint 250	1.45±0.09	15.66±0.14	4.76±0.06	4.27±19.05	12.45±5.08	42.17±0.17
	Mint 500	1.45±0.08	15.66±0.14	4.76±0.06	4.27±19.05	12.45±5.80	42.17±0.17
5 days	Control	1.36±0.23	13.45±0.28	3.04±0.14	2.67±5.89	9.66±3.54	30.27±0.43
	Thyme 250	1.02±0.28	14.42±0.14	3.89±0.09	3.46±12.18	10.87±3.32	35.76±0.30
	Thyme 500	0.87±0.22	15.12±0.20	4.32±0.09	4.05±3.34	11.98±3.43	39.83±0.24
	Basil 250	1.27±0.14	14.56±0.24	3.51±0.03	3.11±9.20	10.42±0.03	32.85±0.24
	Basil 500	0.95±0.07	15.23±0.14	4.53±0.06	3.75±19.05	11.35±0.09	38.35±0.17
	Mint 250	1.21±0.07	14.07±0.14	3.75±0.06	3.23±19.05	10.51±0.07	34.19±0.17
	Mint 500	0.75±0.07	14.89±0.14	4.27±0.06	3.87±19.05	11.96±0.06	41.56±0.17
10 days	Control	1.12±0.13	12.62±0.28	2.58±0.14	2.04±5.89	8.14±0.82	24.19±0.43
	Thyme 250	0.78±0.03	13.39±0.14	3.48±0.09	2.98±12.18	9.57±0.14	30.17±0.30
	Thyme 500	0.69±0.12	14.01±0.20	3.87±0.09	3.56±3.34	10.67±0.30	35.39±0.24
	Basil 250	1.05±0.09	13.02±0.24	2.94±0.03	2.76±9.20	9.19±0.13	27.63±0.24
	Basil 500	0.71±0.08	14.35±0.14	4.02±0.06	3.39±19.05	10.42±0.13	29.34±0.17
	Mint 250	0.94±0.08	13.18±0.14	2.93±0.06	2.82±19.05	9.63±0.13	34.19±0.17
	Mint 500	0.52±0.08	13.76±0.14	3.61±0.06	3.35±19.05	11.15±0.30	35.12±0.17
15 days	Control	0.91±0.33	11.23±0.28	1.85±0.14	1.25±5.89	7.41±0.27	20.37±0.43
	Thyme 250	0.65±0.22	12.78±0.14	2.67±0.09	2.59±12.18	8.62±0.24	27.26±0.30
	Thyme 500	0.50±0.21	13.76±0.20	3.75±0.09	3.21±3.34	9.01±0.18	31.72±0.24
	Basil 250	0.69±0.22	12.38±0.24	2.69±0.03	2.14±9.20	8.24±0.18	26.45±0.24
	Basil 500	0.95±0.08	13.39±0.14	3.78±0.06	2.87±19.05	8.84±0.17	30.39±0.17
	Mint 250	0.85±0.09	12.64±0.14	2.83±0.06	2.65±19.05	8.39±0.21	27.61±0.17
	Mint 500	0.38±0.09	13.25±0.14	3.52±0.06	3.09±19.05	9.35±0.22	31.05±0.17

Data are the mean ± standard error (n=4).

Conclusion

The results of this study indicated that the application of thyme, basil and mint essential oils especially in 500 µl l^{-1} in postharvest could improve the quality and shelf life of the fruits. In this study essential oils are considered as a good postharvest tool to increase the shelf life of sweet cherry cultivars with beneficial effects in terms of increasing the antioxidant potential.

Table 3. Effect of application of MEO, BEO, TEO on enzymic activity of *Prunus avium* L. cv Takdaneh Mashhad

Storage time (day)	Treatment (µl l^{-1})	Catalase (Unit enzyme g^{-1} FW)	Superoxide desmutase (Unit enzyme g^{-1} FW)	POD (Unit enzyme g^{-1} FW)
At harvest	Control (distilled water)	11.38±0.28	4.95±0.09	13.25±2.88
	Thyme 250	11.38±0.22	4.95±0.08	13.25±2.18
	Thyme 500	11.38±0.23	4.95±0.08	13.25±3.23
	Basil 250	11.38±0.22	4.95±0.08	13.25±9.21
	Basil 500	11.38±0.16	4.95±0.08	13.25±19.12
	Mint 250	11.38±0.16	4.95±0.09	13.25±19.12
	Mint 500	11.38±0.16	4.95±0.08	13.25±19.11
5 days	Control	8.61±0.20	3.24±0.11	10.27±5.11
	Thyme 250	9.97±0.12	3.96±0.01	10.92±12.77
	Thyme 500	10.96±0.22	4.61±0.01	12.18±3.65
	Basil 250	9.53±0.21	3.64±0.20	10.71±9.23
	Basil 500	10.48±0.24	4.27±0.11	11.94±1.16
	Mint 250	9.61±0.13	3.83±0.10	11.17±1.34
	Mint 500	10.76±0.13	4.25±0.10	11.63±1.17
10 days	Control	6.94±0.08	2.48±0.11	7.49±4.33
	Thyme 250	8.13±0.18	3.12±0.08	8.82±2.77
	Thyme 500	9.58±0.18	3.59±0.18	10.32±2.19
	Basil 250	7.93±0.22	3.01±0.12	8.65±3.44
	Basil 500	9.12±0.25	3.38±0.16	9.91±2.19
	Mint 250	8.32±0.25	2.95±0.16	8.29±4.44
	Mint 500	9.24±0.25	3.76±0.16	9.95±3.99
15 days	Control	5.62±0.23	2.11±0.11	6.23±1.98
	Thyme 250	7.52±0.17	2.76±0.19	7.75±1.99
	Thyme 500	8.85±0.19	3.04±0.19	9.13±2.44
	Basil 250	7.26±0.19	2.59±0.13	6.97±3.55
	Basil 500	8.31±0.18	2.89±0.01	8.95±3.22
	Mint 250	7.04±0.18	2.51±0.03	6.83±2.23
	Mint 500	8.15±0.18	3.12±0.03	8.76±2.44

Data are the mean ± standard error (n=4).

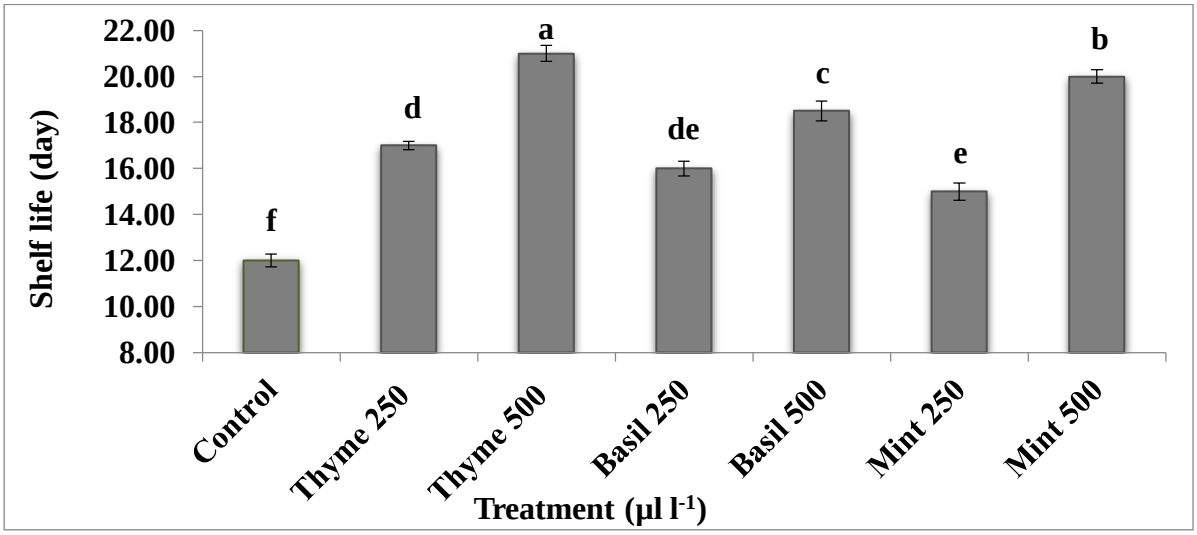

Fig. 5. Effect of application of MEO, BEO, TEO on shelf life of *Prunus avium* L. cv Takdaneh Mashhad, vertical bars indicate standard error (n=4)

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