JOURNAL OF HORTICULTURE AND POSTHARVEST RESEARCH
2021, VOL. 4(1), 115-126

Journal of Horticulture and Postharvest Research

Journal homepage: www.jhpr.birjand.ac.ir

University of Birjand

Effect of tea seed oil on post-harvest quality of Moro blood orange

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ARTICLE INFO

Original Article

Article history:
Received 5 May 2020
Revised 1 August 2020
Accepted 4 August 2020
Available online 18 September 2020

Keywords:
By-product
Citrus
Oil
Quality
Tea

DOI: 10.22077/jhpr.2020.3355.1143
P-ISSN: 2588-4883
E-ISSN: 2588-6169

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ABSTRACT

Purpose: The use of natural and organic products increases to produce a healthy product free of pollutants. Tea seeds contain 15-20% oil, which used as edible oil and an organic pesticide. In previous years, these seeds were used to produce tea seedlings. But now, cuttings are used for tea propagation and seeds are a byproduct of tea production. Therefore, this study aims to compare the effect of TSO with commercial wax on post-harvest quality of *Citrus sinensis* cv. Moro. **Research method:** An experiment was done as Completely Randomized Design; fruits were coated with control (distilled water), commercial wax (XEDASOL- MX20), and tea seed oil. The fruits were stored for 60 days in cold storage. The weight of the fruit skin, the contents of juice, total soluble solids, titratable acidity, and anthocyanins of the fruit were measured. **Findings:** The results showed that fruits coated with commercial wax and tea seed oil have the lowest fruit weight loss, the highest percentage of TSS (10.42%), the most top content of anthocyanins (15.17 mg/l) and flavonoids (196.17 mg/l) that there was a significant difference with control. The lowest titratable acidity (2.28%) was observed in fruits impregnated with tea seed oil, and there was a considerable difference with control. In general, the effect of tea seed oil was similar to commercial wax. **Limitations:** No limitations were founded. **Originality/Value:** These results indicate that the application of tea seed oil proved to be effective in extending the quality and storage time of *Citrus sinensis* (cv. Moro).

INTRODUCTION

Citrus is a semi-tropical fruit that has high economic value. Today, agricultural, commercial, and industrial activities on citrus are known as the Citrus industry (Bousbia et al., 2009).In the tropical area, the shelf life of horticultural products is naturally short due to they have high level of biological activity. To many biochemical activities like evaporation and transpiration, ripening, etc. can lead to decreasing or losing of fruit quality (Thumula, 2006). Materials and methods that reduce the rate of biochemical activity in harvested fruit can maintain the quality and increase the shelf life of the product.

Most farmers stored their products in traditional (cold) warehouses due to the high cost of transporting, storing, or filling refrigerators with other products. Loss of appearance and nutritional value of fruits are accelerated by unfavorable conditions in these places. When the coating method was used for apples and citrus the increasing shelf life and improved, the luster of the fruit for a long time was one of the achievements. Wax is the most common coating for citrus packaging. Today, efforts have been made to reduce the effects of pesticides on the environment and consumers and promote natural and non-toxic substances for reducing storage waste (Aboutalebi & Janparvar, 2010). Okey (2015) examined the effect of leaf extracts of *Azadirachta Indica* and *Chromolaena Odorata* on the biological control of fungal diseases in sweet orange after harvesting and stated that *A. Indica* leaves aqueous extract controlled sweet orange fungal diseases better. Aboutalebi and Janparvar (2010) examined the antifungal properties of peppermint and eucalyptus extracts in reducing waste after harvesting Washington Navel. According to the results, the extracts of both plants had a significant effect on reducing the percentage of rot and preventing weight loss compared to the control. Tolly et al. (2007) examined the effect of thyme and ginger oil extracts on rotting caused by the blue mold of orange fruit in the storage and stated that the oil treatments reduced rotting in 24, 48 ,and 72 hours. Noor-Nature APS (2003; 2004) has introduced the product from the seed of tea that increases the yield of tomatoes, cucumbers, and strawberries and has antifungal effects. Ahmad et al. (2020) reported the effect of plant material on enhancing the shelf life of tomato fruit during storage. They concluded that the post-harvest decay reduced in Tandilo and UTC tomato fruits using ethanolic extracts of *P. guajava* and *J. curcas.* Tea (*Camellia* sp.) seed oil has been accepted in some countries that this seed are abundantly available, as an edible oil (Fazel et al., 2008; Sahari et al., 2004). It is a natural product that has some unique bioactive compounds which do not exist in olive oil, such as polyphenol, glycoside, and saponin (Chen & He, 2005). *C.oleifera*, *C. japonica*, and *C. sasanqua* planted to produce edible oils in China and Japan (Sahari et al., 2004).

Iranian tea gardens are about 28,000 hectares. At the end of leaf plucking, in late October and early November, the tea plants begin to flower and produce seeds. On average, each plant produces about 100 grams of seeds. In previous years, seeds were used to produce seedlings. But now, cuttings are used for propagation. Therefore, a large number of seeds are provided in tea gardens that are currently unused. If they can be used, it will help the farmer's income, develop, and better manage the tea garden. The purpose of the present study is introducing a new safe coating method by using tea oil to saving post-harvest quality of *Citrus sinensis* (Moro blood orange).

MATERIALS AND METHODS

Tea seeds used for this study were obtained from the Feshalam Tea Research station, Tea Research Center of Iran. Tea seeds were collected from seed bushes in October 2017 (Yang et al., 2015). The seeds kernels were thoroughly dried to low moisture content, and the oil was extracted using cold press method (Fig. 1). The reason for using the cold press method was that the seeds were not exposed to heat and did not change the oil composition. The seeds contained 15% oil (w /w). A total of 144 blood sweet orange fruits of Moro cultivar, healthy and free of damage, were prepared with an average of 8.93 total soluble solids from a garden in Liserud village, Langrud, Guilan province. To apply the desired treatments, they were divided into six groups (24 fruits per group). This experiment was conducted to study the effect of tea seed oil on the quantitative and qualitative characteristics of blood sweet orange (*Citrus sinensis* cv. Moro) in cold storage, as a completely randomized design with three treatments including control (distilled water), commercial wax (XEDASOL-MX20), and non-diluted tea seed oil (15%W/W), each treatment was repeated three times. The fruits for discarding dust were washed with water and then dried. The fruits were coated with tea seed oil and commercial wax using a brush to prevent the loss of waxes. Each plastic basket contained eight fruits and a total of 24 fruits for each treatment. After treatment, the fruits were stored for 60 days in the cold storage at 8^{o} C and 85% humidity. After 60 days to measure the weight of the fruit skin, three fruits were selected from each treatment and peeled. The skin of each fruit was weighed and recorded separately. During the peeling, all the skin tissue and albedo were removed from the flesh and weighed.Three fruits from each treatment were selected and manually juiced. The juice of the three fruits was weighed separately and recorded. The fruits used to juicing were the same fruits used to measure skin weight. The content of total soluble solids (TSS) in the purified fruit extract was measured with a PAL-1 refractometer. The percentage of titratable acidity in fruits was measured using a calibration method by a 1 N alkaline solution (Cemeroglu, 1992). The total flavonoid content (TFC) of the extracts was measured by the method provided by Khatiwora et al. (2017). The pH difference method was used to measure anthocyanin levels. The total anthocyanin concentration was expressed using the formula in milligrams of cyanidin 3-glucoside per liter (Giusti & worlstad, 2001). Data analysis was performed using SAS.V9.4 software. Duncan's multi-domain test was used to compare means ($p \leq 0.05$).

RESULTS AND DISCUSSION

Initial weight loss

The ANOVA results of the effect of the treatments on the quality characteristics of Moro Blood Orange are shown in Table 1. The results showed that the treatments slowed down the initial weight loss of the Moro Blood Orange. Mean comparison showed that the lowest fruit weight loss with 1.8%was in fruits soaked in commercial wax (XEDASOL-MX20) (Fig. 2). After that, there was tea seed oil treatment, which has a statistically significant difference with control. Our results correspond with the funding obtained by El-Eleryan (2015) that fruit weight loss significantly reduced with the use of green tea and chitosan either alone or in combination as post-harvest application than the control treatment on Washington navel orange. Also, Ahmed et al. (2014) found that foliar applications of green tea extracts (0.1%) in combination with 100 ppm salicylic acid significantly was preferable than using alone in improving Keitte mango fruit quality. Zaki et al. (2017) reported that jasmine oil and green tea (2%) were more able to prevent weight loss on treated Date fruits than untreated fruits (control) recorded the highest weight loss. The weight of the skin in citrus fruits is one of the important characteristics in storage. Over time, the amount of fruit juice decreases, and in fact, most of the weight of the fruit is the weight of the skin of the fruit. Therefore, the less this feature is reduced, the greater the fruit (edible part). According to Turhan (2009) treated fresh fruits with edible coatings by changing atmospheric storage can decreasing quality changes and slowing down quantity losses through alteration and control of the internal atmosphere of the individual. Zhang et al. (2017) concluded that the application of tea seed oil markedly reduced membrane permeability, which might maintain membrane integrity and contribute to the delay of fruit senescence.

Fig. 1. Procedure of tea seed oil extraction: a. Dry and peeled Tea seeds, b. Cold pressing tea seeds, c. Tea seed oil, and d. Tea seed cake after oiling.

Fruit juice weight

The content of fruit juice is one of the most important properties that is reduced in cold storage. Examining this feature during storage can help better manage after harvesting citrus fruits. The results of the analysis of variance showed that the application of different compounds at the statistical level of one percent did not have a significant effect on the amount of orange juice.

Titratable acidity

The results showed that statistically, the use of different compounds had a significant effect on the titratable acidity of oranges. Comparing the averages, it was found that fruits impregnated with commercial wax have the highest acidity, but there is no significant difference with control treatment. The lowest titratable acidity was observed in fruits infused with tea seed oil (Fig. 3). Hamedani et al. (2014), Barzanooni et al. (2014) and Fallico et al. (1996) also reported similar results. Rapisarda et al. (2008), the reason for the decrease in titratable acidity is related to its consumption in respiration and the consumption of organic acids for energy production and alcoholic fermentation during storage.

Table 1. ANOVA table of variants

S.O.V	df	MS					
		Weight loss	Fruit juice	Titratable acidity	Total Soluble Solids	Flavonoid	Anthocyanin
Treat	2	1238.46**	349.64$^{n.s}$	0.022*	1.89*	697.86**	19.11**
Error	6	6.31	152.47	0.004	0.35	12.89	0.69
Total	8						
C.V. (%)		1.49	17.68	1.50	6.13	1.92	19.11

n.s: Not significant, *p<0.05, **p<0.001.

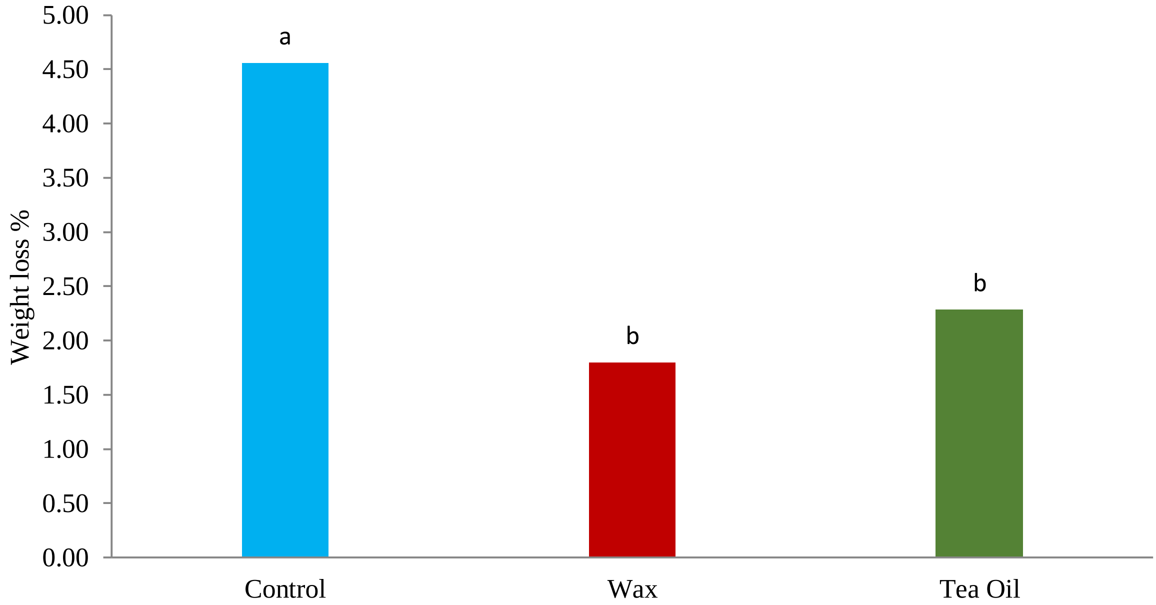

Fig. 2. Effect of treatments on weight loss of Moro Blood Orange (P= 0.01).

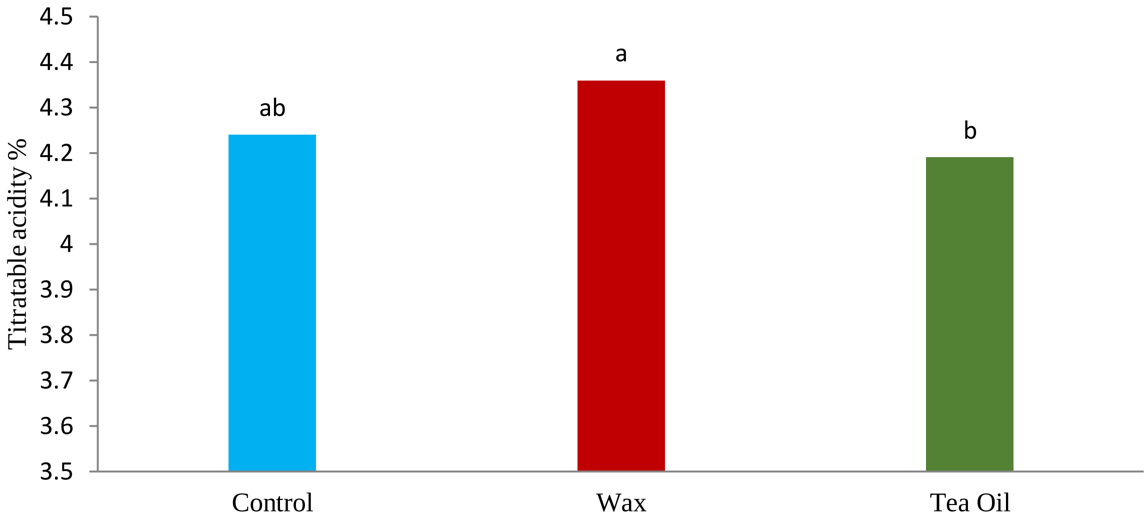

Fig. 3. Effect of treatments on titratable acidityof Moro Blood Orange (P = 0.01).

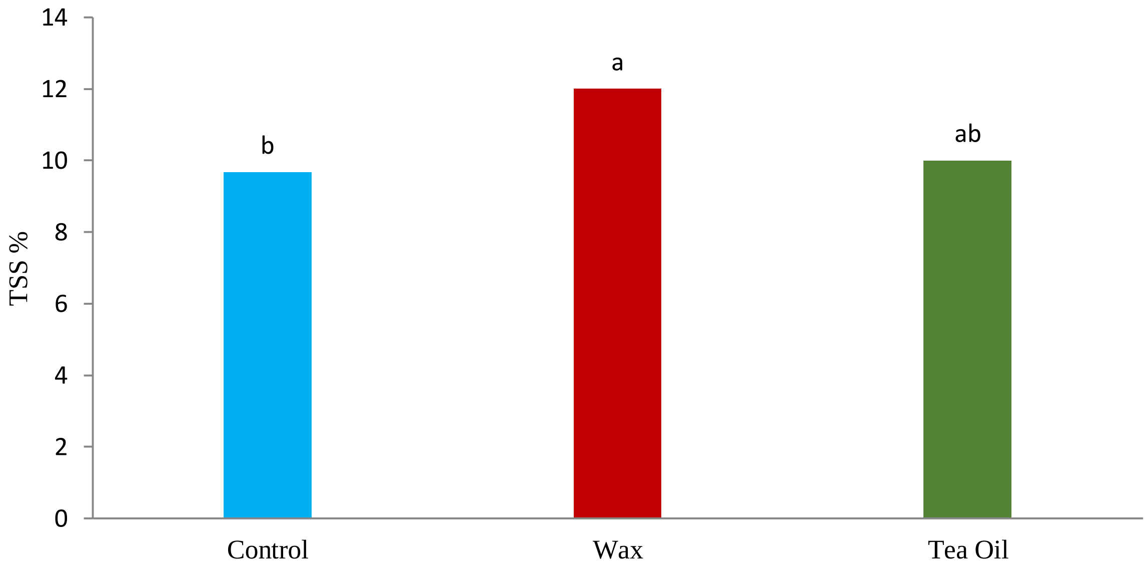

Fig.4. Effect of treatments on the content of total soluble solids of Moro Blood Orange (P = 0.01).

Total soluble solids

The results showed that the application of different compounds had a significant effect on the total soluble solids in oranges. Mean comparison showed that the highest percentage of total soluble solids, with 10.42%, was present in commercial wax-coated fruits (Fig. 4) that do not significantly different from tea seed oil treatment. However, the content of soluble solids increases by about 15% compared to the control treatment. El-Eleryan (2015) reported that Washington navel orange treated with green tea alone, or in combination with jasmine oil, has a higher TSS than other treatments. Chen et al. (2014) showed that tea polyphenols application on litchi fruit markedly alleviated the decreases in the contents of total soluble solids after 30 days of cold storage and the contents of TSS of the fruit treated with tea polyphenols was 13.4% higher than those of the control fruit. Hamedani et al. (2014) reported that by increasing the storage period at 8o C, the content of total soluble solids in blood oranges increases, but they do not differ significantly. Aboutalebi and Janparvar (2010) reported that the effect of peppermint, rosemary, thyme, aloe vera, cumin, and fennel extracts on the fruit flavor of Kinnow tangerine is higher in cold storage than in conventional storage.

Catechins are significant parts of Tea polyphenols (Graham, 1992). ROS scavenging effect of tea polyphenols has much more potent than vitamin E and vitamin C (Zhao et al., 1989). Thus, it had been suggested that reducing lipid peroxidation of pericarp tissues resulted in delayed pericarp browning of litchi fruit during storage of litchi fruit was associated with the intense antioxidant activity of tea polyphenols, (Chen et al., 2014).

The total flavonoids

The results showed that the use of different compounds had a significant effect on the total amount of flavonoids in oranges. Comparing the averages it was found that fruits coated in commercial wax and tea seed oil had the highest amount of flavonoids and was significantly different from the control (Fig. 5). The content of flavonoids is related to the amount of phenol (Scalzo et al., 2004); therefore, storage time and temperature significantly affect the total content of polyphenols (Klimczak et al., 2007). Hamedani et al. (2014) reported that harvest time or commercial fruit ripening time has a more significant effect on the content of flavonoids. The effect of storage time on the content of flavonoids is more affected by the time of fruit harvest. Shoja et al. (2011) reported that flavonoids in Moro and Thomson cultivars increased slightly in the early storage period but decreased in the middle. Flavonoids, as natural compound widely exist in the plants and have some bioactivities properties (Havsteen, 2002). The flavonoids and vitamin E and squalenein tea seed oil, are twice as much as in olive oil (He et al., 2011). Saponins, polyphenols, vitamin E, squalene, and flavonoids are different functional ingredients of Tea seed oil (Lee et al., 2018).Thus, by coating the fruit with tea seed oil, oil could be penetrating the fruit. Therefore, due to the high concentration of flavonoids in the tea seed oil, it is possible to increase or maintain the concentration of flavonoids in the fruit than control.

Concentration of anthocyanins

The application of different compounds had a significant effect on the content of anthocyanins in orange fruit (Fig. 6). Comparing the means it was found that fruits coated in commercial wax and tea seed oil have the highest content of anthocyanins, and there was a significant difference with control. Hamedani et al. (2014) also reported that after 75 days of storage compared to harvest time and before storage, more anthocyanins are synthesized and accumulated. This increase in anthocyanins during storage has been reported by other researchers (Rapisarda et al., 2008). Dela et al. (2003) also reported that the low temperature increased the synthesis of anthocyanins in the fruit. Anthocyanins are a significant sub-group of the flavonoids, with antioxidant activities and responsible for red, purple, and blue color to plant parts (Tsuda, 2012). Also, anthocyanins protected plants from UV-B radiation and invasion from pests and herbivores. In the presence of the catechins, polyphenol oxidase increased the degradation of anthocyanins (Liu et al., 2007). Catechin or anthocyanin, form complex compounds with O-quinone. The oxidation of anthocyanin coupled leads to O-quinone formed regeneration of Catechin partially. The anthocyanin molecule gradually degraded by this coupled oxidation reaction. Polyphenol oxidase inactivation in the green tea processing leads to decreased anthocyanin degradation due to no formation of the reactive Oquinones. Also, between total anthocyanins and total catechins, there was an inverse relationship (Kerio et al., 2012). The major anthocyanins found in the tea plant seem with found in nature (Oh et al., 2008), which is a positive step towards the diversification of tea products and uses of tea.

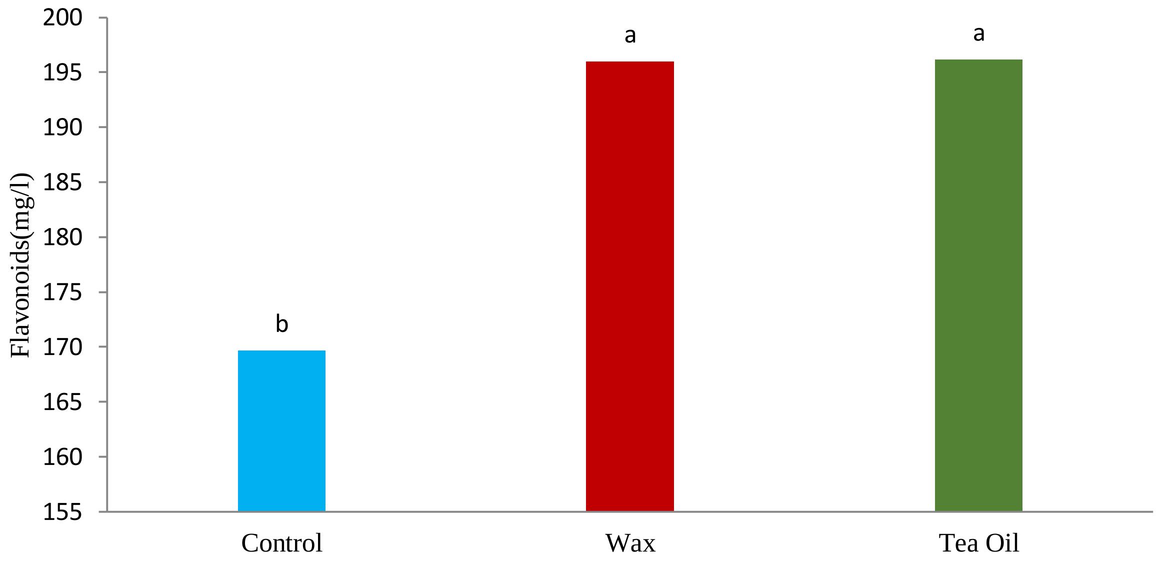

Fig. 5. Effect of treatments on the content of flavonoids Moro Blood Orange (P = 0.01).

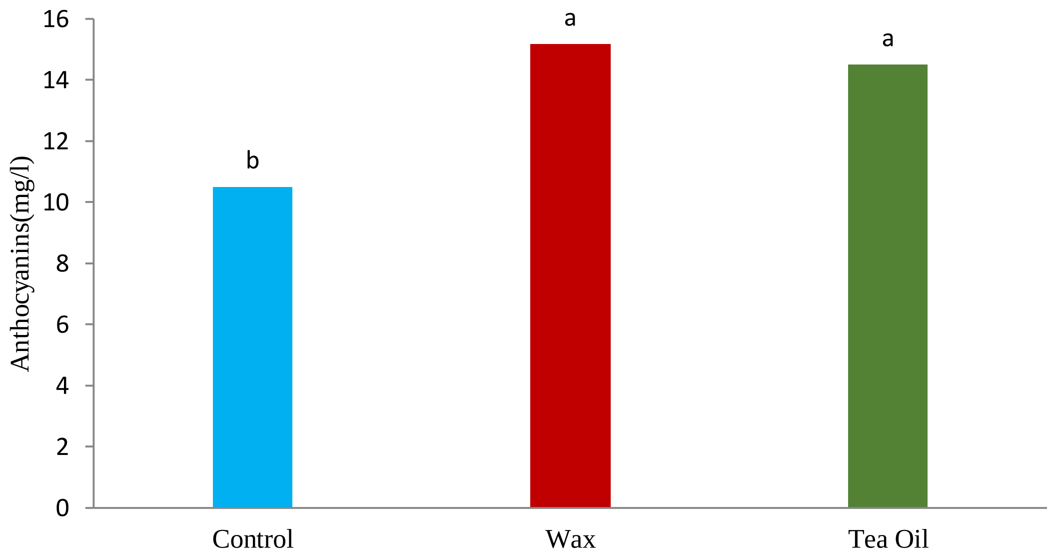

Fig. 6. Effect of treatmentson the content of anthocyanin of Moro Blood Orange (P = 0.01).

CONCLUSION

Based on the results of this study, it can be concluded that the effectiveness of tea seed oil is somewhat equal to commercial wax and have improved and preserved the characteristics of the blood orange of the Moro cultivar during the post-harvest period. Given that tea and citrus fruits are common in Northern provinces, tea seed by-products can be promoted as an alternative to chemical pesticides currently used as fungicides in warehouses.

Acknowledgments
This work was supported by the Zanjan University. We would like to acknowledge Tea Research Center (HSRI, AREEO) and the research team.

Conflict of interest
The authors have no conflict of interest to report.

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