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## **Effect of exogenous postharvest application with thyme and cinnamon oils on quality and storability of cherry tomato**

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**Abstract**---Cherry tomato are classified as perishable fruits that deteriorate vastly after harvest. The use of natural and eco-friendly products, such as essential oils, for preserving the quality of fresh fruits and vegetables is highly demands for the consumers. Thus, the aim of this study was to evaluate the efficiency of exogenous postharvest application with thyme oil (1%), cinnamon oil (1%), and their combination on quality and shelf-life of cherry tomato stored for 28 days at 10°C and 90% RH. The results indicated that both essential oils were able to preserve the quality of cherry tomato by reducing weight loss, decay, appearance, and firmness. Additionally, essential oils application conserved total soluble solids, total carbohydrates, and total phenolic compounds. Lycopene and carotene contents were decreased by essential oils application. In conclusion, the application of both essential oils could be effective in maintain the quality and increase the shelf-life of cherry tomato during refrigerated storage.

**Keywords**---exogenous postharvest application, thyme, cinnamon oils, storability, cherry tomato.

## Introduction

Tomato (*Solanum lycopersicum L.*) is considering one of the most important vegetable crops grown worldwide. due to its economic, process, and health importance. The importance of tomato fruits is related to its considerable levels of antioxidants including lycopene, carotenoids, ascorbic acid, phenolics, and several minerals, which can reduce the development of various types of dangerous human diseases such as prostate, colon, and breast cancers (Ballon-Landa and Parsons, 2018). Tomato is frequently consumed as it represents the predominant source of antioxidants which possess pivotal role in inhibiting oxidative stress, improving vascular function, and preventing cardiovascular disease in humans (Heber and Lu, 2002). Tomato has increased in popularity and has been rapidly expanded into large-scale cultivation during the last half-century. It is today more consumed in the USA and Europe than in the rest of the world. Tomato production has increased worldwide by 164% in 40 years and tomato world consumption has increased by 314% (FAO, 2008). The consumption quantity in the world increased at the average speed of 3% annually (Nicola, 2009). Tomato is considered one of the most important vegetable crops grown in Egypt, which is one of the major tomato producing countries. Egypt's production of tomato in 2018 was 6,779,830 tons, area cultivated was 428,583 feddan, and average production was 16.6 tons/feds (FAOSTATE 2020).

Cherry tomato is a perishable and climacteric fruit with a short shelf-life. Fruits of cherry tomato expose to decay during harvesting, storage, marketing and shipment. The causes of decay during storage and shipment are mainly caused by pathogens such as *Botrytis cinerea*, *Alternaria altermata* and *Rhizopus stolonifer* (Akhtar *et al.*, 1994). Tomato destined for long term storage are generally treated with the fungicides to control postharvest pathogens (Feng *et al.*, 2008). However, the postharvest use of chemicals as fungicides is restricted in most countries (Serrano *et al.*, 2005), particularly those applied after harvest (Feng *et al.*, 2008). In addition, repeated use of certain synthetic fungicides might provide resistance pathogens lines (El-Mogy and Alsanius, 2012).

Postharvest diseases are one of the major factors that affect the quality of horticultural fresh products during storage. Since fruit and vegetables are living organisms, their shelf life is greatly affected by temperature, relative humidity (RH), composition of the atmosphere during and after harvest, and the type and degree of infection by microorganisms or attack by insects (Singh, and Sharma, 2018). Edible coating and resin are natural and volatile compounds, which have a several bioactive compounds, soluble lipids, antibacterial, antiviral, antifungal and insecticides properties in its plant extract. It also, provide effective moisture barrier property and also improve surface appearance (Morillon 2002). It can be used alone or in combination. These natural compounds are generally recognized as safe for environment and human health. In previous research, it was reported that cassia oil, oregano oil, thyme oil, lavender oil, rosemary oil, fennel oil, showed strong inhibitory effect against various post-harvest pathogens in

vitro and in vivo (de Billerbeck et al. 2001; Morillon 2002; Soyulu et al. 2006; Pawar et al. 2006; Fawzi et al. 2009; ).

Cinnamon essential oil (CEO) is an effective antimicrobial agent (Burt, 2004). The effective antimicrobial compound in CEO is cinnamon aldehyde, which is very efficient in reducing viable fungi and bacteria in fruits especially with low pH (3.2–3.6) (Roller and Seedhar, 2002). Treating tomato and strawberry fruits with the vapours of cinnamon oil reduced the fruit decay (Tzortzakis, 2019). Thyme oil, is one of the most important essential oils, is highly active against a broad spectrum of microorganisms. Thymol and carvacrol, are the major phenolic components in thyme oil. The vapour of thyme oil effectively controls grey mold rot (*Botrytis cinerea*) in sweet cherries and brown rot in 'Spring Princess'. Ben Jabeur and Hamada (2014) reported that thym oil controlling gray mold and Fusarium wilt and enhanced the systemic acquired resistance in tomato. To the best of our knowledge, there were no previous work was studied the effect of thyme oil, cinnamon oil, and their combination on shelf-life of cherry tomato. Thus, this study evaluated the efficiency of thyme oil, cinnamon oil, and their combination on physical and chemical parameters of cherry during cold storage at 8°C for 28 days.

## **Materials and Methods**

### **Essential oils preparation**

Cinnamon oil and thyme oil were purchased from El-hawage Co. (ARE). Concentrations of cinnamon oil and thyme oil were made by dissolving the required amounts in 0.5 cm Tween-80, then sterile distilled water was added to obtain 1000 mL of the desired concentration of 1% and 0.5 % from oils.

### **Cherry tomato**

Cherry tomato (*Solanum lycopersicum L*) cv. Festival) were harvested at turning stage of maturity from a private farm at Giza governorate and transferred within 3 hours to the post-harvest laboratory and kept overnight in a cold room. The next morning cherry tomato fruits uniform in size and color, free from defects and molds were chosen and washed under running water and then with distilled water to remove dirt and debris, then left to dray to remove the exceeded water. After that cherry tomato fruits were divided into 4 groups and immersed in the following different solutions for 5 minutes:

1. Cinnamon oil (1%)
2. Thyme oil (1%)
3. Cinnamon oil+ thyme oil (0.5% + 0.5%)
4. Control

After treating with oils, tomato fruits were allowed to dry for 2 h at room temperature. After drying, fruits were packed in polystyrene trays weighed about 200 g of cherry tomato wrapped with stretch film as one replicate. Each tray was individually weighed, labeled and placed in carton box. Each carton box has 4 replicates, and each treatment has 4 carton boxes. All boxes were transferred to

cold rooms at 10°C and 90 % RH. The following measures were taken: weight loss, decay, general appearance, firmness, and TSS. Chemical components (lycopene, carotene, total phenolic, carbohydrates and vitamin C) were also determined every week for 28 days.

#### **Determination of weight loss, appearance, firmness, and total soluble solids**

1. Weight loss percentage was estimated according to the following equation:  
$$\text{Weight loss \%} = \frac{\text{initial fruit weight} - \text{fruit weight at sampling date}}{\text{initial fruit weight}} * 100.$$
2. Decay percentage was estimated as the number of decayed fruits / total count of fruits \* 100.
3. General appearance was determined according to the following score system: 9 = excellent, 7 = good 5 = fair, 3 = poor, and 1 = unacceptable. This scale depends on morphological defects such as shriveling (wilting), color change of fruit surface and the physiological defects. A group of three trained laboratory panelists evaluated the appearance score.
4. The firmness was measured by a digital pressure tester (Force Gauge Model M4-200 MARK; 2 mm diameter flat probe) and values were expressed in Newton (N). To determine total soluble solids (TSS), a digital refractometer (model PR101, Atago [0–45%] Co. Ltd., Tokyo, Japan) was used at room temperature.

#### **Determination of total phenolic compounds, lycopene, carotenoids, and carbohydrates**

Total phenolic compounds (TPC) were calculated by using the Folin–Ciocalteu reagent with some alteration by using gallic acid as a standard curve (Singleton and Rossi, 1965). Briefly, 5 grams of the sample was diluted using 5 mL of methanol (80%). The solution was blended with 2.5 mL of Folin–Ciocalteu (10-fold with distilled water) and added to 2.5 mL of distilled water. Afterwards, 2 mL of aqueous sodium carbonate solution (7.5%, w/v) was added after incubation for 5 min. The final solution was mixed and incubated in the dark at room temperature for 1 h. The absorption was assessed at 765 nm using the spectrophotometer, and the results were expressed as milligrams of gallic acid equivalent (GAE) per 100 mg of fresh fruit weight.

Lycopene and carotenoid contents in fresh fruits were determined as described previously by Abdelgawad et al. (2019). Samples were homogenized and 1 g was mixed with a 10 mL mixture of Acetone-Hexane. The solution was then left to separate into distinct and non-polar layers. Measurement of absorbance at 663, 645, 505, and 453 nm was done by the spectrophotometer (Unico, UV2000, Rochester, NY, USA) was used to measure lycopene and carotenoid content. Total carbohydrates were determined in fresh tomato fruits according to the method in AOAC, (2005).

#### **Statistical Analysis**

The data from the experiment was statistically analyzed using SPSS software (version 14.1). The data were analyzed by one-way analysis of variance (ANOVA)

the treatment means was compared using Duncan's multiple range test at the 0.05 level.

## Results and Discussion

### Weight loss

There was no difference in weight loss between treatments after 7 days of storage (Figure 1). However, after 14 days of storage until the end of storage time, the control treatment showed the highest weight loss, while fruit treated with thyme oil showed lowest weight loss. Weight loss of horticultural products is considering one of the most important factors that affecting the quality and visual appearance as well as economical value (Shehata et al. 2019; Darwish et al. 2021). It has been well known that weight loss increased with increasing storage time due to transpiration, evaporation, and respiration of fruits (El-Mogy et al. 2020). The role of EOs in reducing weight loss during storage might be due to that EOs provide additional layer on the fruits surface that reduce evaporation and transpiration rates (Martínez et al. 2018). Our results are in accordance with Chaemsanit et al. (2018) who found that EOs decrease weight loss of fruits. Also, same results were found by Serrano et al. (2005) in sweet cherries.

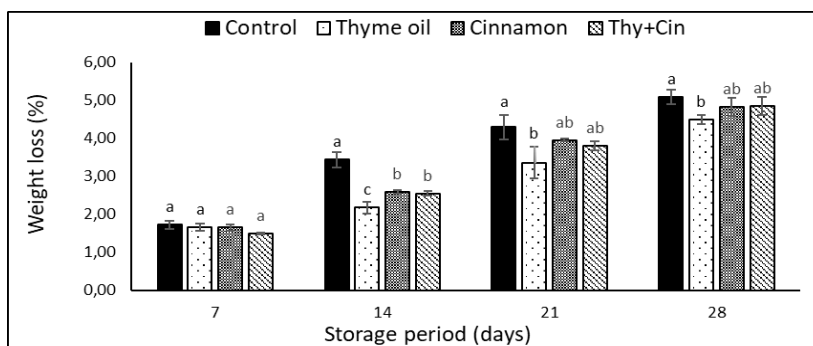


Figure (1): Effect of postharvest treatments on weight loss of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Appearance

Appearance of fresh fruits and vegetables is the main quality parameter for consumers. The high appearance score is related to the freshness and diseases free while low appearance scale is mainly linked to shriveling and spread of diseases (Maryam et al. 2022). The appearance score rating of cherry tomato displayed a slow decline after 21 days of storage until the end of the storage period (Figure 2). However, the thyme recorded the highest score of appearance followed the cinnamon oil treatment and the mixture between thymol oil + cinnamon oil treatments, respectively. The control fruits recorded the lowest score of appearance at the end of storage. In this study, both EOs maintain the appearance. In agreement with our study, previous works reported the benefits

effects of EOs for maintain appearance of fruits such as strawberry (Shao et al., 2013) and mangosteen (Owolabi et al., 2021).

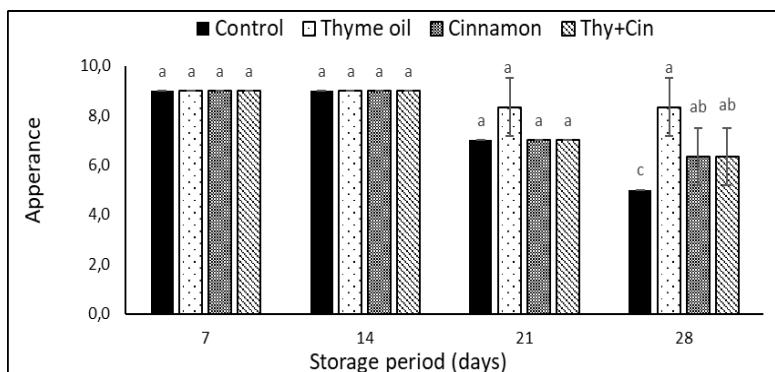


Figure (2): Effect of postharvest treatments on appearance of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Decay

There were no signs of decay in cherry tomato fruits after 7 and 14 days of storage (Figure 3). However, after 21 days of storage until the end, the control treatment showed the highest decay percent. The lowest decay percent was observed in thyme oil treatment followed by cinnamon and thyme + cinnamon. Many previous works indicated the role of antimicrobial compounds for reducing fruit spoilage that found in EOs (Aloui et al. 2016; Torres-Alvarez et al. 2017; Kizil et al. 2010). For example, cinnamon, oregano, cassia, and mandarin EOs application reduced the microbial growth in guava (Etemadipoor et al. 2019), cherry tomato (Barreto et al. 2016), strawberry (El-Mogy and Alsanius 2012), and dates (Aloui et al. 2014). Additionally, application of EOs reducing weight loss and maintain high CO<sub>2</sub> surrounding the fruit surface that suppressed the growth of microbes (Shehata et al. 2020).

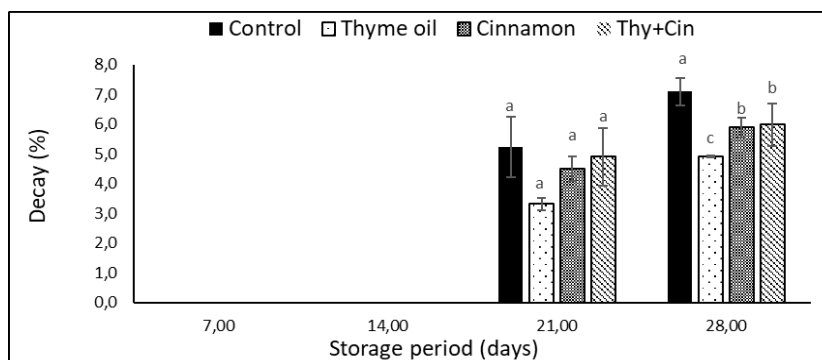


Figure (3): Effect of postharvest treatments on decay of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Total soluble solids (TSS)

As shown in Figure 4, an increase in the TSS of cherry tomato was observed from beginning of storage until 21 days for all treatments and then decreased. After 21 and 28 days of storage, control treatment showed the lowest TSS values compared to other treatments. Thyme oil application was the superior treatment for conserving TSS during cold storage. The increasing of TSS during the first 3 periods of storage might be due to water loss from fruits that increase TSS concentration (Badawy et al., 2016). However, the decrease of TSS at the end of storage could be due to the use of TSS in respiration processes (Shehata et al., 2020). The role of EOs for conserving TSS during cold storage could be explained by its role for reducing respiration process (Aloui et al. 2016).

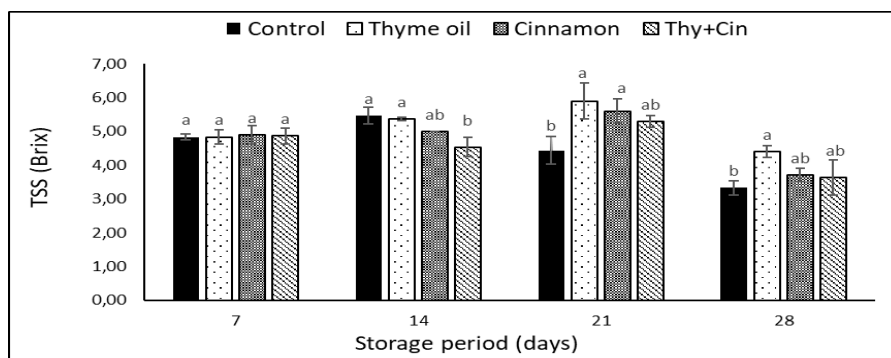


Figure (4): Effect of postharvest treatments on TSS of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Firmness

Firmness of the cherry tomato fruits decreased from 7 to 14 days of cold storage both in treated and control samples then increased (Figure 5). The decrease of firmness during storage might be due to the degradation of cell wall by hydrolysis enzymes, water loss, and respiration process (Chaemsanit et al., 2018). On the other hand, the increasing of firmness at the end of storage could be related to the water loss which causes leathery of fruit skin. There was no significant difference between treatments during all storage periods. These results are in agreement with Locali-Pereira et al. (2021) who did not find any difference between treated and untreated tomato fruits with EOs. The same result was also recorded by Buendía-Moreno et al. (2019).

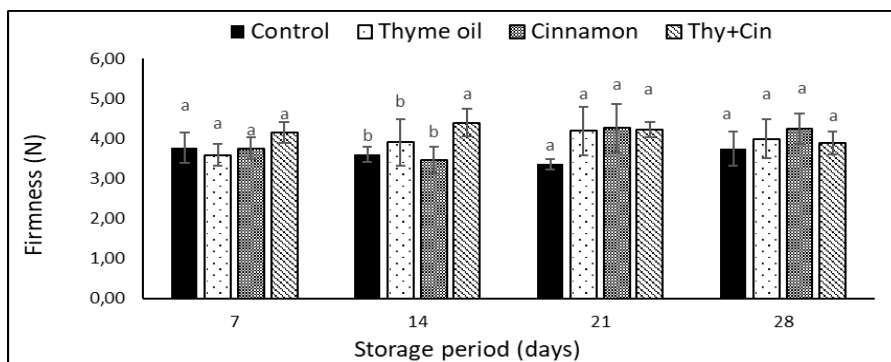


Figure (5): Effect of postharvest treatments on firmness of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Lycopene content

The red color of tomato is mainly linked with lycopene (Liu et al. 2022). Lycopene content was increased during the storage until 21 days and then decreased (Figure 6). Also, Fagundes et al. (2015) recorded the increasing of lycopene content in cherry tomato during cold storage. Thyme oil treatment showed the lowest lycopene content values in fruits during the storage time. At the end of storage period, the control treatment showed the highest lycopene content followed by cinnamon and thyme + cinnamon treatments without difference between them. Tomato classified as climacteric fruits which ripening after harvest which enhances lycopene biosynthesis. Treated fruits with EOs reducing ripening resulted in lower lycopene biosynthesis. This result is similar to results reported by Tzortzakis et al. (2019) who found that thyme oil application reduced lycopene biosynthesis in tomato fruits compared to untreated fruits. Also, Locali-Pereira et al. (2021) found a decrease in lycopene content in cherry tomato which treated with pink pepper essential oils during cold storage.

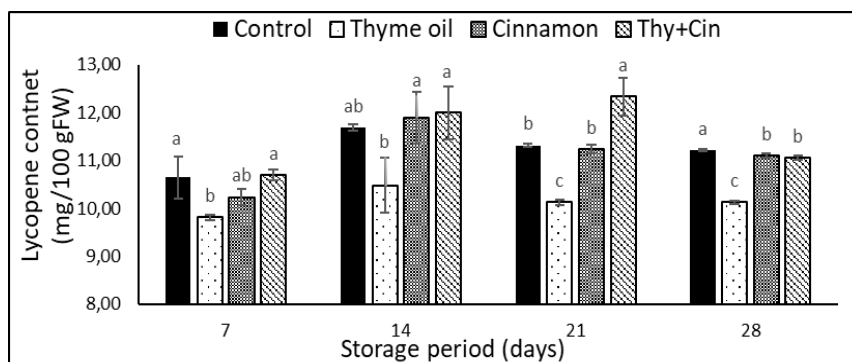


Figure (6): Effect of postharvest treatments on lycopene content of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.



## Carotene content

Carotene content in tomato fruits decreased with increasing storage time (Figure 7). The same findings were obtained by Santoro et al. (2018). The reduction in carotene content could be due to the oxidation, respiration, and senescence processes during storage. Thyme + cinnamon treatment showed the lowest values of carotene during all storage periods. Also, cinnamon and thyme treatments showed the highest carotene content after 14 and 21 days of storage compared with the control. Our results are in agreement with Tzortzakakis et al. (2019) who found that carotene content in tomato fruits was decreased by EO treatment. Previous study carried out by Santoro et al. (2018) found that postharvest application with thyme oil didn't affect the content of carotene content in peaches and nectarine.

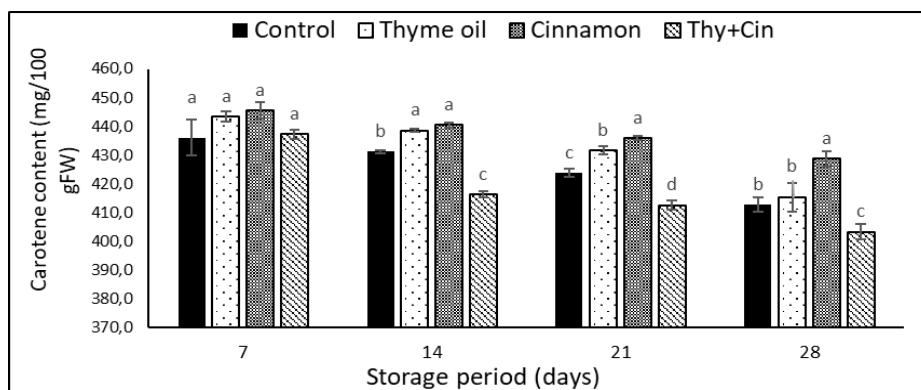


Figure (7): Effect of postharvest treatments on carotene content of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

## Total carbohydrates

Total carbohydrates in cherry tomato were decreased by increasing storage periods (Figure 8). The decreasing of carbohydrates during storage might be due to use it in respiration (Locali-Pereira et al. 2021). After 7 days of storage, thyme + cinnamon treatment showed the lowest values of total carbohydrates. Thyme treatment resulted in higher total carbohydrates compared to other treatments after 14 and 21 days. No significant difference was found between treatments at the end of storage. Our results agreed with the findings of Aminifard and Mohammadi (2013) who found that total carbohydrates in sweet cherries were conserved by three EOs.

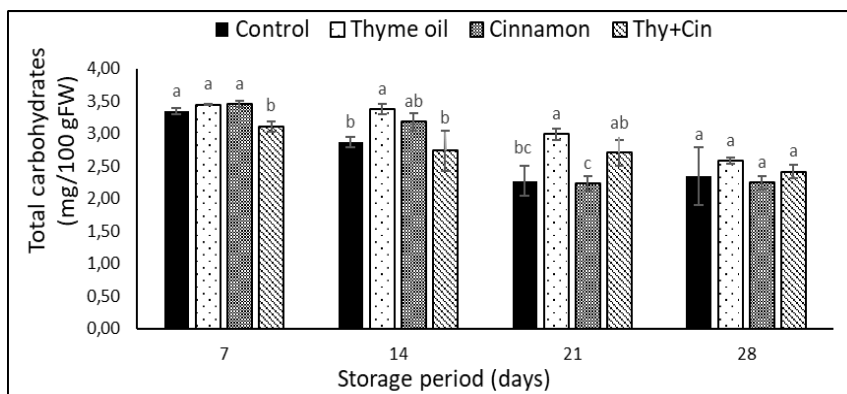


Figure (8): Effect of postharvest treatments on total carbohydrates of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

### Total phenolic compounds

The change in total phenolic compounds over storage periods was not observed (Figure 9). Also, Tzortzakis et al. (2019) reported that EOs treatment had no effect of phenolics of tomato until 14 days of the cold storage. Cinnamon treatment significantly conserved total phenolic compounds during the whole storage time compared to other treatments and the control until 21 days of storage while thyme oil had no effect. At the end of storage, thyme + cinnamon treatments showed the highest phenolic compounds. Similar results were obtained by Chrysargyris et al. (2021) who found that EOs had no or little effect on phenolic compounds in tomato during storage.

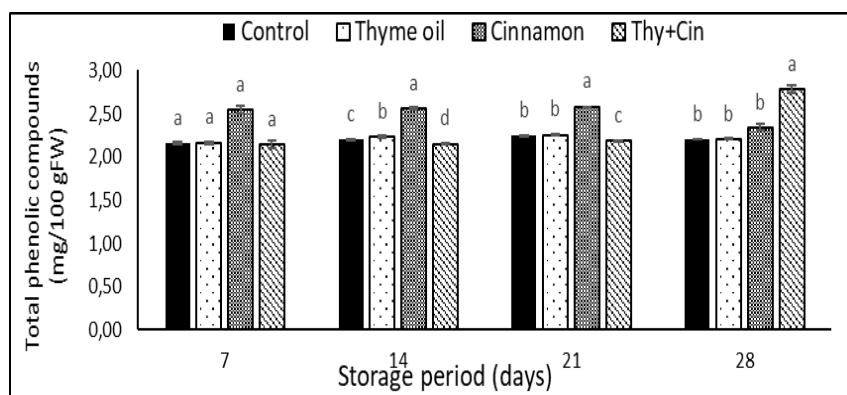


Figure (9): Effect of postharvest treatments on total phenolic compounds of cherry tomato stored for 28 days at 12° C. Different letters indicate significant differences ( $p < 0.05$ ) using the Tukey test at every storage point. Data are means of three replicates and vertical bars indicate standard error.

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