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Influence of Chitosan and Some Plant Extracts as Postharvest Treatment on Quality and Storability of Cherry Tomatoes

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ABSTRACT

This study was carried out on cherry tomatoes cv. Katalina-522 during 2024 and 2025 seasons in Lab. of Vegetable Postharvest Research Dep., HRI, ARC, Giza, Egypt to study the impact of dipping fruits for 5 min. in olive leaves extract at 1%, rosemary extract at 1%, lemon grass extract at 1%, solution of chitosan at 1%, olive leaves extract at 1% then chitosan at 1%, rosemary extract at 1% then chitosan at 1%, lemon grass extract at 1% then chitosan at 1% in addition to untreated control (dipping in distilled water) on quality attributes and storability during storage at 10ºC and 90-95 % RH for 35 days. The results showed that cherry tomato fruits coated with post-harvest treatments were effective in decreasing weight loss, loss of firmness, color change and modifying the atmosphere inside the package, as well as preserving ascorbic acid, total phenolic content, antioxidant activity and the overall appearance of fruits during storage as comparison with untreated control. Fruits treated with rosemary extract plus chitosan, olive leaves extract plus chitosan and lemon grass extract plus chitosan treatments didn't show noticeable decay till the end of storage. Furthermore, rosemary extract plus chitosan was the most effective treatment in maintaining all the quality attributes and gave an excellent appearance of fruits for 35 days at 10ºC, while olive leaves extract plus chitosan and lemon grass extract plus chitosan gave a good general appearance at the same period. The composition of gases inside the package treated with rosemary extract plus chitosan treatment had high O_2 % and low CO_2 % and lower accumulation of ethylene hence the process of ripening can be slowed dramatically prolong the storage life of fruits.

KEYWORDS: cherry tomatoes, rosemary extract, olive leaves extract, lemon grass extract, chitosan, storability.

1. INTRODUCTION

Cherry tomato (*Lycopersicon esculentum* Mill. var. cerasiforme Dunal) is a climacteric variety (various shapes and colors) (Gudeva and Dedejski, 2012). An important nutritional source for humans diet (minerals, vitamins and antioxidants). Cherry tomatoes are eaten fresh but have a short shelf life, easily damaged and susceptible to fungal and bacterial diseases, quality degradation and rapid fruit ripening and senescence (Nitin et al., 2020). Ripening is accompanied by a beak in respiration and a

concomitant sharp increase in ethylene production which negatively affects attributes of quality such as firmness, color, soluble solid content and other changes in sensory quality (Gharezi et al., 2012).

Therefore, it is very necessary to use modern techniques that are effective in delaying ripening, maintaining quality and extending shelf life of cherry tomatoes in conjunction with low temperatures.

Recently, edible coatings have several roles, including delaying physiological processes (transpiration and respiration), and preserving the texture and flavour of the fruit, thus maintaining quality and extending shelf life (Ali et al., 2011). Generally, these films consist of a layer of polysaccharides (chitosan, alginate, lipids and proteins) and are used to protect the entire fruit and are used commercially (Chen et al., 2016).

The chitosan coating improves the shelf life of many perishable fruits, such as artichokes, strawberries, and tomatoes (Hernández-Muñoz et al., 2006; Atala et al., 2019 and Shehata et al., 2021). Chitosan has also been helpful in delaying tomato ripening (Sucharitha et al., 2018) and reduced decay percentage and hence prolong the fruit life (Shehata et al., 2021).

Olive leaves (*Olea europaea* L.) are considered waste during the extraction process of olive oil (Hassan et al., 2022). The aqueous extract of the leaves is rich in phenolic substances, which are considered an important antioxidant and potent antimicrobial activities against bacteria, fungi and mycoplasma (Abd-Alla et al., 2013 and Sabry, 2014).

The edible coating contains broad spectrum natural extracts that extend the shelf life of vegetables. Zam (2019) found that Olive leaf extract and chitosan or alginate coating have positive effects on the properties (physicochemical) of sweet cherries. It has been proven to delay the ripening process, maintain the highest levels of phenolic compounds and antioxidants, prevent the growth of bacteria and fungi, maintain the quality characteristics and prolong the shelf life of sweet cherries.

Rosemary leaves contain many antioxidants, due to the presence of rosmarinic, carnosol, carnosic and caffeic acids (Hras et al., 2000).

Rosemary also has antibacterial and antifungal properties, which play an important role in reducing post-harvest losses and enhancing the shelf life of fruits (Rasooli et al., 2008).

Mahmoud et al. (2017) revealed that dipping Navel orange fruits in rosemary aqueous extract at 4% preserve fruit quality (decreasing weight loss, delayed decay and delayed the juice changes, T.S.S., acidity, content of carotenes and vitamin C) during storage, it extends the post-harvest life during marketing, and it is also safe for the environment and human health.

Extracted lemon grass leaves have been found to have several activities against fungal and bacteria (antimicrobial and antifungal) for several plant pathogens (Hyun et al., 2015) and reduced the incidence diseases (Abirami, 2009).

Application of lemon grass extract after postharvest significantly affected the characteristics of Persimmon quality and maintained the pH, weight, firmness, acidity, vit. C, and T.S.S.-acid ratio during storage (Haseeb et al., 2021). It also maintains the quality characteristics of Chinese lemon fruits and maintains the maximum chemical and physical properties (Samad et al., 2019).

Omoba and Onyekwere (2016) indicated that the treatment of chitosan at 1% combined with lemon grass extract at 1% as an edible coating significantly reduced decay, weight loss, maintaining the firmness and TA and maintains the maximum chemical and physical properties of cucumber fruits during storage.

The target of this investigation was examining the effect of chitosan and three aqueous plants extracts; olive leaves, rosemary and lemon grass on attributes of quality of cherry tomatoes during cold storage.

2. MATERIALS AND METHODS

Cherry tomatoes (*Solanum lycopersicum* var. cerasiforme) cv. Katalina-522 were harvested at the pink stage (red color covering between 50 to 60% of the fruit surface) on 4th and 9th of January in 2024 and 2025 seasons, respectively, from a private Farm in Wadi El-Natrun District, Beheira Governorate and then the fruits were brought to the Lab. of Vegetable Postharvest Research Dep., HRI, ARC, Giza, Egypt. Fruits

free from any visual damage or defects and uniform in size (20-25 mm in diameter) and color were selected.

2.1. Preparation of plant extracts:

An aqueous extract of Olive leaves (*Olea europaea* L.), Rosemary (Rosmarinus officinalis) and Lemon grass (Cymbopogon citratus), each plant part was thoroughly washed with distilled water, cleaned and chopped into pieces and air dried. The dried pieces were finely ground using a domestic grinder and sieved to afford uniform size powdered material .The extracts were obtained by maceration method. Thus the powdered plant material (150g) was soaked in distilled water (500 mL) and allowed to stand for 24 h. The mixtures were filtered and the solvents removed using rotary evaporator at 40°C to afford thirty six aqueous extracts (Hassan et al., 2020).

Determination of the antioxidant activity with DPPH by Brand-Williams et al. (1995). Identification of phenolic by High Performance Liquid Chromatography (HPLC) according to Fernández de Simón et al. (1990).

Table 1. The leaf extract composition of olive, rosemary and lemon grass (mg/100g).

Phenolic compound	Rosemary extract	Lemon grass extract	Olive extract
Pyrogallol	219.47	56.45	18.35
Gallic acid	7.84	35.17	1.54
Protocatchoic acid	20.97	5.18	2.78
Rosmarinic acid	533.70	----	----
Catechein	14.39	94.23	19.60
Chlorogenic acid	19.93	22.62	54.27
Salycilic acid	5.57	33.20	----
Catechol	73.42	60.56	10.31
Caffeic acid	18.83	17.54	1.82
Vanillic acid	0.532	43.32	5.57
Caffeine	7.43	5.18	1.55
p-coumaric	34.60	5.50	3.65
Ferulic	233.50	4.93	0.89
Iso-ferulic	6.27	1.10	11.90
Coumarin	13.42	1.40	4.92
3,4,5-methoxy-cinnamic	5.62	15.33	2.33

Cherry tomato fruits were dipped for 5 min. in olive leaves extract at 1%, rosemary extract at 1%, lemon grass extract at 1%, solution of chitosan at 1%, olive leaves extract at 1% then chitosan at 1%, rosemary extract at 1% then chitosan at 1%, lemon grass extract at 1% then chitosan at 1% and control (dipping 5 min. in distilled water). All the treatments were packed in transparent plastic punnets which contains 250 g of fruits after air dried. Every 3 punnets were sealed with polypropylene film (30 µm thickness, 15 × 25 cm size) represented as one replicate. Fifteen replicates were prepared for each treatment and stored at 10ºC and 90-95% RH for 35 days. All samples were arranged in a complete randomized design. Three replicates from each treatment were taken at random and examined immediately after harvest and after 7, 14, 21, 28 and 35 days of cold storage at 10ºC and 90-95% RH to determine the following properties:

1. Weight loss (%): It was calculated according to the equation = [(Wi –Ws)/ Wi] x100. Where, Wi = fruit weight at initial period, Ws = fruit weight at sampling period.

2. Decay percentage: Decayed fruits were counted and recorded by visual examination (decayed fruits included all the injured or spoiled, resulting from microorganisms infections) percentage of decay was calculated in relation to the total initial weight of stored fruits (Cheour et al., 1990).

Decayed fruits % = (A / B)* 100 Where: A = weight of decayed fruits at time of sampling, B = weight of the initial.

3. General appearance was measured using a scale from 9 to 1, with 9 = excellent, 7 = good, 5 = fair, 3 = poor and 1 = unsalable; fruits rated 5 or lower were considered unmarketable, according to Kader et al. (2002).
4. External surface color was evaluated by using a Minolta CR-400 Chroma Meter (Minolta Co., Ltd., Osaka, Japan) to measure the L* describes lightness (L*=0 for black, L*=100 for white) according to McGuire (1992).
5. Fruit firmness was determined by a hand pressure tester (Italian model) with an 8 mm plunger expressed in kg/cm^2 (Abbott, 1999).
6. Ascorbic acid content (mg/100g fresh weight) was determined by titration method using 2,6 dichloro-phenol-indo-phenol the dye as described in AOAC (1990).
7. Lycopene content: The lycopene content was measured as method as Ito and Horie (2009). This method contains of two main steps, extraction of juiced tomato to get lycopene extract and standard, then measured the absorbance value of the solution at 505 nm (U-1900 spectrophotometer, Hitachi, Japan), and absorbance value used to get the lycopene content of the samples and calculated lycopene content using equation: lycopene content = 10× absorbance value ÷ 0.315 × sample value (g).
8. Total phenolic content (mg/100g fresh weight) was measured by the Folin-Ciocalteu method, according to Singleton et al. (1999).
9. Antioxidant activity (%) was measured by determining of the free radical scavenging activity evaluated by 2.2-diphenyl-1-picrylhydrazyl (DPPH), according to Sánchez-Moreno et al. (2003).
10. Gas composition in packages: Gas composition inside the packages was measured using F-950 Handheld Ethylene Analyzer that measures 3 critical gases: Ethylene, CO_2 and O_2 to maintain optimum produce quality at every phase of handling during storage.

2.2. Statistical analysis

Using MSTATC software, statistical analysis of the data was performed to calculate the means, variance and standard error. The LSD value at the 5% level was calculated to estimate mean separations (Snedecor and Cochran, 1980).

3. RESULTS AND DISCUSSION

3.1. Weight loss percentage:

Results in Table (2) cleared that the weight loss percentage of cherry tomatoes has been raised with extending storage time. These results concur with Saad et al. (2023) this is due to respiration processes, moisture transfer from the surface of the fruit, and some other oxidation processes (Zhu et al., 2008).

However, all postharvest treatments maintained their weight in comparison to the control. After 35 days of storage at 10ºC, rosemary extract plus chitosan significantly reduced weight loss percentage, followed by olive leaves extract plus chitosan and lemon grass extract plus chitosan treatments with significant differences between them in the two seasons. The highest value was noticed with control, and these concur with Bina et al. (2016); Omoba and Onyekwere (2016); Zam (2019); Haseeb et al. (2021) and Shehata et al. (2021) and may be due to olive leaves, rosemary, lemon grass extracts and chitosan controlling of decay and reducing its damage through several biological activities, where a thin layer surrounds the fruits and creates a modification in the air around the fruits, which reduces the rates of fruit respiration, reduces transpiration and oxidation reaction rates through stomata, reduces other metabolic activities, and thus reduces the rate of weight loss (Omoba and Onyekwere, 2016; Mahmoud et al., 2017; Talei et al., 2017 and Lin et al., 2020).

3.2.Fruit decay percentage:

Data in Table (3) indicate that decay percentage of cherry tomatoes increased with the prolongation of storage periods. These results agree with Abdullah and Ibrahim (2018) on cherry tomatoes, which could be because of various successive biochemical and chemical

Table 2. Effect of chitosan and some plant extracts as postharvest treatment on weight loss percentage of cherry tomato during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)

	7	14	21	28	35	Mean
			2024 season			
Lemon grass extract	0.16 s-u	0.25 pq	0.42 mn	0.51 kl	0.78 g	0.43 C
Rosemary extract	0.11 vw	0.16 s-u	0.35 o	0.41 n	0.62 i	0.33 E
Olive leaves extract	0.13 t-w	0.21 qr	0.39 no	0.49 l	0.71 h	0.39 D
Chitosan	0.19 rs	0.29 p	0.47 lm	0.60 ij	0.84 f	0.48 B
Lemon grass extract + chitosan	0.09 wx	0.14 s-v	0.28 p	0.34 o	0.55 jk	0.28 F
Olive leaves extract + chitosan	0.08 wx	0.11 u-w	0.23 qr	0.26 pq	0.43 mn	0.22 G
Rosemary extract + chitosan	0.04 x	0.09 wx	0.18 r-t	0.22 qr	0.34 o	0.18 H
Control	1.14 e	1.67 d	2.06 c	3.24 b	4.02 a	2.43 A
Mean	0.24 E	0.37 D	0.55 C	0.76 B	1.04 A	
			2025 season			
Lemon grass extract	0.13 v-y	0.23 st	0.40 m-o	0.50 jk	0.75 fg	0.40 C
Rosemary extract	0.09 w-z	0.15 u-x	0.34 n-q	0.39 m-o	0.61 h	0.32 D
Olive leaves extract	0.12 w-y	0.20 t-v	0.38 n-p	0.48 j-l	0.69 g	0.37 C
Chitosan	0.15 u-x	0.26 r-t	0.45 k-m	0.58 hi	0.82 f	0.45 B
Lemon grass extract + chitosan	0.08 x-z	0.13 v-y	0.27 q-s	0.32 p-r	0.53 ij	0.27 E
Olive leaves extract + chitosan	0.06 yz	0.10 w-z	0.22 s-u	0.25 r-t	0.41 l-n	0.21 F
Rosemary extract + chitosan	0.03 z	0.08 yz	0.16 u-w	0.20 s-u	0.33 o-q	0.16 G
Control	1.08 e	1.60 d	2.02 c	3.22 b	3.99 a	2.38 A
Mean	0.22 E	0.34 D	0.53 C	0.74 B	1.02 A	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

changes, like the transformation of complex compounds into simple compounds that may be susceptible to infection by various fungi (Wills et al., 1989).

All treatments reduced the percentage of decay and thus extended the storage time in comparison to the control treatment. However, rosemary extract plus chitosan, olive leaves extract plus chitosan and lemon grass extract plus chitosan treatments didn't show any decay. However, decay began in the control fruits after 14 days of cold storage, then it increased till the end of storage in both seasons, and it concurs with Bina et al. (2016) and Haseeb et al. (2021).

This decreasing in decay percentages of treated fruits with rosemary, olive leaves, lemon grass extracts possible due to increase defense by treatments on surface and its effect on delaying infection with pathogens is a result of the main components in the extracts e.g. carnosol, carnosic acid, rosmarinic acid and phenolic diterpenoids in rosemary extract (Ibrahim and Ebady, 2014), There are also phenolic compounds in olive leaves extract, which are: verbascoside, caffeic acid, luteolin 7-O-glucoside, oleuropein, rutin, luteolin 40-O-glucoside and apigenin 7-O-glucoside (Hendel et al., 2016) and there are also some compounds in Lemon grass extract i.e. saponins, flavonoids,

Table 3. Effect of chitosan and some plant extracts as postharvest treatment on decay (%) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)

	0	7	14	21	28	35	Mean
				2024 season			
Lemon grass extract	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	15.52 e	2.59 C
Rosemary extract	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	10.87 g	1.81 E
Olive leaves extract	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	12.74 f	2.12 D
Chitosan	0.00 h	0.00 h	0.00 h	0.00 h	13.25 f	22.18 d	5.91 B
Lemon grass extract + chitosan	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 F
Olive leaves extract + chitosan	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 F
Rosemary extract + chitosan	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 h	0.00 F
Control	0.00 h	0.00 h	15.29 e	31.62 c	33.48 b	36.73 a	19.52 A
Mean	0.00 E	0.00 E	1.91 D	3.95 C	5.84 B	12.26 A	
				2025 season			
Lemon grass extract	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	14.89 e	2.48 C
Rosemary extract	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	10.62 h	1.77 E
Olive leaves extract	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	12.16 g	2.03 D
Chitosan	0.00 i	0.00 i	0.00 i	0.00 i	12.77 f	21.53 d	5.72 B
Lemon grass extract + chitosan	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 F
Olive leaves extract + chitosan	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 F
Rosemary extract + chitosan	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 i	0.00 F
Control	0.00 i	0.00 i	14.62 e	30.75 c	32.91 b	36.06 a	19.06 A
Mean	0.00 E	0.00 E	1.83 D	3.84 C	5.71 B	11.91 A	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

alkanoids, anthraquinones, tannins, steroids and phenols (Asaolu et al., 2009). The different extracts tested in the present study contain phenol compounds that have a great antifungal activity and they can affect the enzymes responsible for the germination of fungal spores and are also recognized as biologically active components (Tabassum and Vidyasagar, 2013; Abd-El Wahab, 2015). Besides, the positive effects of treatment with chitosan on prevent post-harvest diseases and reduce decay percentages (Ahmed et al., 2016).

Data in Table (4) indicate that there was a significant decrease in the general appearance of cherry tomato fruits with the extension of the storage time, and these are in agreement with Saad et al. (2023) on cherry tomatoes and could be because of shriveling, decay, wilting, deterioration and color change (Zeng et al., 2020). However, cherry tomato fruits treated with all treatments had a significantly higher general appearance score. After 35 days of storage at 10ºC, rosemary extract in addition to the chitosan treatment showed the best overall appearance and did not show any changes and

3.3.General appearance:

Table 4. Effect of chitosan and some plant extracts as postharvest treatment on general appearance (score) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
2024 season							
Lemon grass extract	9.00 a	9.00 a	7.67 bc	7.00 cd	5.67 ef	5.00 fg	7.22 DE
Rosemary extract	9.00 a	9.00 a	9.00 a	7.67 bc	7.00 cd	6.33 de	8.00 C
Olive leaves extract	9.00 a	9.00 a	8.33 ab	7.00 cd	6.33 de	5.67 ef	7.56 D
Chitosan	9.00 a	9.00 a	7.67 bc	7.00 cd	5.00 fg	4.33 gh	7.00 E
Lemon grass extract + chitosan	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 bc	7.00 cd	8.33 BC
Olive leaves extract + chitosan	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 bc	8.67 AB
Rosemary extract + chitosan	9.00 a	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab	8.89 A
Control	9.00 a	7.00 cd	5.00 fg	3.67 hi	3.00 i	1.67 j	4.89 F
Mean	9.00 A	8.75 A	8.08 B	7.33 C	6.50 D	5.75 E	
2025 season							
Lemon grass extract	9.00 a	9.00 a	7.67 bc	7.00 cd	5.67 ef	5.00 fg	7.22 DE
Rosemary extract	9.00 a	9.00 a	9.00 a	7.67 bc	7.00 cd	6.33 de	8.00 C
Olive leaves extract	9.00 a	9.00 a	8.33 ab	7.00 cd	6.33 de	5.67 ef	7.56 D
Chitosan	9.00 a	9.00 a	7.67 bc	7.00 cd	5.00 fg	4.33 gh	7.00 E
Lemon grass extract + chitosan	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 bc	7.00 cd	8.33 BC
Olive leaves extract + chitosan	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab	7.67 bc	8.67 AB
Rosemary extract + chitosan	9.00 a	9.00 a	9.00 a	9.00 a	9.00 a	8.33 ab	8.89 A
Control	9.00 a	7.00 cd	5.00 fg	3.67 hi	3.00 i	1.67 j	4.89 F
Mean	9.00 A	8.75 A	8.08 B	7.33 C	6.50 D	5.75 E	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

gave an excellent appearance. While olive leaves extract plus chitosan and lemon grass extract plus chitosan treatments rated good appearance. On another side, the untreated fruits had an unsalable appearance at the same time in both seasons, and these concur with Karakasov et al. (2012) and Shehata et al. (2021). Previous studies have shown that chitosan enhances the overall appearance and visual quality of tomatoes, which aligns with our results and may be due to the beneficial impacts of chitosan in maintaining the fruits appearance throughout storage due to reduced lycopene degradation (Kibar and Sabir, 2018), delays the ripening of the fruits and prevents the growth and evolution of unwanted microbes (Velickova et al., 2013).

Zam, (2019) found that the ripening process in sweet cherries is slightly delayed when a special coating of chitosan with olive leaf extract is added.

3.4.Color (L* value):

The lightness of tomato fruits (L* value) is considered the most important color factor that is greatly affected during storage (Shehata et al., 2021).

Data in Table (5) indicate that there was a significant decrease in L* value with raising the

Table 5. Effect of chitosan and some plant extracts as postharvest treatment on color (L* value) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)

	0	7	14	21	28	35	Mean
				2024 season			
Lemon grass extract	49.29 a	48.31 b-e	46.14 i-k	45.12 l-n	43.52 p	40.89 r	45.55 F
Rosemary extract	49.29 a	48.76 a-c	47.26 f-h	46.14 i-k	45.13 l-n	42.43 q	46.50 D
Olive leaves extract	49.29 a	48.62 a-d	46.83 g-i	45.57 k-m	44.41 n-p	41.86 q	46.10 E
Chitosan	49.29 a	48.27 b-e	45.81 j-l	44.55 no	42.54 q	39.56 s	45.00 G
Lemon grass extract + chitosan	49.29 a	48.87 a-c	47.79 d-f	46.65 g-j	45.62 k-m	43.97 op	47.03 C
Olive leaves extract + chitosan	49.29 a	49.05 ab	48.01 c-f	47.46 e-g	46.74 g-j	45.02 l-n	47.59 B
Rosemary extract + chitosan	49.29 a	49.12 ab	48.69 a-d	48.38 a-e	47.51 e-g	46.49 h-k	48.25 A
Control	49.29 a	47.97 c-f	44.78 m-o	42.23 q	39.11 s	35.48 t	43.14 H
Mean	49.29 A	48.62 B	46.91 C	45.76 D	44.32 E	41.96 F	
				2025 season			
Lemon grass extract	53.22 a	52.26 c-e	50.08 j-m	49.05 n-p	47.42 s	44.82 u	49.48 F
Rosemary extract	53.22 a	52.70 a-c	51.19 g-i	50.04 k-m	49.02 op	46.36 t	50.42 D
Olive leaves extract	53.22 a	52.57 a-d	50.76 h-j	49.49 m-o	48.30 qr	45.79 t	50.02 E
Chitosan	53.22 a	52.23 c-e	49.74 l-n	48.47 p-r	46.44 t	43.49 v	48.93 G
Lemon grass extract + chitosan	53.22 a	52.82 a-c	51.72 e-g	50.56 i-k	49.51 m-o	47.90 rs	50.96 C
Olive leaves extract + chitosan	53.22 a	53.00 ab	51.94 d-f	51.37 f-h	50.63 i-k	48.95 o-q	51.52 B
Rosemary extract + chitosan	53.22 a	53.08 a	52.62 a-d	52.29 b-e	51.39 f-h	50.42 j-l	52.17 A
Control	53.22 a	51.93 d-f	48.71 pq	46.15 t	43.02 v	39.41 w	47.07 H
Mean	53.22 A	52.57 B	50.85 C	49.68 D	48.22 E	45.89 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

storage period of cherry tomato fruits showing darker fruits in both seasons, and these concur with Saad et al. (2023) on cherry tomatoes. This could be connected to surface dehydration which reduces the surface glossiness (Perdones et al., 2016).

However, all postharvest treatments significantly maintained L* values in comparison to untreated fruits. At the end of the storage period, cherry tomato fruits coated with rosemary extract plus chitosan had a significantly higher L* value (lighter indicator), tracked by olive leaves extract plus chitosan treatment. While the untreated control had the lowest L* value (darker indicator) in both seasons, and these concur with Al-Baarri et al. (2020) and Shehata et al. (2021).

The larger loss in tomato peel gloss in the control groups is likely related to the higher water loss in the control (Koyuncu et al., 2019), while applying chitosan as an edible coating on the surface of the fruit can give additional gloss to the surface of the fruit which raises and maintains L* during cold storage (Baldwin et al., 2011).

3.5.Fruit firmness:

Data in Table (6) indicate that there was a significant reduction in the firmness due to the prolongation of storage in the two seasons, and these are in agreement with Saad et al. (2023) on cherry tomatoes. This may be a result of decreased cell wall hydrolase activity as well as intracellular turgor pressure, which leads to softening of the fruit wall (Tokala et al., 2021).

Table 6. Effect of chitosan and some plant extracts as postharvest treatment on firmness (kg/cm^2) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						
	0	7	14	21	28	35	Mean

				2024 season			
Lemon grass extract	1.95 a	1.78 b-i	1.63 j-o	1.45 p-s	1.27 t-w	1.13 wx	1.54 DE
Rosemary extract	1.95 a	1.85 a-f	1.72 f-k	1.57 l-p	1.45 p-s	1.32 s-v	1.64 C
Olive leaves extract	1.95 a	1.80 b-h	1.68 h-m	1.52 n-r	1.35 s-u	1.20 v-x	1.58 D
Chitosan	1.95 a	1.75 d-j	1.58 k-p	1.40 r-t	1.22 u-w	1.07 x	1.49 E
Lemon grass extract + chitosan	1.95 a	1.88 a-d	1.78 b-i	1.65 i-n	1.55 m-q	1.42 q-s	1.71 B
Olive leaves extract + chitosan	1.95 a	1.90 a-c	1.80 b-h	1.73 e-j	1.63 j-o	1.50 o-r	1.75 B
Rosemary extract + chitosan	1.95 a	1.92 ab	1.87 a-e	1.83 a-g	1.77 c-j	1.67 h-m	1.83 A
Control	1.95 a	1.70 g-l	1.50 o-r	1.27 t-w	1.07 x	0.90 y	1.40 F
Mean	1.95 A	1.82 B	1.70 C	1.55 D	1.41 E	1.28 F	
				2025 season			
Lemon grass extract	2.30 a	2.15 a-f	1.98 c-j	1.80 h-o	1.65 l-q	1.48 pq	1.89 E
Rosemary extract	2.30 a	2.22 a-c	2.08 a-g	1.92 e-k	1.82 h-n	1.67 k-q	2.00 CD
Olive leaves extract	2.30 a	2.17 a-e	2.05 a-h	1.87 g-m	1.73 j-p	1.55 o-q	1.94 DE
Chitosan	2.30 a	2.13 a-f	1.95 d-j	1.75 j-o	1.60 n-q	1.42 q	1.86 E
Lemon grass extract + chitosan	2.30 a	2.25 ab	2.13 a-f	2.02 b-i	1.90 f-l	1.77 i-o	2.06 BC
Olive leaves extract + chitosan	2.30 a	2.27 ab	2.15 a-f	2.10 a-g	1.98 c-j	1.85 g-n	2.11 AB
Rosemary extract + chitosan	2.30 a	2.28 a	2.22 a-c	2.18 a-d	2.13 a-f	2.02 b-i	2.19 A
Control	2.30 a	2.08 a-g	1.87 g-m	1.62 m-q	1.45 q	1.15 r	1.74 F
Mean	2.30 A	2.19 B	2.05 C	1.91 D	1.78 E	1.61 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

Furthermore, softening changes in the fruit were associated with degradation of the middle lamina of cortical parenchyma cells, which in turn leads to a significant raise in pectin solubilization (García et al., 2014).

However, all treatments had a significant impact on reducing the loss of firmness in comparison to untreated fruits. At the end of the storage period, cherry tomatoes dipped in rosemary extract plus chitosan gave the greatest value of firmness, tracked by olive leaves extract plus chitosan and lemon grass extract plus test. chitosan with no significant difference between them. The least value for firmness was in the control treatment in both seasons, and it is consistent with Omoba and Onyekwere (2016); Al-Baarri et al. (2020); Haseeb et al. (2021) and Shehata et al. (2021).

The role of chitosan in reducing the availability of oxygen to tissues may be the reason for reducing enzymes responsible activity for the loss of firmness of tomato fruits, such as pectin esterase and polygalacturonase, which keeps the firmdness higher (Hesami et al., 2021).

Olive leaves extract inhibit tissue softening by delaying the ripening process so that the process of degradation of the cell wall becomes slower (Al-Baarri et al., 2020).

Adding chitosan layers to lemon grass extract inhibits the hydrolase enzyme activities and thus maintains the firmness of the fruit.

3.6.Ascorbic acid content:

The most important antioxidant compound in tomatoes is ascorbic acid (Zhang et al., 2021). Ascorbic acid powerfully removes free radicals and thus prevents deterioration of the fruit during the ripening process (Al-Snafi, 2016). Data in Table (7) indicated that ascorbic acid content has been lowered significantly until the end of the storage duration in the two seasons, and these concur with Saad et al. (2023) on cherry tomatoes.

This decrease could be because of the usage of ascorbic acid in the process of respiration (Hesami et al., 2021) or the oxidation (de Siqueira Oliveira et al., 2018).

However, all treatments significantly lowered the loss of cell content of ascorbic acid during storage durations in comparison with untreated fruits. At the end of the storage period, rosemary extract plus chitosan treatment recorded the greatest values of ascorbic acid content, tracked by olive leaves extract plus chitosan treatment with significant difference between them in both seasons, while untreated fruits recorded the least values of ascorbic acid in both seasons, and these are in conformity with Mahmoud et al. (2017); Samad et al. (2019); Zam (2019); Haseeb et al. (2021) and Shehata et al. (2021).

Table 7. Effect of chitosan and some plant extracts as postharvest treatment on ascorbic acid content (mg/100g F. W.) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
2024 season							
Lemon grass extract	32.80 a	31.60 cd	29.97 i-k	29.03 mn	27.07 s	24.83 v	29.22 E
Rosemary extract	32.80 a	31.67 cd	30.63 gh	29.67 j-l	28.10 o-q	25.97 tu	29.81 D
Olive leaves extract	32.80 a	31.63 cd	30.50 g-i	29.40 k-m	27.83 p-r	25.43 u	29.60 D
Chitosan	32.80 a	31.37 de	29.53 k-m	28.40 op	26.33 t	24.07 w	28.75 F
Lemon grass extract + chitosan	32.80 a	32.30 ab	31.23 d-f	30.47 g-i	29.20 lm	27.37 rs	30.56 C
Olive leaves extract + chitosan	32.80 a	32.37 ab	31.33 de	30.70 fgh	29.37 lm	28.47 no	30.84 B
Rosemary extract + chitosan	32.80 a	32.63 ab	32.10 bc	31.57 cd	30.97 e-g	30.13 h-j	31.70 A
Control	32.80 a	31.27 d-f	29.17 lm	27.57 q-s	25.40 uv	22.43 x	28.11 G
Mean	32.80 A	31.85 B	30.56 C	29.60 D	28.03 E	26.09 F	
2025 season							
Lemon grass extract	35.27 a	34.07 cd	32.47 h-j	31.50 lm	29.50 q	27.30 u	31.68 E
Rosemary extract	35.27 a	34.17 cd	33.13 g	32.13 i-k	30.53 no	28.43 rs	32.28 D
Olive leaves extract	35.27 a	34.13 cd	32.97 gh	31.87 kl	30.27 op	27.93 st	32.07 D
Chitosan	35.27 a	33.87 de	32.00 j-l	30.87 n	28.80 r	26.53 v	31.22 F
Lemon grass extract + chitosan	35.27 a	34.80 ab	33.70 d-f	32.93 gh	31.67 kl	29.83 pq	33.03 C
Olive leaves extract + chitosan	35.27 a	34.83 ab	33.83 de	33.17 fg	31.83 kl	30.97 mn	33.32 B
Rosemary extract + chitosan	35.27 a	35.13 ab	34.60 bc	34.03 d	33.43 efg	32.57 hi	34.17 A
Control	35.27 a	33.77 de	31.63 kl	30.07 op	27.83 tu	24.90 w	30.58 G
Mean	35.27 A	34.35 B	33.04 C	32.07 D	30.48 E	28.56 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

The maximum retention of vit. C in tomato fruits treated with rosemary extract could be because of the antioxidant activities in rosemary extracts (Hendel et al., 2016), which lowers the oxidation of ascorbic acid.

Also, plants leave extracts and chitosan coating maintained the content of ascorbic acid during storage might be because these materials reduced respiration process (Olawuyi et al., 2019 and Haseeb et al., 2021) which conserved ascorbic acid content from the loss.

3.7.Lycopene content (mg/100 g FW):

These results agree with Abdullah and Ibrahim (2018) on cherry tomatoes. The red color gradually develops during the ripening and ripening of tomato fruits due to the decomposition of chlorophyll and the formation of the pigment lycopene (Wu and Kubota, 2008). All treatments gave significantly lower lycopene content of cherry tomatoes in comparison to untreated control during storage periods.

Table 8. Effect of chitosan and some plant extracts as postharvest treatment on lycopene content (mg /100 g F. W.) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	0.53 z	0.80 vw	1.12 r	1.93 l	2.64 h	3.53 d	1.76 C
Rosemary extract	0.53 z	0.77 v-x	1.02 s	1.72 n	2.26 j	2.91 f	1.54 E
Olive leaves extract	0.53 z	0.79 vw	1.07 rs	1.83 m	2.53 i	3.39 e	1.69 D
Chitosan	0.53 z	0.82 uv	1.19 q	2.05 k	2.79 g	3.66 c	1.84 B
Lemon grass extract + chitosan	0.53 z	0.74 wx	0.95 t	1.48 o	1.99 kl	2.57 hi	1.38 F
Olive leaves extract + chitosan	0.53 z	0.71 xy	0.88 tu	1.33 p	1.75 n	2.29 j	1.25 G
Rosemary extract + chitosan	0.53 z	0.66 y	0.81 u-w	1.21 q	1.49 o	1.96 l	1.11 H
Control	0.53 z	0.89 t	1.76 mn	2.84 fg	3.81 b	4.98 a	2.47 A
Mean	0.53 F	0.77 E	1.10 D	1.80 C	2.41 B	3.16 A	
				2025 season			
Lemon grass extract	0.46 \	0.75 xy	1.06 rs	1.86 l	2.55 h	3.46 d	1.69 C
Rosemary extract	0.46 \	0.72 yz	0.96 tu	1.65 n	2.18 j	2.84 f	1.47 E
Olive leaves extract	0.46 \	0.74 x-z	1.01 st	1.76 m	2.45 i	3.32 e	1.62 D
Chitosan	0.46 \	0.77 w-y	1.13 qr	1.98 k	2.70 g	3.59 c	1.77 B
Lemon grass extract + chitosan	0.46 \	0.66 z[	0.88 uv	1.41 o	1.91 kl	2.50 hi	1.31 F
Olive leaves extract + chitosan	0.46 \	0.63 [	0.81 v-x	1.26 p	1.67 mn	2.22 j	1.18 G
Rosemary extract + chitosan	0.46 \	0.58 [	0.74 xyz	1.15 q	1.42 o	1.89 kl	1.04 H
Control	0.46 \	0.85 vw	1.71 mn	2.77 fg	3.71 b	4.91 a	2.40 A
Mean	0.46 F	0.71 E	1.04 D	1.73 C	2.32 B	3.09 A	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

Cherry tomatoes dipped in rosemary extract plus chitosan gave the lowest values of lycopene content, tracked by olive leaves extract plus chitosan treatment with significant differences between them, indicating reduction in color development and the fruits become less redness, while chitosan treatment was less effective in retarding the development of color. The untreated control gave the highest content for lycopene resulting in more redness in the two seasons, and these are consistent with Shehata et al. (2021).

Chitosan treatment can lower O_2 levels and increase CO_2 levels around tomato fruits resulting in delayed ripening and development of color (Breda et al., 2017).

This result was attributed to the vital role of rosemary, olive leaves, lemon grass extracts and chitosan for lowering respiration and maturity process (Mahmoud et al., 2017; Talei et al., 2017; Olawuyi et al., 2019 and Lin et al., 2020) resulting in a delay in fruit ripening and lycopene biosynthesis.

The effect of the interaction between treatments and storage periods, the results obtained from rosemary plant extract with chitosan revealed a significant reduction in lycopene content in comparison to the other treatments until the end of storage in both seasons.

3.8.Total phenolic content:

Phenols are one of the most effective non-enzymatic antioxidants in scavenging ROS (Rastegar et al., 2020), potentially alter the activity of some enzymes and chelate metal ions (Peretto et al., 2017). Data in Table (9), the total phenolic content (TPC) significantly reduced until the end of the storage duration in the two seasons, and these concur with Saad et al. (2023) on cherry tomatoes. The decline in total phenolics during storage was associated with their consumption to inhibit free radicals (Naser et al., 2018). Also, senescence results from the breakdown of cell structures and phenolic oxidation through enzymatic activities such as PPO (Razzaq et al., 2014). However, all treatments significantly decreased the loss in total phenolic content during storage durations as compared with untreated fruits.

At the end of the period, rosemary extract plus chitosan treatment recorded the greatest values of total phenolic, tracked by olive leaves extract plus chitosan treatment with no significant difference between them in the first season, while untreated fruits recorded the least values of total phenolic content in both seasons, and these are in conformity with Melo et al. (2018); Zam (2019) and Moccia et al. (2021).

Zam (2019) found that fruits coated with chitosan enriched with OLE showed a higher rate of total phenolic content values compared to uncoated fruits. This may be due to a decrease in oxygen permeability and thus a reduction in the respiration rate and production of ethylene from the fruits and a reduction in respiratory enzyme activity (Wang and Gao, 2013).

3.9. Antioxidant activity:

Antioxidant activity helps fruits overcome oxidative stress and prevents membrane damage via their antioxidant activity against ROS (Rastegar et al., 2020). DPPH radical scavenging capacity ratio is frequently used to assess the antioxidant activity of fruits (Zhang et al., 2018). Data in Table (10), the antioxidant activity (%) of cherry tomatoes decreased significantly with extension of storage duration in the two seasons, and these concur with Saad et al. (2023) on cherry tomatoes. This may be attributed to the oxidation of polyphenols (Razzaq et al., 2014) and ascorbic acid (Hosseini et al., 2018) during storage, which decreased DPPH scavenging activities (Lecholocholo et al., 2022).

Table 9. Effect of chitosan and some plant extracts as postharvest treatment on total phenolic content (mg / 100 g fresh weight) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	36.83 a	35.64 c-i	34.42k-n	33.24 o-r	32.28 r-t	30.26 vw	33.78DE
Rosemary extract	36.83 a	36.25 a-f	35.32 f-k	34.14 l-o	33.28 o-r	31.35 tu	34.53 C

Olive leaves extract	36.83 a	35.76 b-h	34.66 i-n	33.61 n-q	32.72 q-s	30.74 uv	34.06 D
Chitosan	36.83 a	35.54 d-j	34.18 l-o	32.91 p-s	31.89 st	29.65 w	33.50 E
Lemon grass extract + chitosan	36.83 a	36.59 a-d	35.94 a-g	34.49 j-n	33.82 m-p	32.23 r-t	34.99 B
Olive leaves extract + chitosan	36.83 a	36.68 a-bc	36.35 a-f	35.96 a-g	35.09 g-l	33.75 n-q	35.78 A
Rosemary extract + chitosan	36.83 a	36.72 ab	36.49 a-e	36.19 a-f	35.46 e-k	34.44 k-n	36.02 A
Control	36.83 a	34.85 h-m	32.34 r-t	30.19 vw	28.43 x	24.69 y	31.22 F
Mean	36.83 A	36.00 B	34.96 C	33.84 D	32.87 E	30.89 F	
				2025 season			
Lemon grass extract	39.86 a	38.69 e-h	37.46 kl	36.30 no	35.32 pq	33.29 s	36.82 F
Rosemary extract	39.86 a	39.30 a-d	38.36 g-i	37.20 lm	36.32 no	34.38 r	37.57 D
Olive leaves extract	39.86 a	38.81 d-g	37.70 j-l	36.67mn	35.76 op	33.77 s	37.10 E
Chitosan	39.86 a	38.60 f-h	37.23 lm	35.99 o	34.94 qr	32.68 t	36.55 G
Lemon grass extract + chitosan	39.86 a	39.63 ab	38.97 c-f	37.54 kl	36.86 mn	35.26 pq	38.02 C
Olive leaves extract + chitosan	39.86 a	39.72 ab	39.38a-d	39.01 c-f	38.13 h-j	36.78mn	38.81 B
Rosemary extract + chitosan	39.86 a	39.76 ab	39.52a-c	39.24b-e	38.50 f-h	37.47 kl	39.06 A
Control	39.86 a	37.91 i-k	35.39 pq	33.27 s	31.48 u	27.72 v	34.27 H
Mean	39.86 A	39.06 B	38.00 C	36.90 D	35.91 E	33.92 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

The treatments used significantly reduced the loss of antioxidant activity at the end of the storage period in comparison to untreated fruits. Rosemary extract plus chitosan treatment significantly contributed to preserving the antioxidant activity of fruits, tracked by olive leaves extract plus chitosan treatment with no significant difference between them. While the untreated fruits had the least values of antioxidant activity in both seasons, and these are in agreement with Zam (2019) who found that the retention of phytochemicals was closely associated with the preservation of antioxidants in sweet cherry fruits coated with OLE-enriched chitosan after 20 days. The preservation of antioxidant activity (AOA) might be partly because of the modification of the internal atmosphere resulting from the edible coatings leading to the initial accumulation of phenolic compounds (Frusciante et al., 2007).

Table 10. Effect of chitosan and some plant extracts as postharvest treatment on antioxidant activity (DPPH scavenging %) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	69.43 a	67.98 c-f	66.26 j-m	64.15 op	61.83 rs	58.62 u	64.71 E
Rosemary extract	69.43 a	68.45 a-e	67.22 f-j	66.05 k-m	64.89 no	62.73 qr	66.46 C
Olive leaves extract	69.43 a	68.31 b-e	66.78 h-k	65.37 mn	63.81 p	61.46 st	65.86 D
Chitosan	69.43 a	67.64 e-i	65.64 l-n	63.25 pq	60.61 t	57.06 v	63.94 F
Lemon grass extract + chitosan	69.43 a	68.93 a-c	67.92 d-g	66.89 h-k	65.64 l-n	64.03 op	67.14 B
Olive leaves extract + chitosan	69.43 a	69.18 ab	68.48 a-e	67.65 e-h	66.65 i-k	65.36 mn	67.79 A
Rosemary extract + chitosan	69.43 a	69.24 ab	68.64 a-d	67.91 d-g	66.97 g-k	66.01 k-m	68.03 A
Control	69.43 a	66.59 j-l	63.98 op	60.76 t	57.61 v	53.64 w	62.00 G
Mean	69.43 A	68.29 B	66.86 C	65.25 D	63.50 E	61.11 F	
				2025 season			
Lemon grass extract	73.32 a	71.89 d-f	70.16 i-k	68.04 o	65.74 r	62.51 t	68.61 E
Rosemary extract	73.32 a	72.36 c-e	71.12 gh	69.94 j-l	68.79 n	66.62 q	70.36C
Olive leaves extract	73.32 a	72.22 c-f	70.68 hi	69.28 l-n	67.71 op	65.35 r	69.76D
Chitosan	73.32 a	71.55 fg	69.54k-m	67.17 pq	64.52 s	60.95 u	67.84 F
Lemon grass extract + chitosan	73.32 a	72.85a-c	71.83 ef	70.81 hi	69.54k-m	67.92 o	71.05B
Olive leaves extract + chitosan	73.32 a	73.10 ab	72.39 c-e	71.57 fg	70.55 h-j	69.25 mn	71.69A
Rosemary extract + chitosan	73.32 a	73.16 ab	72.55 b-d	71.83 ef	70.87 h	69.90 j-m	71.94A
Control	73.32 a	70.50 h-j	67.88 o	64.68 s	61.52 u	57.53 v	65.90G
Mean	73.32A	72.20 B	70.77 C	69.17 D	67.40 E	65.01 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

3.10.Gas composition in package:

The data presented in Tables (11, 12, 13) indicate a significant reduction in the percentage of O_2 and a raise in the percentage of CO_2 and ethylene concentration in the containers during the storage period in the two seasons, and they concur with Saad et al. (2023) and could be because of the production of CO_2 and consumption of O_2 throughout the respiration process of cherry tomato fruit (Albornoz et al., 2019).

Increased ethylene production during storage indicates that cherry tomatoes are climacteric fruits that exhibit characteristics of increased ethylene production during ripening (Gharezi et al., 2012). At the end of storage, the gaseous composition inside the packages treated with rosemary extract plus chitosan and olive leaves extract plus chitosan treatments had high O_2 and low CO_2 and ethylene concentrations with significant differences between them, tracked by package treated with lemon grass extract plus chitosan treatment. These results concur with Yonemoto et al. (2002) and Dong et al. (2004).

The impact of rosemary, olive leaves, lemon grass extracts and chitosan treatments on O_2 %, CO_2 % and ethylene production was may be because of the slow metabolic activity and respiration of the fruit, thus retarding the ripening process, modifying the internal atmosphere by decreasing O_2 and/or increasing CO_2 and preventing the evolution of ethylene (Dong et al., 2004; Mahmoud et al., 2017; Talei et al., 2017 and Lin et al., 2020).

Table 11. Effect of chitosan and some plant extracts as postharvest treatment on O_2 (%) of cherry tomato fruit during cold storage at 10°C in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	20.80 a	20.57 a-c	19.20 ij	17.78 n	16.50 r	15.42 t	18.38 F
Rosemary extract	20.80 a	20.65 a-c	19.77 fg	18.80 kl	17.70 no	16.75 qr	19.08 D
Olive leaves extract	20.80 a	20.62 a-c	19.37 hi	18.12 m	16.95 q	15.98 s	18.64 E
Chitosan	20.80 a	20.52 b-d	18.97 jk	17.32 p	16.07 s	14.97 u	18.11 G
Lemon grass extract + chitosan	20.80 a	20.68 a-c	20.03 ef	19.17 ij	18.18 m	17.43 op	19.38 C
Olive leaves extract + chitosan	20.80 a	20.70 a-c	20.28 de	19.60 gh	18.72 kl	17.95 mn	19.67 B
Rosemary extract + chitosan	20.80 a	20.75 ab	20.45 cd	19.97 f	19.33 hi	18.73 kl	20.01 A
Control	20.80 a	20.43 cd	18.60 l	16.83 q	15.35 t	14.12 v	17.69 H
Mean	20.80 A	20.61 B	19.58 C	18.45 D	17.35 E	16.42 F	
				2025 season			
Lemon grass extract	20.80 a	20.58 a-d	19.23 ij	17.85 no	16.55 r	15.47 t	18.41 F
Rosemary extract	20.80 a	20.67 a-d	19.80 gh	18.87 kl	17.75 o	16.80 q	19.11 D
Olive leaves extract	20.80 a	20.63 a-d	19.38 i	18.18 m	17.00 q	16.03 s	18.67 E
Chitosan	20.80 a	20.53 b-e	19.00 jk	17.38 p	16.13 s	15.02 u	18.14 G
Lemon grass extract + chitosan	20.80 a	20.70 a-c	20.05 f	19.23 ij	18.22 m	17.50 p	19.42 C
Olive leaves extract + chitosan	20.80 a	20.72 ab	20.30 e	19.67 h	18.75 l	18.02 mn	19.71 B
Rosemary extract + chitosan	20.80 a	20.77 ab	20.47 c-e	20.03 fg	19.37 i	18.80 kl	20.04 A
Control	20.80 a	20.45 de	18.63 l	16.90 q	15.43 t	14.15 v	17.73 H
Mean	20.80 A	20.63 B	19.61 C	18.51 D	17.40 E	16.47 F	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

Table 12. Effect of chitosan and some plant extracts as postharvest treatment on CO_2 (%) of cherry tomato fruits during cold storage at 10°C in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	0.03 [	0.17 x-z	0.76 t	1.68 n	2.91 g	3.64 d	1.53 C
Rosemary extract	0.03 [	0.14 x-z	0.68 uv	1.40 p	2.15 k	2.83 h	1.21 E
Olive leaves extract	0.03 [	0.15 x-z	0.73 tu	1.60 o	2.72 i	3.43 e	1.44 D
Chitosan	0.03 [	0.18 xy	0.77 t	1.75 n	3.21 f	3.96 b	1.65 B
Lemon grass extract + chitosan	0.03 [	0.12 yz	0.63 v	1.35 p	2.06 l	2.71 i	1.15 F
Olive leaves extract + chitosan	0.03 [	0.11 z	0.47 w	1.09 r	1.70 n	2.39 j	0.97 G
Rosemary extract + chitosan	0.03 [	0.10 z[	0.42 w	0.77 t	1.26 q	1.84 m	0.74 H
Control	0.03 [	0.20 x	1.01 s	2.21 k	3.77 c	4.60 a	1.97 A
Mean	0.03 F	0.15 E	0.68 D	1.48 C	2.47 B	3.18 A	
				2025 season			
Lemon grass extract	0.03 [	0.15 w-y	0.73 s	1.62 n	2.86 g	3.59 d	1.50 C
Rosemary extract	0.03 [	0.11 x-z	0.64 tu	1.33 p	2.13 k	2.77 h	1.17 E
Olive leaves extract	0.03 [	0.12 w-z	0.69 st	1.53 o	2.70 hi	3.37 e	1.41 D
Chitosan	0.03 [	0.16 wx	0.74 s	1.69 mn	3.16 f	3.92 b	1.62 B
Lemon grass extract + chitosan	0.03 [	0.09 y-[	0.59 u	1.27 pq	2.05 l	2.64 i	1.11 F
Olive leaves extract + chitosan	0.03 [	0.08 yz[	0.43 v	1.01 r	1.69 m	2.32 j	0.93 G
Rosemary extract + chitosan	0.03 [	0.07 z[	0.38 v	0.69 st	1.25 q	1.76 m	0.70 H
Control	0.03 [	0.19 w	0.99 r	2.16 k	3.73 c	4.56 a	1.94 A
Mean	0.03 F	0.12 E	0.65 D	1.41 C	2.45 B	3.12 A	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

Table 13. Effect of chitosan and some plant extracts as postharvest treatment on ethylene concentration (ppm) of cherry tomato fruits during cold storage at 10ºC in 2024 and 2025 seasons.

Treatments	Storage period (days)						Mean
	0	7	14	21	28	35	
				2024 season			
Lemon grass extract	0.00 y	0.08 s-v	0.19 l-n	0.28 g-i	0.39 de	0.43 cd	0.23 C
Rosemary extract	0.00 y	0.05 u-x	0.12 o-s	0.19 l-n	0.25 i-k	0.30 gh	0.15 E
Olive leaves extract	0.00 y	0.07 s-w	0.15 n-q	0.23 j-l	0.33 fg	0.37 ef	0.19 D
Chitosan	0.00 y	0.09 r-v	0.24 i-l	0.32 gh	0.41 c-e	0.46 c	0.25 B
Lemon grass extract + chitosan	0.00 y	0.04 v-y	0.10 q-u	0.15 n-p	0.22 j-l	0.27 h-j	0.13 E
Olive leaves extract + chitosan	0.00 y	0.02 w-y	0.06 t-x	0.12 o-s	0.17 m-o	0.21 k-m	0.10 F
Rosemary extract + chitosan	0.00 y	0.01 xy	0.05 u-y	0.08 s-v	0.11 p-t	0.14 n-r	0.07 G
Control	0.00 y	0.13 o-r	0.32 gh	0.43 cd	0.52 b	0.61 a	0.34 A
Mean	0.00 F	0.06 E	0.15 D	0.23 C	0.30 B	0.35 A	
				2025 season			
Lemon grass extract	0.22 f-h	0.01 st	0.07 m-q	0.18 hi	0.27 ef	0.37 bc	0.22 C
Rosemary extract	0.14 i-k	0.00 t	0.04 p-t	0.11 j-n	0.18 hi	0.23 f-h	0.14 E
Olive leaves extract	0.18 hi	0.00 t	0.06 n-r	0.14 i-k	0.22 f-h	0.31 de	0.18 D
Chitosan	0.25 fg	0.00 t	0.08 l-p	0.23 f-h	0.31 de	0.40 b	0.25 B
Lemon grass extract + chitosan	0.12 j-m	0.00 t	0.03 q-t	0.09 l-p	0.13 i-l	0.21 gh	0.12 F
Olive leaves extract + chitosan	0.09 l-p	0.00 t	0.01 r-t	0.05 o-s	0.10 k-o	0.16 ij	0.09 G
Rosemary extract + chitosan	0.05 o-s	0.00 t	0.00 t	0.04 p-t	0.06 n-r	0.10 k-o	0.05 H
Control	0.33 cd	0.00 t	0.12 j-m	0.31 de	0.42 b	0.51 a	0.33 A
Mean	0.00 F	0.05 E	0.14 D	0.21 C	0.29 B	0.34 A	

The values that contain the same capital or small letters in the same columns and rows indicate that there are no significant variations between each other at level 0.05.

4. CONCLUSION

Cherry tomato fruits cv. Katalina-522 dipped in solution of chitosan at 1% enriched by rosemary leaves extract at 1% for 5 min. was the most effective treatment for delaying fruits ripening and maintaining quality of fruits during storage and gave excellent appearance after 35 days of storage at 10ºC without any decay.

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الملخص العربي

تأثير الشيتوزان وبعض المستخلصات النباتية كمعاملة ما بعد الحصاد على الجودة والقدرة التخزينية لثمار الطماطم الشيرى.

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أجريت الدراسة الحالية خلال موسمي ٢٠٢٤ و ٢٠٢٥ على الطماطم الشيرى صنف كتالينا ٥٢٢ فى معمل بحوث تداول الخضر، معهد بحوث البساتين، مركز البحوث الزراعية، مصر لدراسة تأثير غمر الثمار لمدة ٥ دقائق في مستخلص أوراق الزيتون بتركيز ١٪، ومستخلص الروزميرى بتركيز ١٪، ومستخلص حشيشة الليمون بتركيز ١٪، و الشيتوزان بتركيز ١٪، ومستخلص أوراق الزيتون بتركيز ١٪ ثم الشيتوزان بتركيز ١٪، ومستخلص الروزميرى بتركيز ١٪ ثم الشيتوزان بتركيز ١٪ ، ومستخلص حشيشة الليمون بتركيز ١٪ ثم الشيتوزان بتركيز ١٪ بالإضافة إلى المعاملة الكنترول (الغمر في الماء المقطر لمدة ٥ دقائق) علي صفات الجودة والقدرة التخزينية خلال التخزين على درجة ١٠ °م ورطوبة نسبية ٩٠-٩٥٪ لمدة ٣٥ يوم. أشارت النتائج إلى أن ثمار الطماطم الشيرى المعاملة بجميع معاملات ما بعد الحصاد كانت فعالة في تقليل الفقد في الوزن، الفقد في الصلابة، التغير في اللون، وتعديل الجوالهوائى داخل العبوة، وكذلك الحفاظ على حمض الأسكوربيك، محتوى الفينولات الكلية، نشاط مضادات الأكسدة، والمظهر العام للثمار خلال التخزين مقارنة بالمعاملة الكنترول. لم يلاحظ أي تلف حتى نهاية التخزين فى الثمار المعاملة بمستخلص الروزميرى مع الشيتوزان، مستخلص أوراق الزيتون مع الشيتوزان ومستخلص حشيشة الليمون مع الشيتوزان. علاوة على ذلك، كانت المعاملة بمستخلص الروزميرى مع الشيتوزان هي الأكثر فاعلية في الحفاظ على جميع صفات الجودة للثمار وأعطت مظهرًا ممتازًا للثمار لمدة ٣٥ يوم من التخزين على درجة ١٠ °م، بينما أعطت المعاملة بمستخلص أوراق الزيتون مع الشيتوزان ومستخلص حشيشة الليمون مع الشيتوزان مظهرًا عاما جيدًا للثمار خلال نفس الفترة. المحتوى الغازى داخل العبوة للمعاملة بمستخلص الروزميرى مع الشيتوزان اعطت نسبة عالية للاكسجين ونسبة اقل من ثاني أكسيد الكربون وأقل تراكم لغاز الإيثيلين مما ادى الى إبطاء عملية النضج بشكل واضح وإطالة فترة التخزين للثمار .

الكلمات المفتاحية: الطماطم الشيرى، مستخلص الروزميرى، مستخلص أوراق الزيتون، مستخلص حشيشة الليمون، الشيتوزان، القدرة التخزينية.