



## Effect of using calcium gluconate and calcium lactate with some sanitizers on quality attributes and storability of cantaloupe fruits

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### ABSTRACT

This study was carried out during 2021 and 2022 seasons on cantaloupe fruits cv. Primal, Galia type to investigate the impact of post-harvest treatments of calcium gluconate and calcium lactate alone and in combined with sanitizers like Ozone and Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), as well as distilled water as control treatment on maintaining the quality attributes, overall appearance, firmness, color, decay reduction, weight loss prevention, and shelf life extension of cantaloupe fruits during storage at 5°C and 95% RH for 28 days. The findings indicated that all postharvest treatments outperformed the control treatment in decreased weight loss, decay and maintained firmness, color, total soluble solids, total sugar content and ascorbic acid. Further were cantaloupe fruits treated with calcium gluconate with H<sub>2</sub>O<sub>2</sub> was the most effective in preserving quality attributes and giving fruits a good overall appearance after 28 days of storage at 5°C.

**Keywords:** Cantaloupe- Calcium treatments- Post-harvest life- Decay- Ascorbic acid.

### INTRODUCTION

Cantaloupe (*Cucumis melo* L. cv. Galia) is an important vegetable crop in Egypt, grown in open fields, tunnels, and plastic houses. The ripening process of the Galia melon, a climacteric fruit, is regulated by increase respiration rate and ethylene production (Seymour and McGlasson, 1993). Climacteric fruit ripening is characterized by softening of the flesh, an increase in the sugar/acid ratio, improved color development, higher respiratory activity, and a rise in ethylene production. The life of climacteric and other fruits and vegetables after harvest is shortened by ethylene exposure, whether from internal or external sources (Resende et al., 2001). Therefore, it is necessary to use some techniques to maintain the quality attributes of cantaloupe fruits during storage.

Many fruits have longer shelf life due to post-harvest calcium salt treatments, which prolong senescence, maintain firmness, and lower respiration rates, protein breakdown, and ethylene production (Arthur, 2014). According to Arpassorn and Sanguansri (2014), organic calcium salts such as lactate, citrate, and gluconate boost nutritional value without having an off-putting flavor. They, also, have a higher antioxidant potential and are more bioavailable than inorganic salts like calcium chloride.

It is essential for maintain structural of membranes and cell walls, promoting cell adhesion and cohesion. After harvest calcium salt treatments control physiological disorders, reduce fungal pathogen incidence, and maintain fruit firmness (Bakshi & Ta, 2005). Calcium and phosphorus in diets are balanced by phosphorus-free calcium sources such as lactate and gluconate. The food industry is urged to boost the calcium content of its products, thereby offering consumers new ways to supplement their calcium intake. Calcium lactate and calcium gluconate are used when coal is keeping or increasing of the product firmness (Cerklewski, 2005).

Microorganisms on product surfaces and in washing water are being destroyed by the intense oxidation of ozone. According to Jamieson et al. (2009), it functions well at low concentrations and brief contact times without leaving any detectable residues. Ozone has been tested for treatment after harvest of fruits and vegetables, applied as gas or ozonated water, (Karaca and Velioglu, 2007) and used for water disinfection and sanitizing surfaces (Artés et al., 2007). It eliminates chemical residues, suppresses microbial and fungal infections, and prolongs the shelf life of perishable food (Lamikanra and Watson, 2007). Ozone's efficacy as a sanitizing agent may be



restored by its capacity to destroy germs through the oxidation of cell membranes (Sothornvit, 2008). Ozonated water, effective at low temperatures, offers an alternative to traditional sanitizers (Carletti et al., 2013). Studies have indicated that, in contrast to control treatments, H<sub>2</sub>O<sub>2</sub> increases ascorbic acid level and extends the marketing life of melon fruits (Kim et al., 2007; Bhagwat, 2006). According to, Sapers et al. (2001) H<sub>2</sub>O<sub>2</sub> is authorized for use in

## MATERIALS AND METHODS

On a private farm in the Fayed region of the Ismailia Governorate, Egypt, melon plants (*Cucumis melo* cv. Primal, Galia type) were grown under tunnels. In 2021 and 2022 seasons, the fruits were picked on April 23 and 25, respectively, when they were still a light yellow tint with green coloring stage. The cantaloupes were sent right away to the Horticultural Research Institute, Agriculture Research Center, Giza Governorate, Egypt, Department of Vegetable Handling and Postharvest Research Section laboratory.

Fruits were selected based on their uniform size and weight (750-800g) free of visual defects and disinfected with 150 ppm sodium hypochlorite for 10 minutes, followed by washing with distilled water. Subsequently, the cantaloupes were divided into seven groups and dipped for 2 minutes to the following treatments: 2% calcium gluconate solution, 2% calcium gluconate plus 1% ozone, 2% calcium gluconate plus 1% hydrogen peroxide, 2% calcium lactate, 2% calcium lactate plus 1% ozone, 2% calcium lactate plus 1% hydrogen peroxide and a control group that dipped in distilled water. After drying the fruits then all treatments were placed in carton boxes (23 cm x 33 cm x 12.5 cm) serving as experimental units (EU). Twelve EUs were prepared for each treatment with three fruits into each box. Samples were arranged in a completely randomized design then stored at 5°C and 95% RH for 28 days. Three replicate samples (EU) were randomly chosen and examined at harvest and at every seven-day intervals for 28 days for the following properties:

### Physical properties:

- **Weight loss (%):** was determine and using the equation:  $\text{weight loss\%} = (\text{initial}$

organic crop production and reduces microbial populations on fresh goods, prolonging their shelf life without leaving behind significant residue.

The purpose of the current study is to assess how calcium gluconate and calcium lactate alone and in combined with sanitizers, affect the sensory qualities and quality attributes of cantaloupe fruits that are stored in the refrigerator.

weight of fruit – weight of fruit at each sampling date)/initial weight of the fruit x 100.

- **Decay score:** Decay was measured on a scale of 1= none, 2= slight, 3= moderate, 4= severe and 5= extreme (Risse and Miller, 1986).
- **General Appearance:** Assessed based on a scoring system: 9 (excellent), 7 (good), 5 (fair), 3 (poor), and 1 (unsalable), considering morphological and pathological defects (**Gorny et al., 2002**).
- **Fruit firmness:** Measured in pounds per square inch (Lb/in<sup>2</sup>) using a TA-1000 texture analyzer equipped with a 1 mm diameter penetrating cylinder.
- **Total soluble solids percentage (°Brix):** Determined using a PR-101 digital refractometer.
- **External and internal flesh surface color:** Using a color difference meter (Minolta CR200) to evaluated the b value (McGuire, 1992).

### Chemical Composition:

- **Ascorbic acid content (mg/100g FW):** Determined by titration with 2, 6, and phenol indophenols, as described by A.O.A.C. (2000).
- **Total sugar content:** Determined using the Lane and Eynon method, according to A.O.A.C. (2000).

**Statistical Analysis:** This study used a completely randomized design (CRD) with three replicates, utilizing a factorial design with two factors. Duncan's Multiple Range Test was used to assess mean comparisons at the 5% significance level. It was statistically analyzed according to Snedecor and Cochran (1982).



## RESULTS AND DISCUSSION

### 1- Weight loss:

As shown in Figure 1, all treatments exhibited significant differences in weight loss percentages during storage at 5°C.

The weight loss of whole fruits increased as storage time was extended, in both seasons. Similar findings were documented by Prajapati et al. (2021).

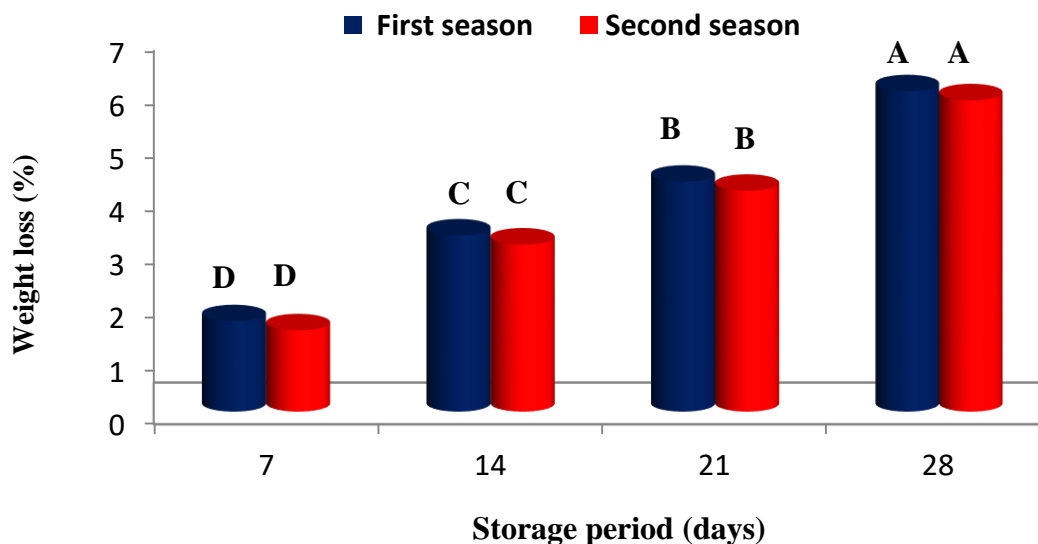


Fig (1). Effect of storage period on weight loss percentage of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Weight loss in fruits during storage predominantly results from key processes such as respiration, moisture exchange, and oxidation, as identified by Atrass and Attia (2011). The primary cause of this weight reduction is the decrease in

moisture content, which is further accelerated by quickened ripening processes and increased respiratory activity, thereby hastening transpiration (Khuram et al., 2015).

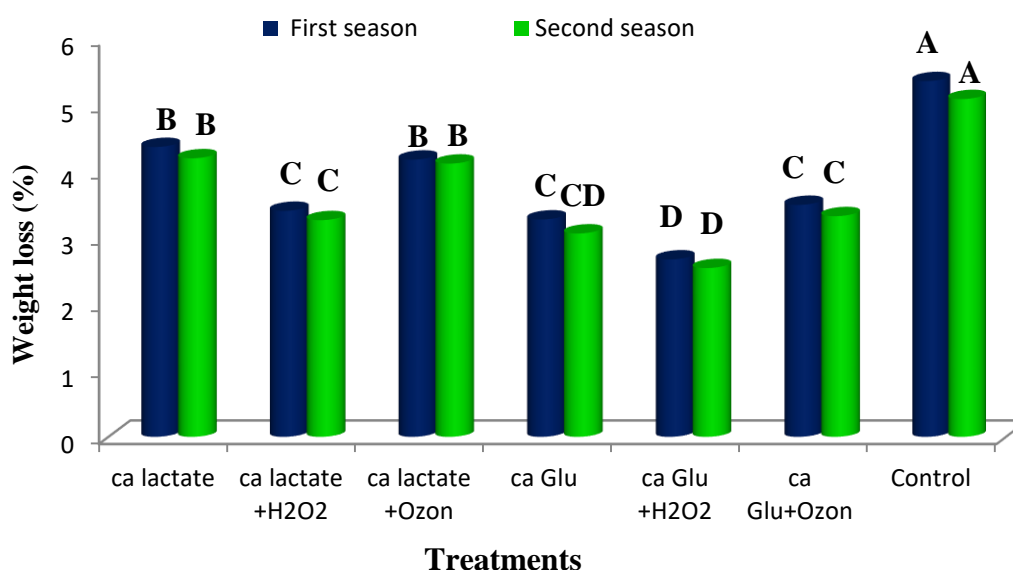
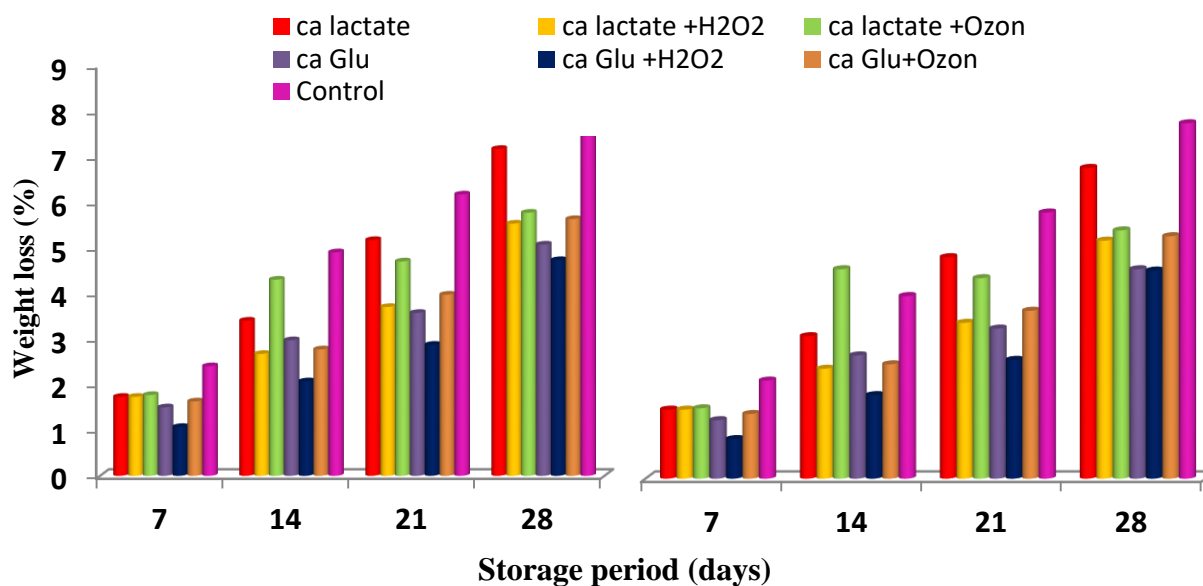


Fig (2). Effect of calcium lactate and calcium gluconate treatments on weight loss percentage of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



**Fig (3). Interaction effect between postharvest treatments and storage periods on weight loss percentage of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.**

As demonstrated in **Figure (2)**, all treated groups exhibited significantly lower weight loss percentages than untreated fruits. Notably, the combination of 2% calcium gluconate with 1% H<sub>2</sub>O<sub>2</sub> consistently showed the most substantial reduction in weight loss, achieving 2.68–2.55% across both evaluated seasons.

**Figure (2)** demonstrates that all treatments effectively reduced weight loss percentages during cold storage compared to the untreated fruits. The highest weight loss was observed in the control group, recording 5.36–5.09% in both seasons, while the lowest loss (2.68–2.55%) occurred in fruits treated with 2% Calcium gluconate plus 1% H<sub>2</sub>O<sub>2</sub> in both seasons. A similar result was obtained by (Dike, 2004). Calcium gluconate's crucial role in reinforcing cell walls and membranes is pivotal for enhancing the structural integrity of fruit tissues, aiding in the management of various physiological disorders (Bakshi and Ta, 2005). Additionally, treatments with calcium lactate have been shown to bolster membrane integrity, which helps reduce transpiration and respiration rates and subsequently delays the senescence of fruits (Lara et al., 2004). These properties are essential for maintaining fruit physiology,

stabilizing cell membranes, and sustaining turgor pressure through interactions with pectic acid in cell walls.

The use of hydrogen peroxide, particularly in combination with calcium treatments, has proven effective in extending the shelf life of melons, surpassing traditional chlorine treatments in efficacy (Bhagwat, 2006). Furthermore, Chen et al. (2020) reported that lactic acid treatments combined with antioxidants performed comparably to plain tap water in preserving fruit quality, underscoring their practical utility.

Overall, the interactions between various postharvest treatments and storage durations were meticulously analyzed and illustrated in **Figure (3)**. The data conclusively showed that applying 2% calcium gluconate with 1% H<sub>2</sub>O<sub>2</sub> in the end of storage yielded the most effective results in minimizing weight loss across both seasons. In stark contrast, fruits in the control group experienced the highest weight loss rates.

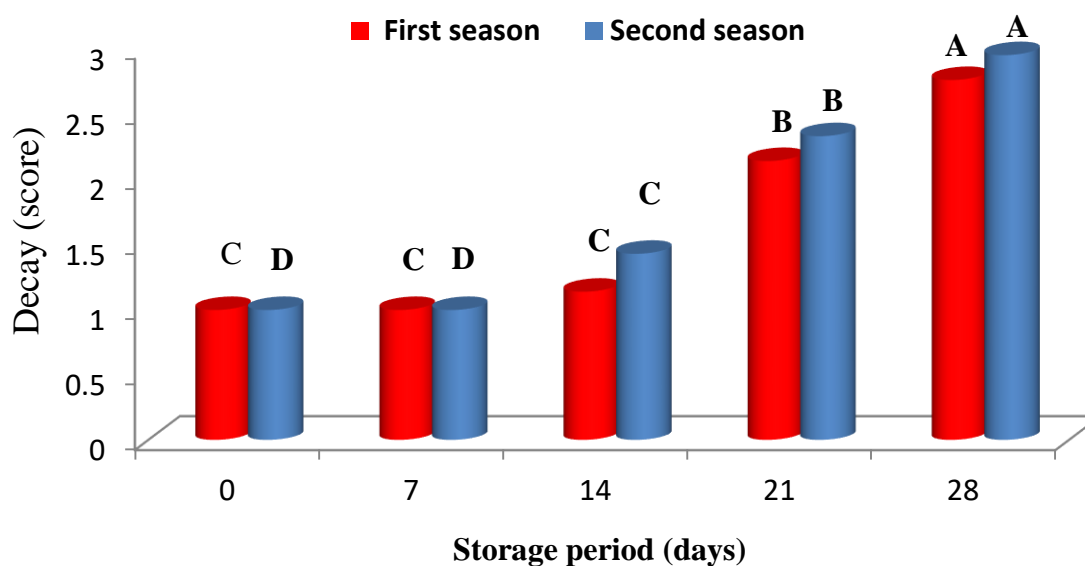
## 2- Decay:

Analysis presented in **Figure (4)** revealed a consistent and significant increase in the decay of whole cantaloupe fruits as storage time at 5°C extended over two seasons.

These findings align with earlier research conducted by Prajapati et al. (2021).

As depicted in **Figure (5)**, cantaloupe fruits subjected to treatments with Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> Calcium gluconate, and Calcium lactate plus H<sub>2</sub>O<sub>2</sub> demonstrated enhanced resistance to decay during the first season, showing comparable effectiveness among these treatments. These results were more pronounced when compared to other treatments and the untreated fruits in the second season, with Calcium gluconate plus

Ozone also showing notable efficacy in the first season. In the second season, fruits treated with Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> continued to show superior resistance to decay, closely followed by Calcium gluconate and Calcium lactate plus H<sub>2</sub>O<sub>2</sub>, with no significant variance observed between them relative to other treatments and control fruits. These observations are supported by findings from Prajapati et al. (2021), AL-Saikhan and Shalaby (2019), and Dike (2004).



**Fig. (4).** Effect of storage period on decay (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Calcium is recognized for its ability to strengthen tissue resistance against bacterial and fungal invasions by reinforcing or stabilizing cell walls (Hafez 2016). The observed reduction in decay in fruits treated with calcium lactate is likely due to delayed ripening and enhanced firmness, which hinder pathogen entry and extend shelf life (Sugar and Basile, 2011). Because hydrogen peroxide is a reactive oxygen species (ROS) and is essential in the fight against plant diseases, it is helpful at reducing degradation (Kapsiya et al., 2015). In addition, the application of

hydrogen peroxide therapy enhances the quality of fruit by delaying the ripening processes (Bayoumi, 2008), functioning as a direct antibacterial agent, and triggering the development of disease resistance responses in infected tomatoes (Malolepsza and Rozalska, 2005). According to Karaca and Velioglu (2007), ozone treatments are useful in getting rid of mycotoxins and microorganisms that contaminate food. Calcium is known to promote tissue resistance against bacterial and fungal invasions by strengthening or reinforcing cell walls (Hafez 2016).

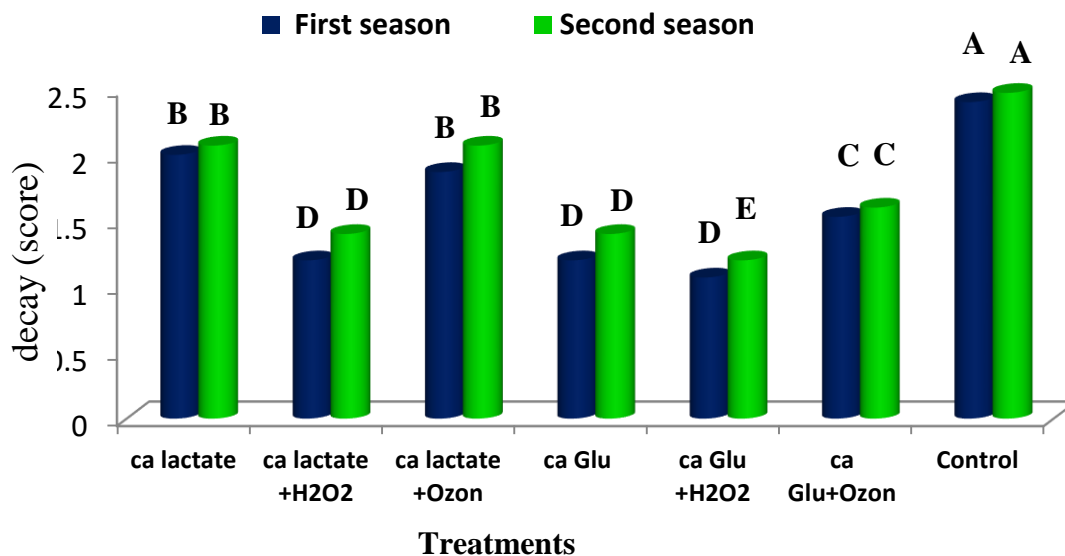


Fig. (5). Effect of calcium lactate and calcium gluconate treatments on decay (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

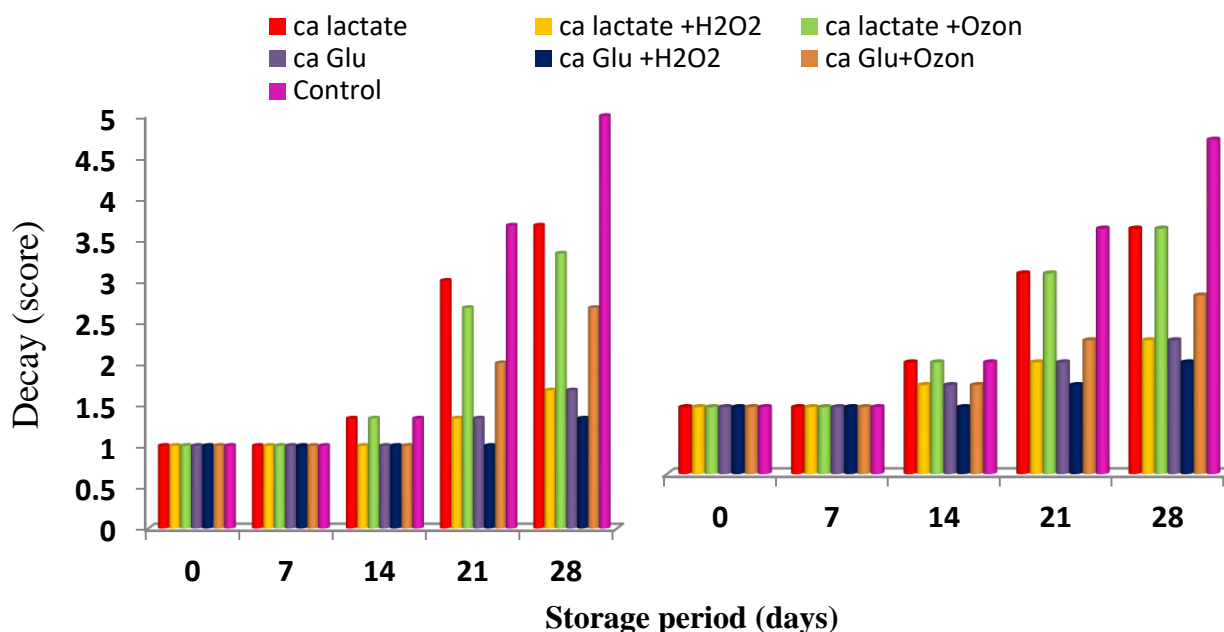


Fig (6). Interaction effect between postharvest treatments and storage periods on decay (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

According to **Figure (6)**, the analysis of the interaction between storage durations and postharvest treatments indicated that the percentage of decay did not significantly change after 28 days of storage at 5°C. However, when compared to other treatments and controls, cantaloupe fruits treated with calcium gluconate with hydrogen peroxide proved to be the most effective treatments in reducing deterioration over the course of two seasons.

### 3- General Appearance (GA):

Data presented in **Figure (7)** indicates a decline in the general appearance (GA) of cantaloupe fruits as storage time increases, consistent with findings by Munira et al. (2013). Fernández-León et al. (2013), who explained that weight loss and a decline in the fruits' post-harvest nutritional content, are the causes of this general appearance decline during the storage period.

It has been demonstrated that calcium therapies have the ability to slow down respiration and delay fruit maturation. When comparing the different postharvest treatments for cantaloupe fruits to the control group, analysis of **Figure (8)** shows significant variations in the overall appearance of the fruits. The treatments including calcium gluconate alone, calcium lactate plus H<sub>2</sub>O<sub>2</sub>, and calcium gluconate plus ozone in both seasons were

shown to be less effective than the combination of calcium gluconate and H<sub>2</sub>O<sub>2</sub>, which achieving the highest appearance scores. These effects are consistent with those published by Dik (2004) and Munoz et al. (2006). Additionally, Du et al. (2007) observed that H<sub>2</sub>O<sub>2</sub> not only retards fruit ripening but also reduces the rate of respiration and prompts the closing of stomata in guard cells.

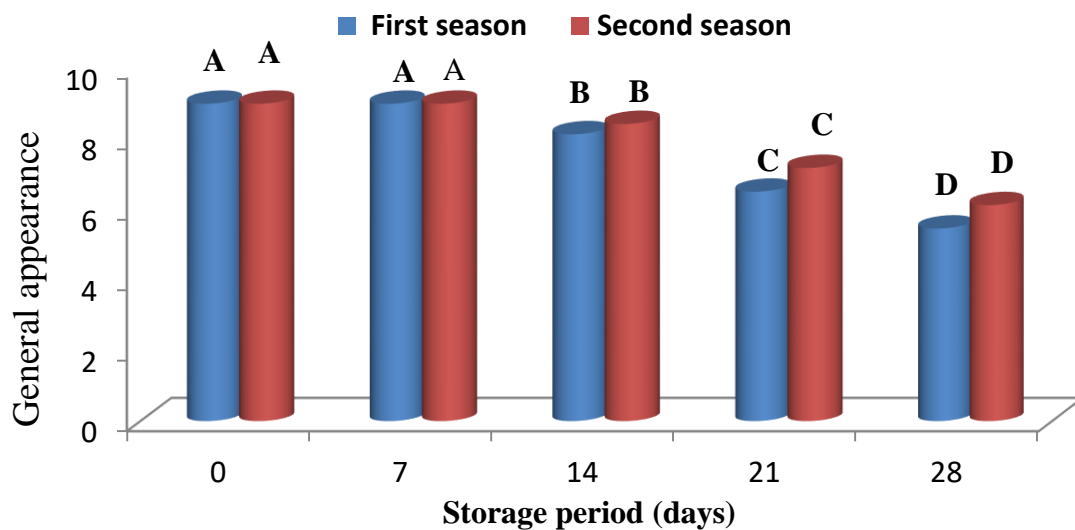


Fig. (7). Effect of storage period on the general appearance (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons

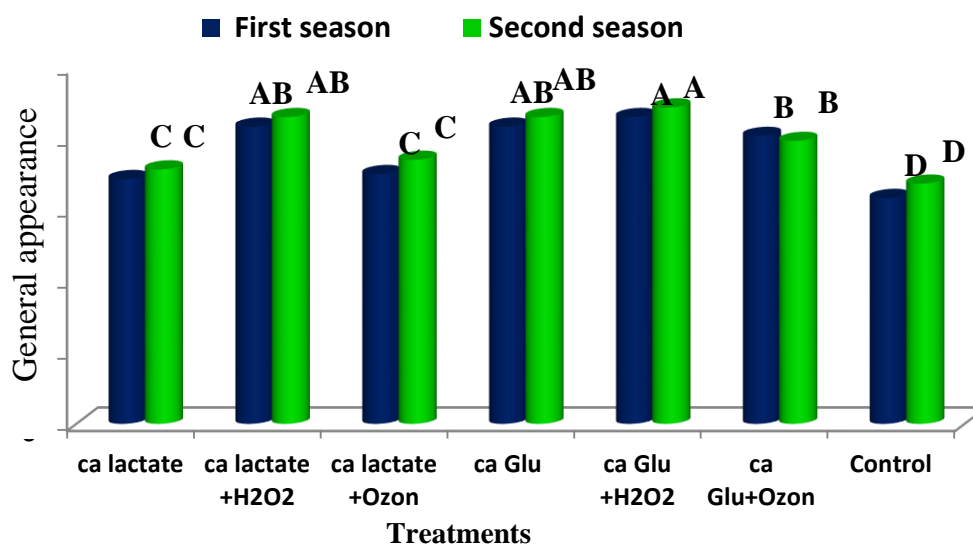
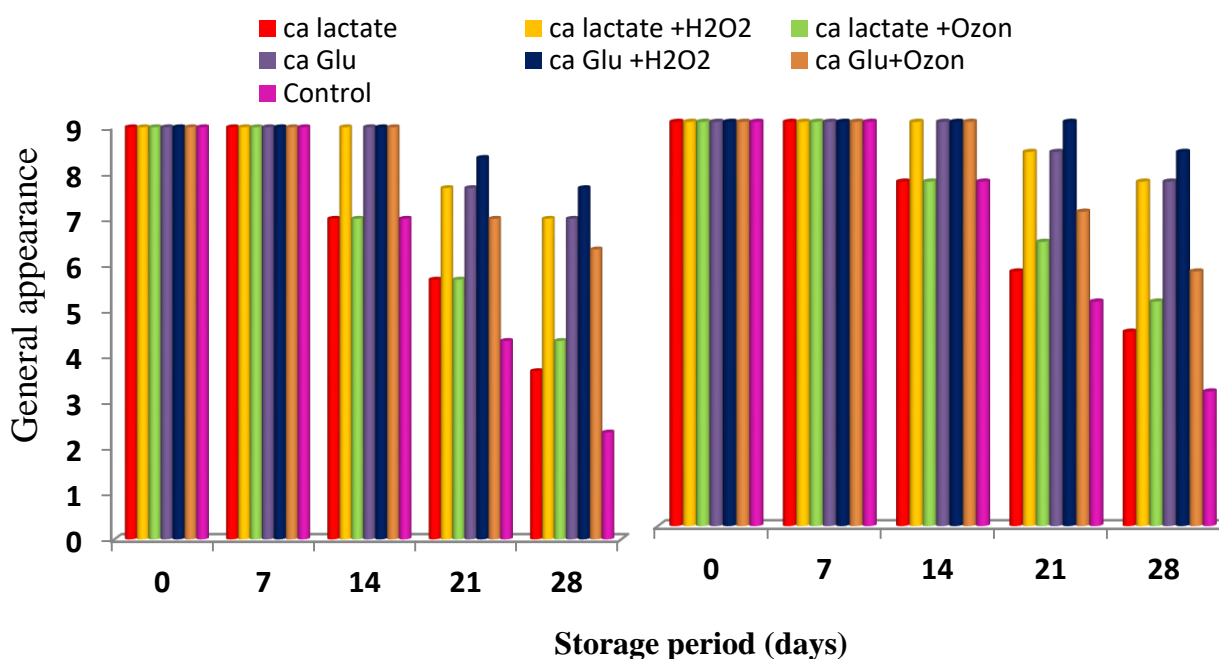


Fig. (8). Effect of calcium lactate and calcium gluconate treatments on general appearance (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



**Fig (9). Interaction effect between postharvest treatments and storage periods on general appearance (score) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.**

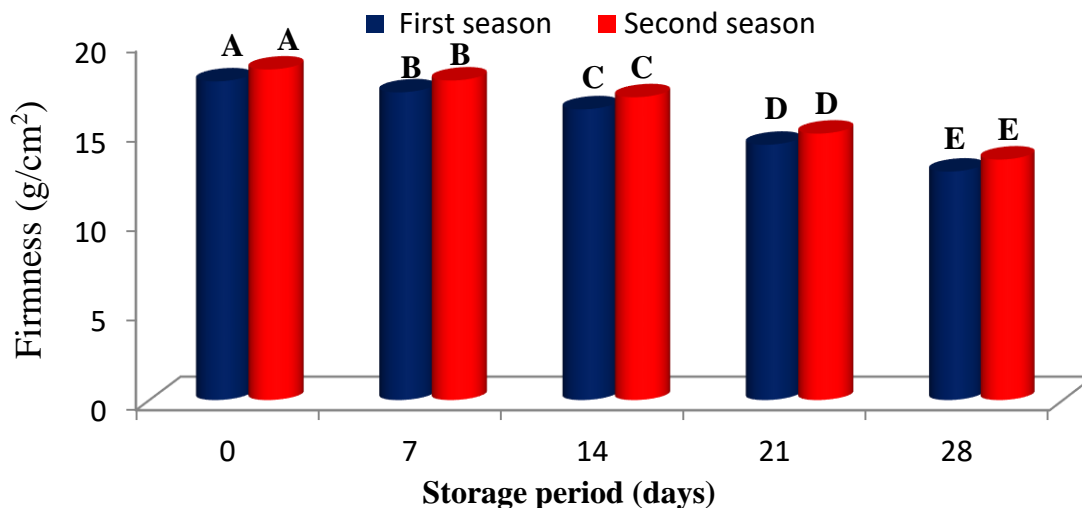
As depicted in **Figure (9)**, after 28 days of cold storage, cantaloupe fruits treated with calcium gluconate with H<sub>2</sub>O<sub>2</sub> maintained good general appearance than those treated with calcium gluconate alone. On the other hand, after only 21 days of cold storage, in both seasons, the general appearance of the control fruits significantly declined.

**4- Firmness (g/cm<sup>2</sup>):**

Data illustrated in **Figure (10)** highlighted significant variances in the firmness of cantaloupe fruits among different postharvest treatments during cold storage. Cantaloupe firmness generally declined gradually over time; recorded firmness values initially varied

from 17.78 and 18.88, then dropped to 12.77 and 13.44 after 28 days of storage at 5°C in the first and second season respect. This pattern aligns with findings from Prajapati et al. (2021) and Botondi et al. (2016). Kaur and Dhillon (2014) reported that prolonged storage leads to decreased fruit firmness due to degradation of soluble pectin by the enzyme endopolygalacturonase, resulting in tissue softening. Furthermore, Bico et al. (2009) observed that a slower rate of firmness loss is associated with reduced transpiration and respiration rates, which subsequently helps delay the ripening and senescence of fruits.

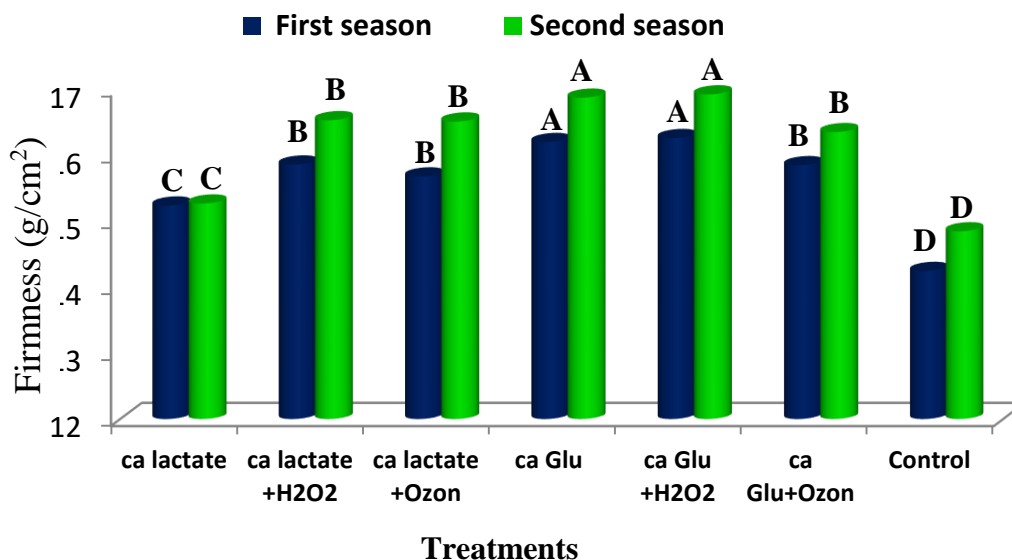




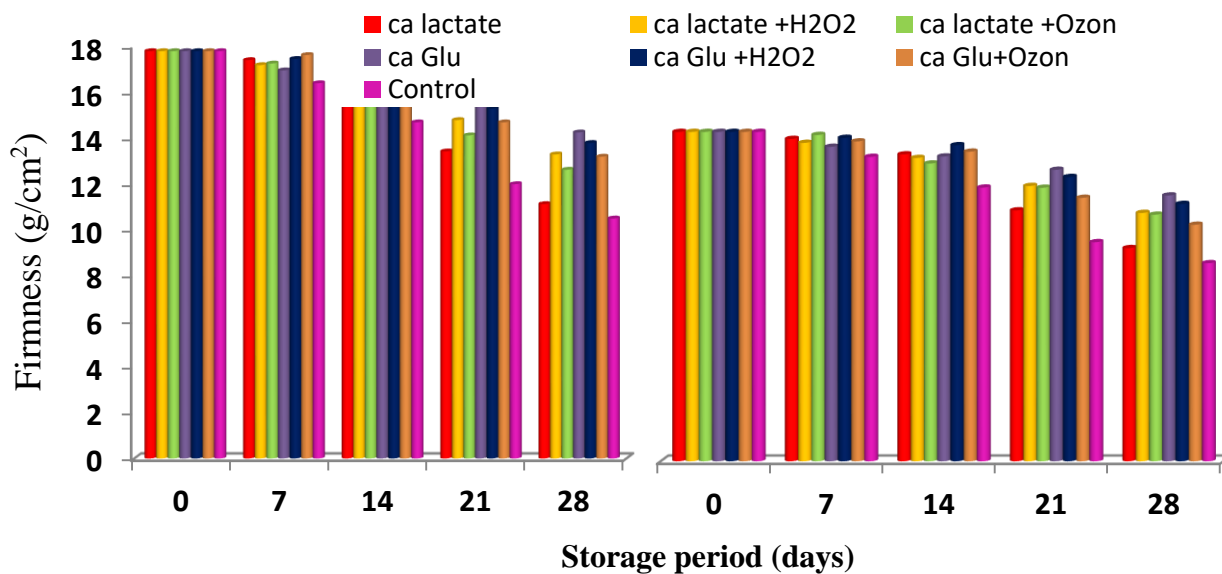
**Fig. (10).** Effect of storage period on firmness (g/cm<sup>2</sup>) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Figure (11) showed Calcium gluconate combined with H<sub>2</sub>O<sub>2</sub> and Calcium gluconate alone, were the most effective treatments at preserving firmness, exhibiting minimal reductions. These results were closely followed by Calcium lactate plus H<sub>2</sub>O<sub>2</sub>, Calcium lactate plus Ozone, and Calcium gluconate plus Ozone, which demonstrated no significant

differences among them throughout both seasons. These observations were supported by Attia (2014), who highlighted the critical role of calcium ions in enhancing tissue firmness by boosting cell turgor pressure and improving membrane integrity, thereby aiding in structural maintenance (Alandes et al., 2006).



**Fig. (11).** Effect of calcium lactate and calcium gluconate treatments on firmness (g/cm<sup>2</sup>) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



**Fig (12).** Interaction effect between postharvest treatments and storage periods on firmness ( $\text{g}/\text{cm}^2$ ) of cantaloupe fruits during cold storage at  $5^\circ\text{C}$  in the 2021 and 2022 seasons.

It has been established that calcium gluconate plays a critical role in the structural maintenance of membranes and cell walls, which is essential for controlling a number of physiological disorders, lowering the incidence of fungal infections, and sustaining the firmness of fruit (Bakshi and Ta, 2005).

Changes in pectin and hemicellulose polysaccharides, which are typified by a net loss of non-cellulosic neutral carbohydrates, are closely associated with firmness loss. Enzymes like galactosidase and endo-polygalacturonase are frequently responsible for these alterations (Botondi et al., 2000).

Furthermore, after 28 days of cold storage at  $5^\circ\text{C}$  across two seasons, the interaction between storage durations and postharvest treatments was significant, as seen in **Figure (12)**. The fruit firmness was significantly preserved by the calcium gluconate alone, calcium gluconate combined with  $\text{H}_2\text{O}_2$  and other calcium-based treatments. However, the fruit firmness of the untreated control was the lowest values.

#### 5- Total soluble solids (TSS) percentage:

Analysis from **Figure (13)** demonstrated a significant decrease in the total soluble solids (TSS) percentage of cantaloupe fruits over two seasons. These findings align with the studies conducted by Atrass and Attia (2011) and Hafez (2016) the decline in TSS during storage is typically attributed to a greater rate of sugar consumption during respiration compared to water loss through transpiration, as discussed by Rageh (2003). Significant variations in TSS percentages between different postharvest treatments and the untreated control were seen in both seasons, as further analysis in Figure 14 revealed. The least amount of TSS % reduction was achieved by treatments using calcium gluconate alone and in combination with  $\text{H}_2\text{O}_2$ . Calcium lactate, calcium lactate plus ozone, and calcium gluconate plus ozone followed shortly behind, with no significant differences between them. The control group, however, showed the lowest TSS percentage. The credibility of the observed trends is further supported by Erbaş and Koyuncu (2020).

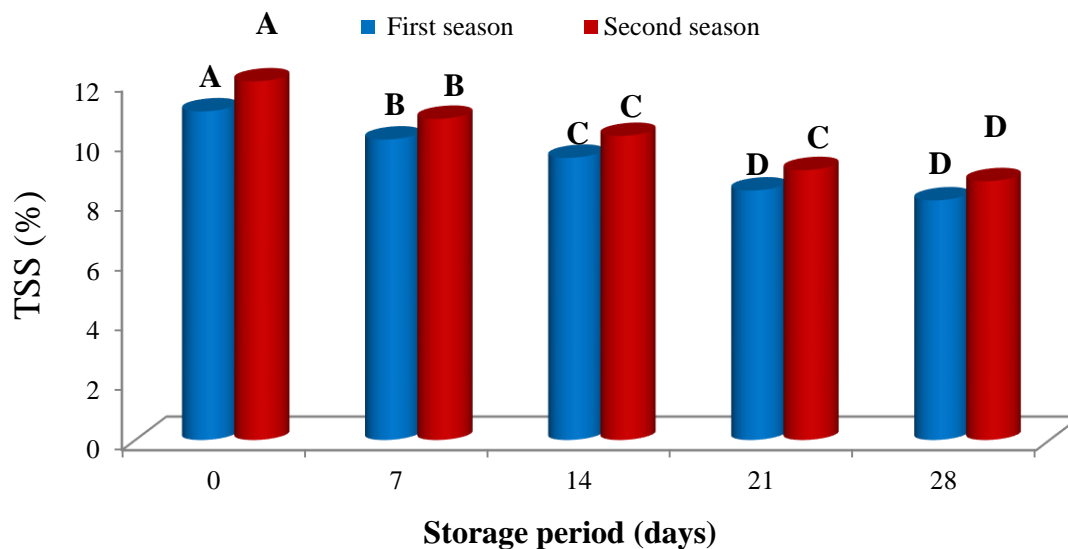


Fig. (13). Effect of storage period on the TSS (%) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

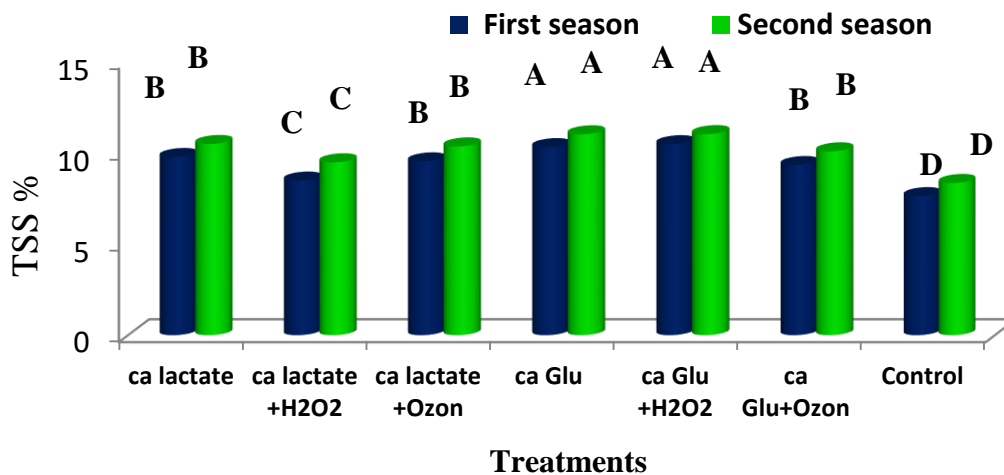


Fig.(14). Effect of calcium lactate and calcium gluconate treatments on TSS (%) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

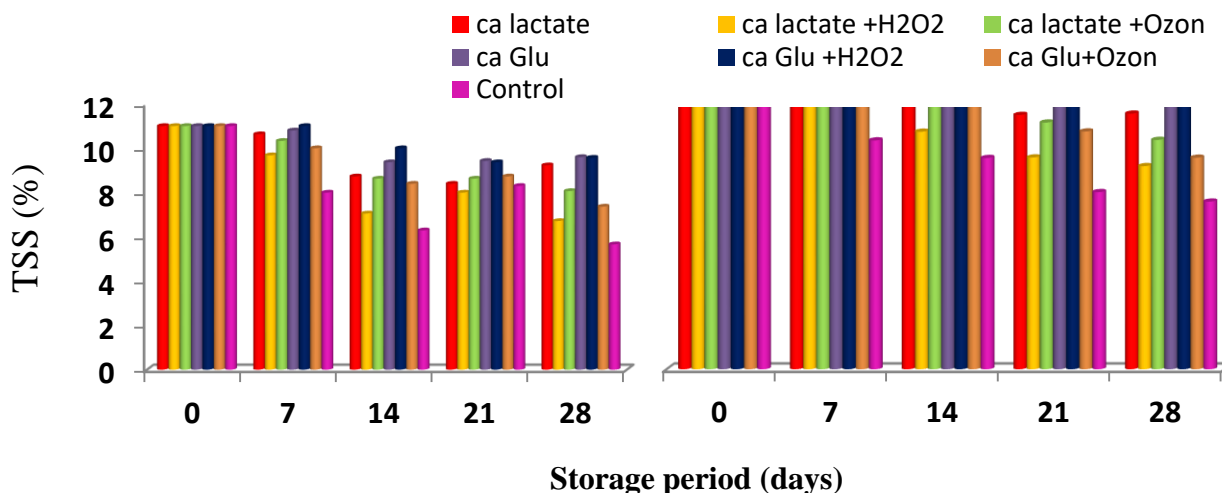


Fig (15). Interaction effect between postharvest treatments and storage periods on TSS (%) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



According to the data presented in Figure 15, the interaction between storage periods and postharvest treatments was significant. The combination of calcium gluconate with H<sub>2</sub>O<sub>2</sub> proved to be the most effective treatment in reducing the deterioration of TSS percentages compared to other treatments and the control after 28 days of cold storage at 5°C, in both seasons.

**6- Color (lightness) L\* value (skin):**

Data from Figure 16 show that the lightness of the outer skin surface of fruits, significantly, diminished as storage time increased at 5°C and 95% RH across both seasons. These observations align with

previous findings by Atrass and Attia (2011) and Hafez (2016).

According to results displayed in Figure 17, there were marked differences in color quality among all the postharvest treatments compared to the control during the two tested seasons. Treatments involving calcium gluconate plus H<sub>2</sub>O<sub>2</sub> and calcium gluconate alone were notably more effective in preserving color quality than other treatments. These findings are consistent with those reported by Erbas and Koyuncu (2020), Attia (2014) and Wang and Long (2015) noted that calcium's role in mitigating or delaying color changes could be linked to its ability to protect against senescence.

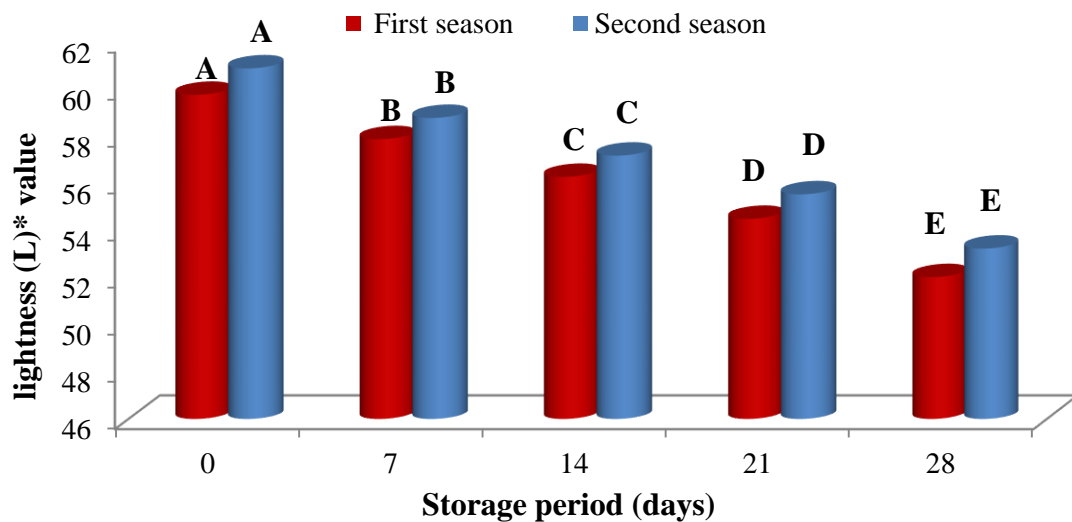


Fig. (16). Effect of storage period on the color lightness (L)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

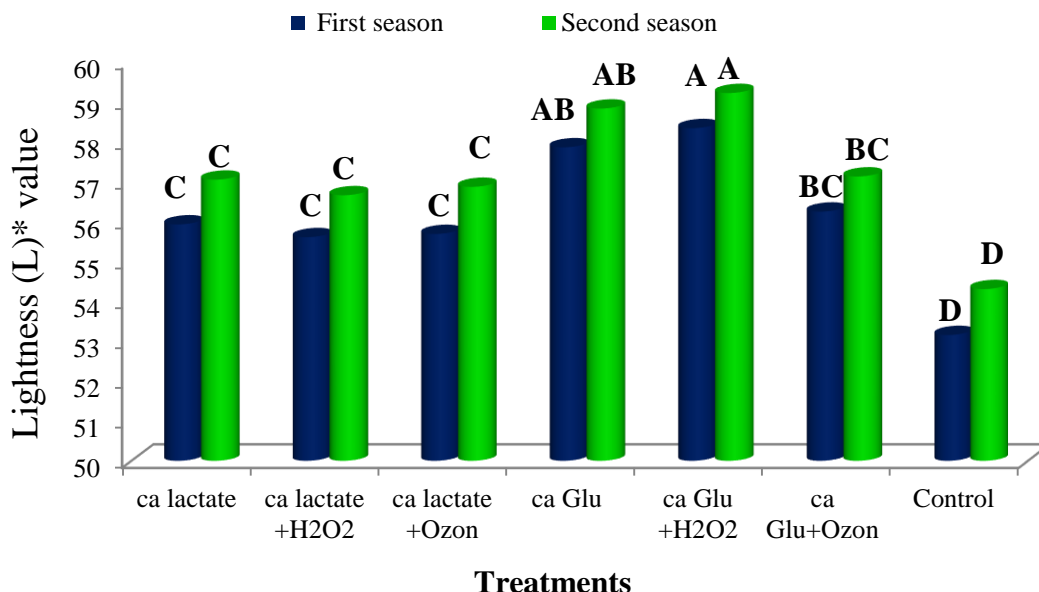


Fig.(17). Effect of calcium lactate and calcium gluconate treatments on the color lightness (L)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

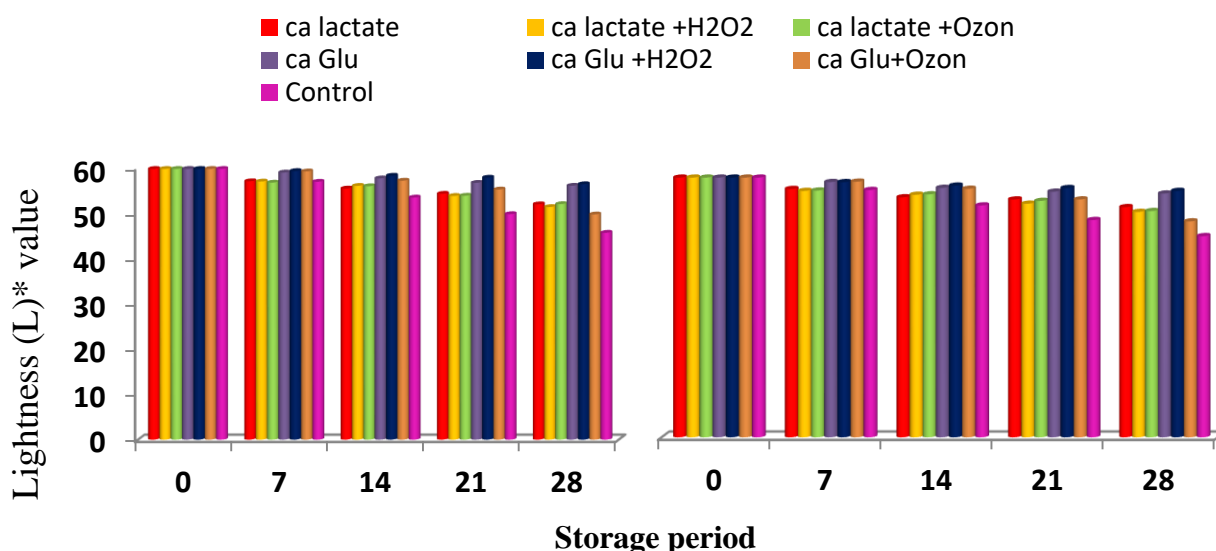


Fig (18). Interaction effect between postharvest treatments and storage periods on the color lightness (L)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

The comprehensive analysis of interactions between storage durations and postharvest treatments, as illustrated in Figure 18, showed that the treatment with calcium gluconate combined with H<sub>2</sub>O<sub>2</sub> was the most effective at maintaining color quality over 28 days of cold storage at 5°C in both seasons, outperforming other treatments and the untreated control.

**7- Color (lightness) L\* value (flesh):**

Findings from **Figure (19)** revealed that the lightness of the internal flesh of cantaloupe fruits significantly

diminished over time during storage at 5°C and 95% RH across two seasons. These observations align with prior studies by Attia (2014) and Munira et al. (2013), who noted that the decrease in color brightness in fresh cantaloupe is closely linked to the ripeness stage of the fruit, as discussed by Rageh (2003). Additionally, the reduction in L\* values was related to the appearance of translucent or water-soaking symptoms, as identified by Supapvanich and Tucker (2011).

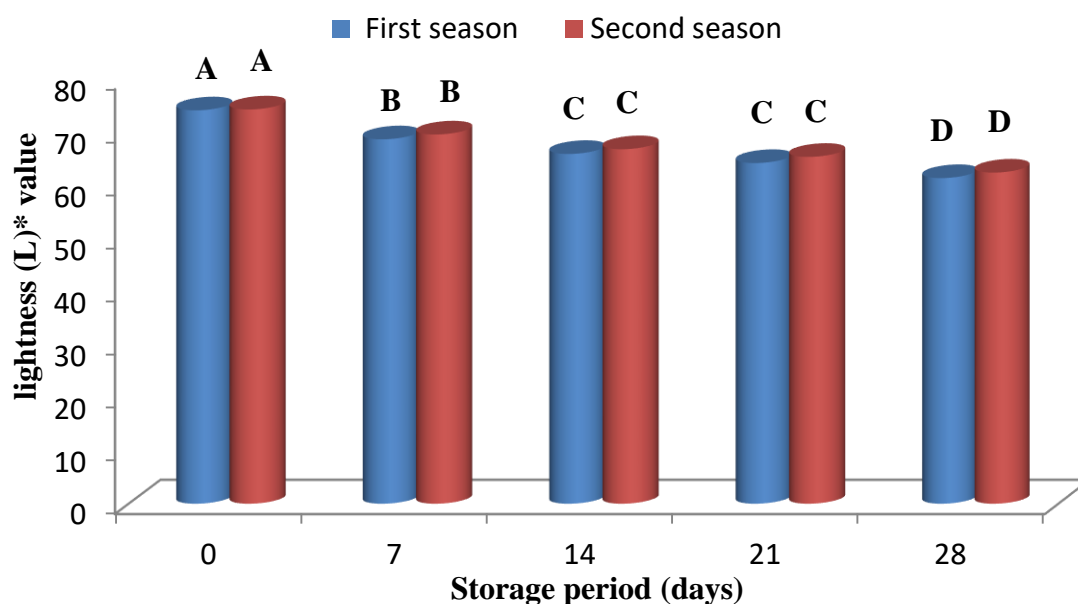
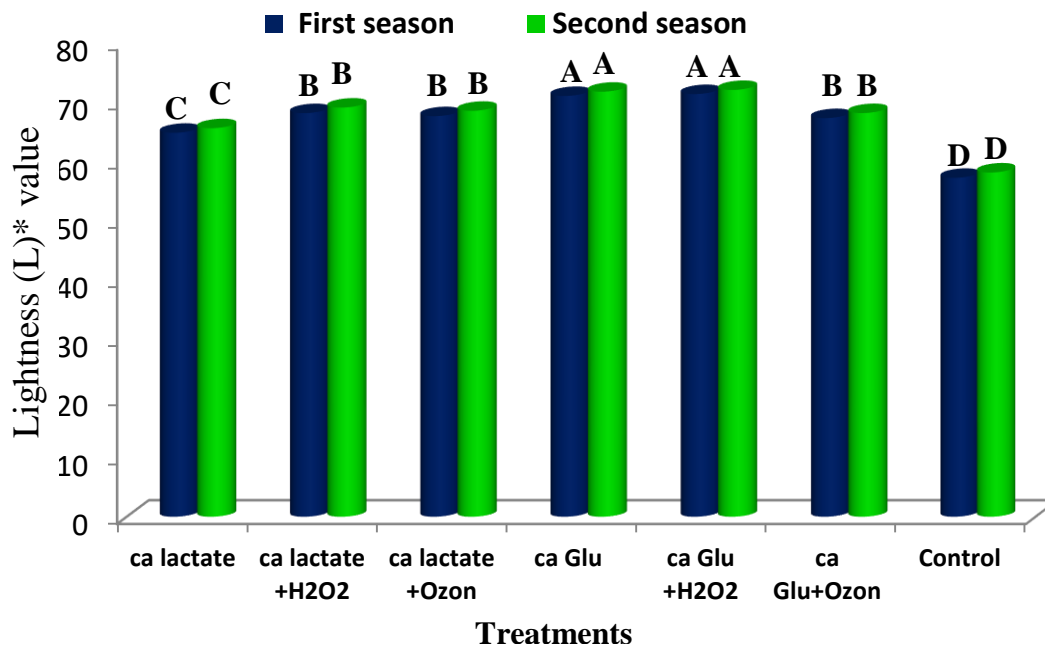


Fig. (19). Effect of storage period on the color lightness (L)\* value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

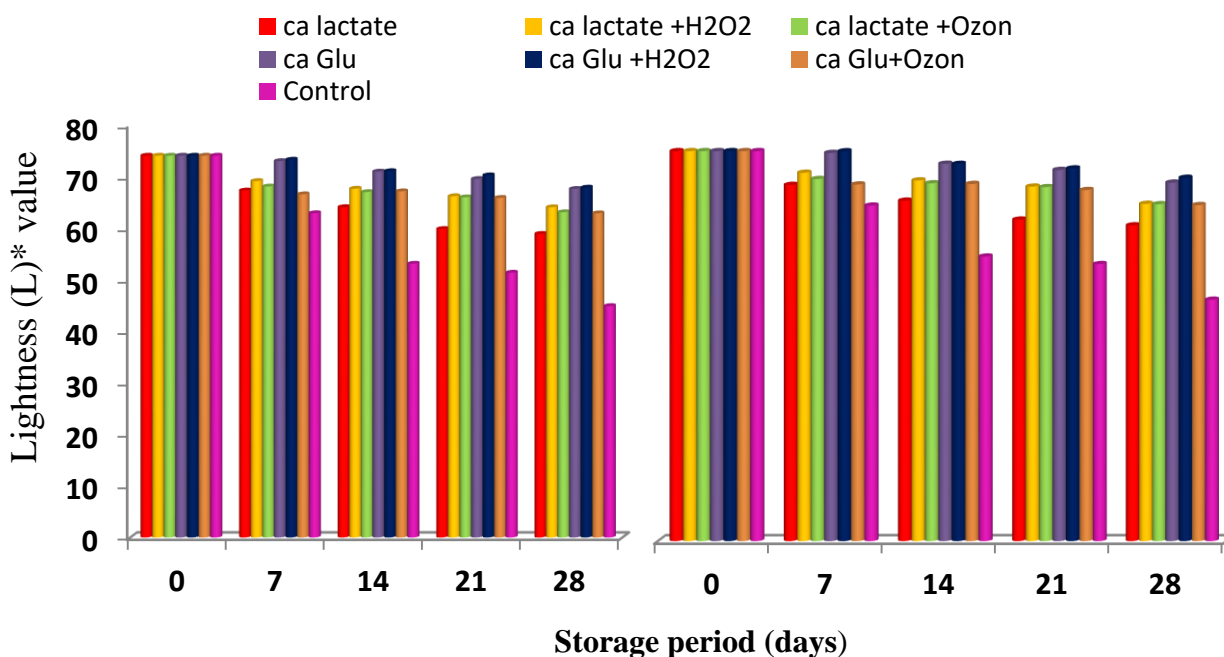


Data from **Figure (20)** highlighted distinct differences in the lightness values of internal flesh among the various postharvest treatments compared to the control across the tested seasons. Treatments with Calcium gluconate plus H<sub>2</sub>O<sub>2</sub>, and Calcium gluconate alone, were

particularly effective in maintaining the flesh color, corroborating findings by Munoz et al. (2006). The ability of calcium treatments to delay color changes or prevent darkening is potentially linked to their role in inhibiting senescence (Wang and Long 2015).



**Fig.(20).** Effect of calcium lactate and calcium gluconate treatments on the color lightness (L)\* value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



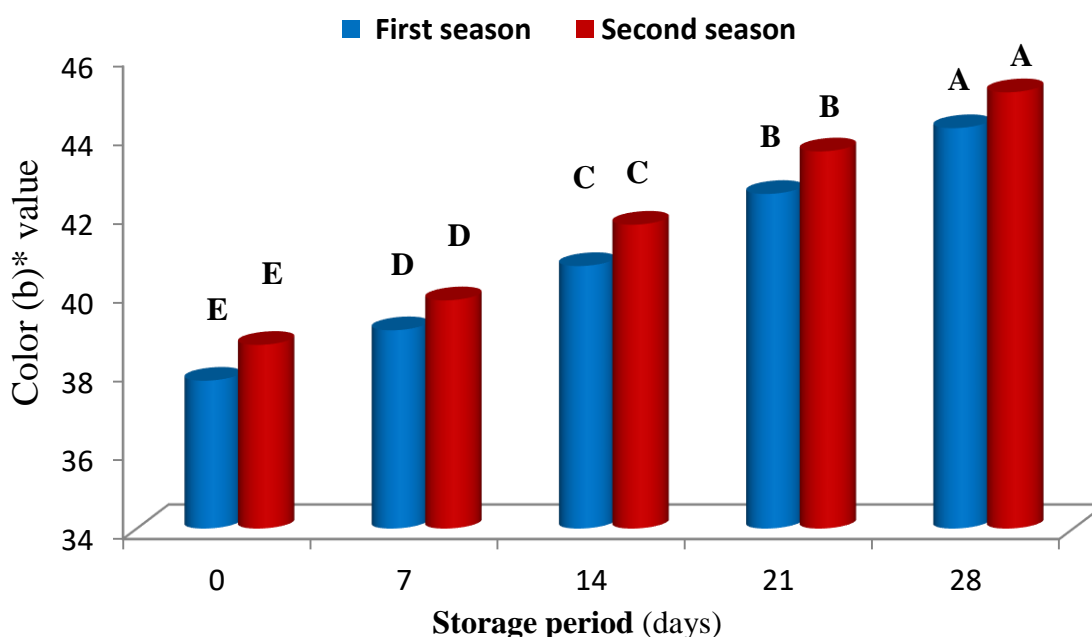
**Fig (21).** Interaction effect between postharvest treatments and storage periods on the color lightness (L)\* value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Furthermore, after 28 days of cold storage at 5°C in both seasons, an analysis of the relationship between storage durations and postharvest treatments illustrated in **Figure (21)** showed that the combination of calcium gluconate plus H<sub>2</sub>O<sub>2</sub> was the most effective treatments in maintaining color quality when compared to other treatments and the untreated control.

#### 8- Color (b)\* value (skin):

**Figure (22)** revealed that the (b)\* value, indicative of the yellow to orange

hue on the outer skin surface of fruits, increased significantly as the storage period extended at 5° and 95% RH over two seasons. These findings are consistent with previous studies by Atrass and Attia (2011) and Hafez (2016). The color transformation in cantaloupe from yellow to orange during storage is attributed to the degradation of chlorophyll and the synthesis of carotenoids, which contribute to the fruit's orange pigmentation (Muharrem et al., 2005).



**Fig. (22).** Effect of storage period on the color (b)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Data presented in **Figure (23)** highlighted significant differences in the (b\*) values among various postharvest treatments compared to the untreated control across both seasons. Treatments with Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> and

Calcium gluconate alone, were particularly effective, in delaying the color change. This was closely followed by the treatment with Calcium lactate plus H<sub>2</sub>O<sub>2</sub>. These results corroborate findings from Attia (2014) and Dike (2004).

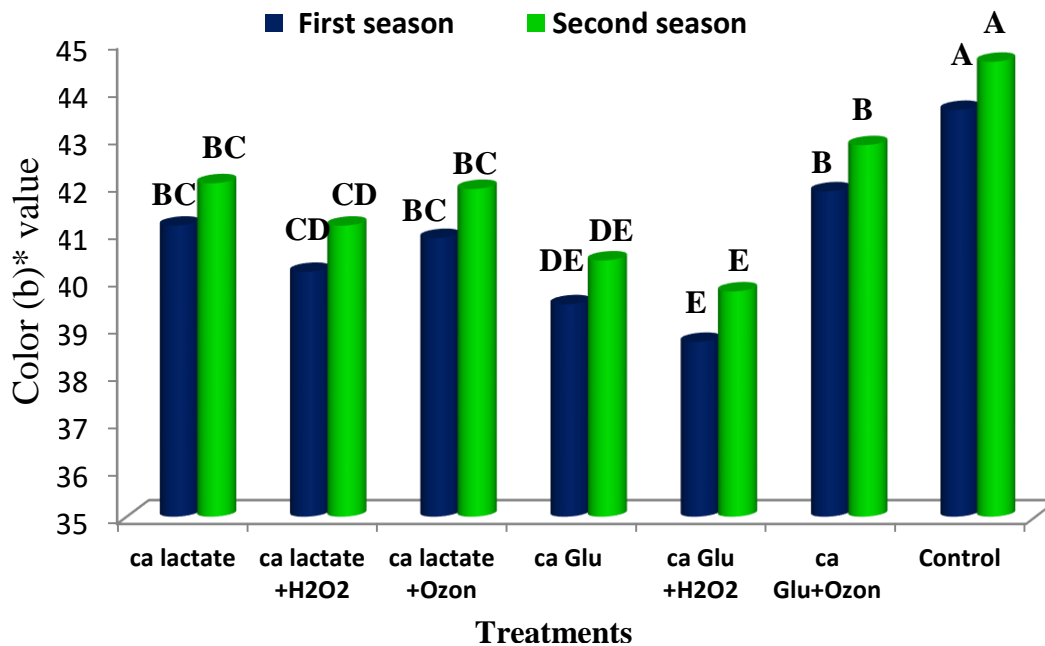


Fig.(23). Effect of calcium lactate and calcium gluconate treatments on the color (b)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

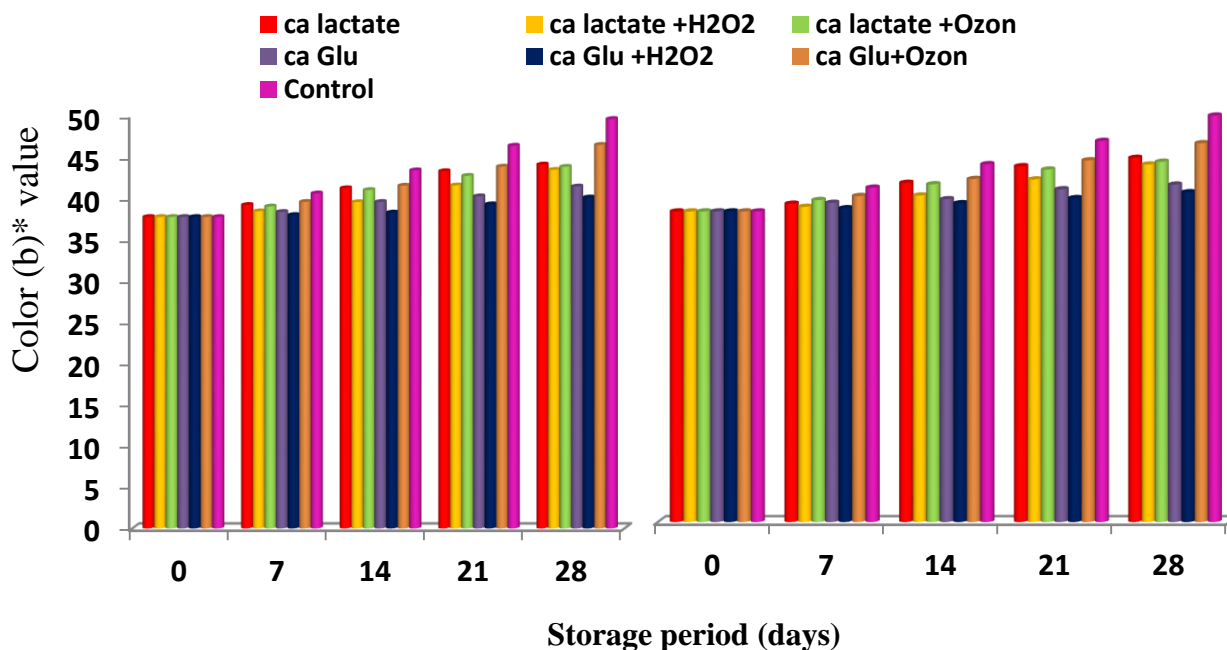


Fig (24). Interaction effect between postharvest treatments and storage periods on the color (b)\* value in the outer skin surface of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Furthermore, after 28 days of cold storage at 5°C over two seasons, the treatments involving Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> and Calcium gluconate alone were the most effective treatments in

maintaining color quality, outperforming other treatments and the control, as illustrated by the interactions between storage durations and postharvest treatments, as shown in **Figure (24)**.

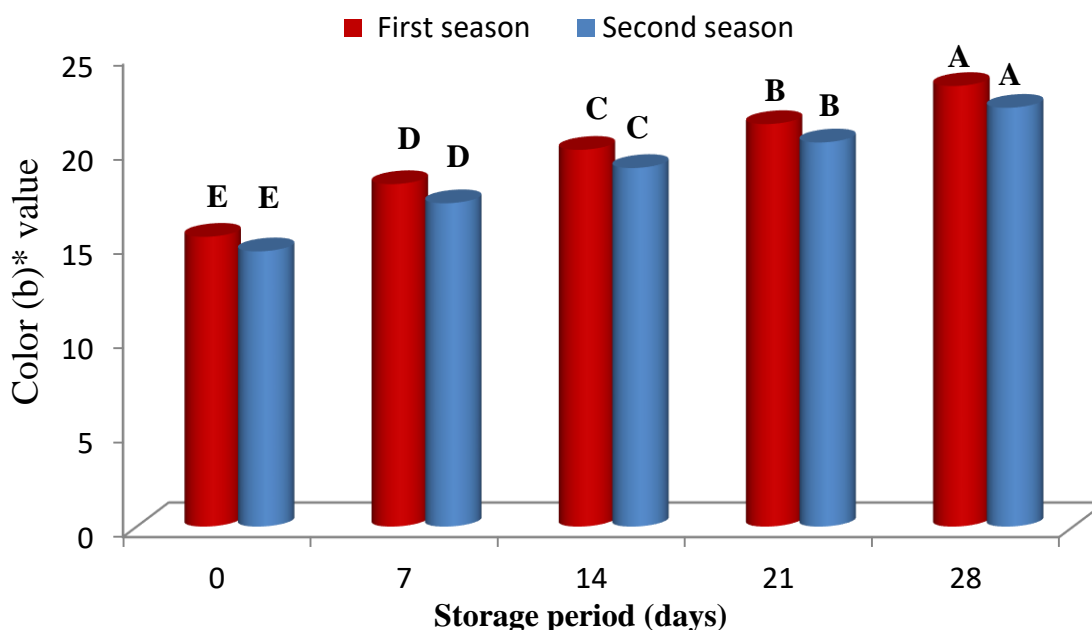


### 9- Color (b)\* value (flesh):

Analysis from **Figure (25)** demonstrated that the (b)\* value, which measures the yellow to orange tint of the internal flesh of cantaloupe fruits, significantly increased as the storage period extended at 5°C and 95% RH over two seasons. These findings align with previous studies by Atrass and Attia (2011) and Hafez (2016).

Results shown in **Figure (26)** revealed significant differences in the (b)\* values

across all postharvest treatments compared to untreated fruits during both seasons. Treatments involving Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> were particularly effective, exhibiting the lowest decline in color quality, closely followed by Calcium lactate, Calcium gluconate, and Calcium gluconate plus Ozone, with no significant differences noted among them. These outcomes are consistent with earlier research by Attia (2014) and Dike (2004).



**Fig. (25).** Effect of storage period on the color (b)\* value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Regarding the interaction between postharvest treatments and storage periods, data in **Figure (27)** indicated that Calcium gluconate plus H<sub>2</sub>O<sub>2</sub> was the most

effective treatment in keeping color quality compared to the remaining treatments and untreated control after 28 days of storage at 5°C in two seasons.

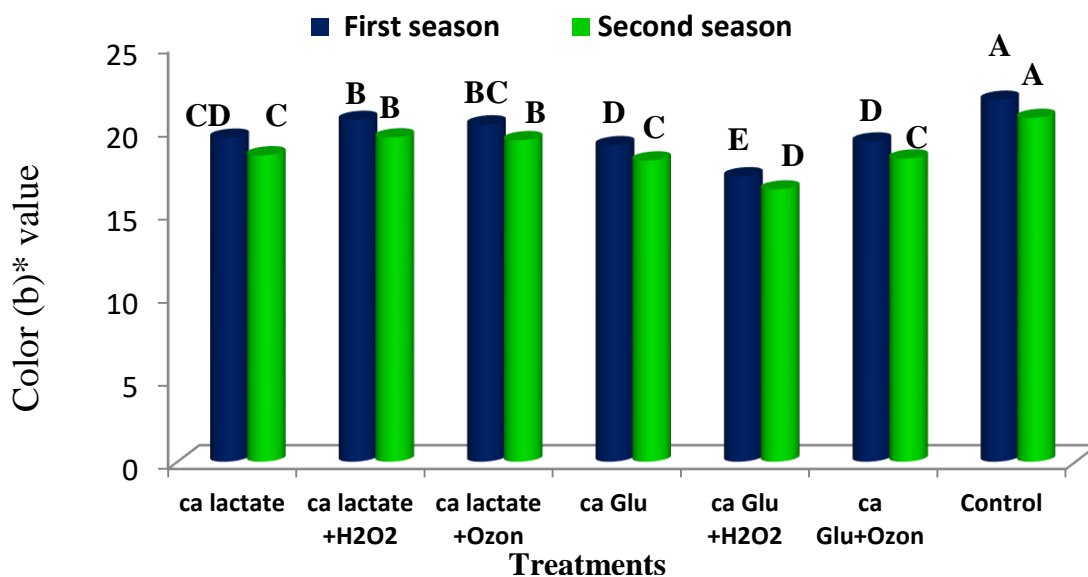


Fig.(26). Effect of calcium lactate and calcium gluconate treatments on the color (b) value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

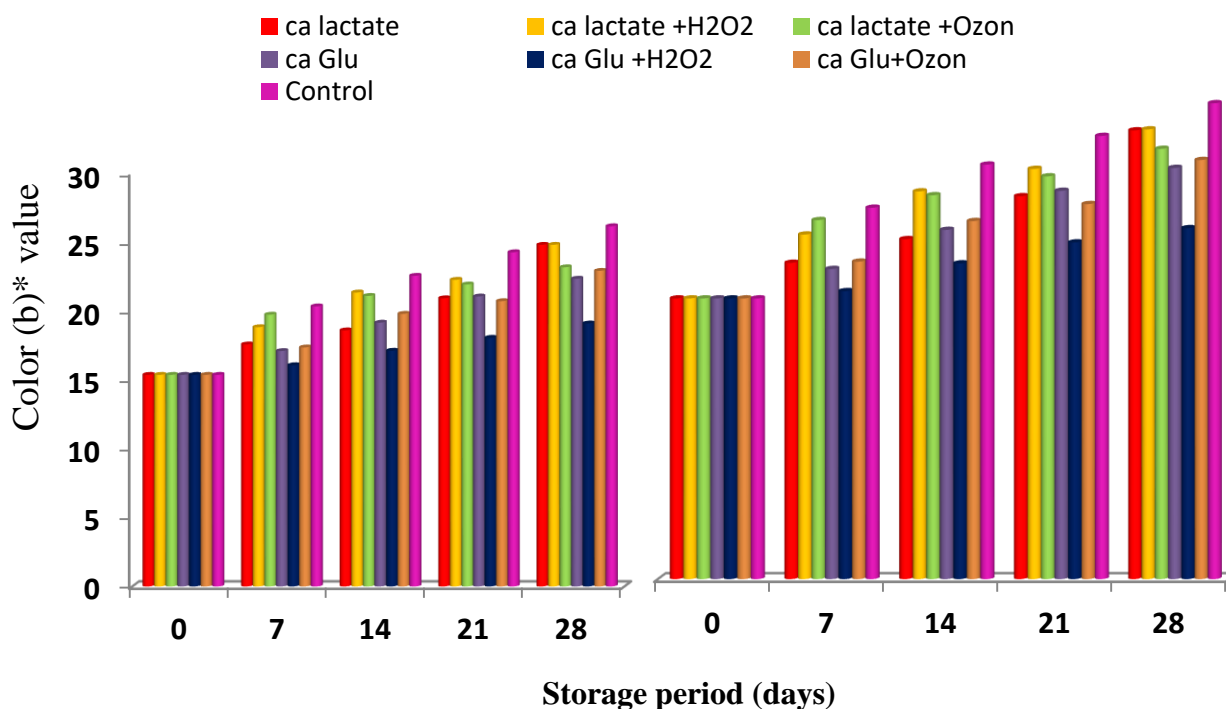


Fig (27). Interaction effect between postharvest treatments and storage periods on the color (b)\* value in the internal flesh of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

**10- Ascorbic acid content:**

Further findings in **Figure (28)** showed a significant reduction in L ascorbic acid content over 28 days of storage at 5°C, corroborating results by Hafez (2016). The impact of postharvest treatments on ascorbic acid levels was significant, as detailed in **Figure (29)**. Treatments with Calcium gluconate plus

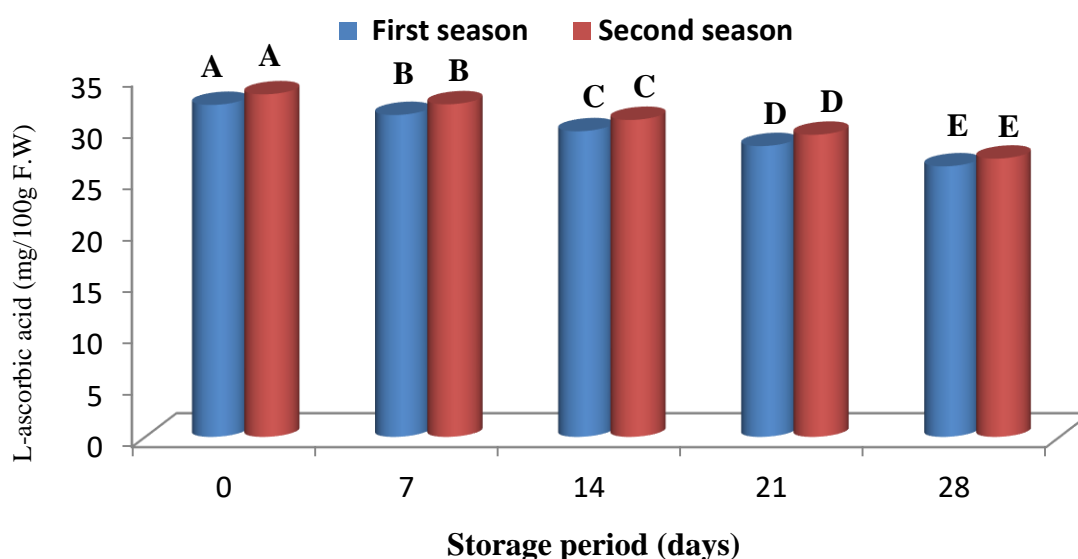
H<sub>2</sub>O<sub>2</sub>, and calcium gluconate alone, succeeded in preserving higher levels of ascorbic acid compared to the lowest levels observed in the untreated control. These consistent results across two seasons support the observations made by Erbaş and Koyuncu (2020). The ascorbic acid content in fruits increases in the ripening period could be due to availability of fruit



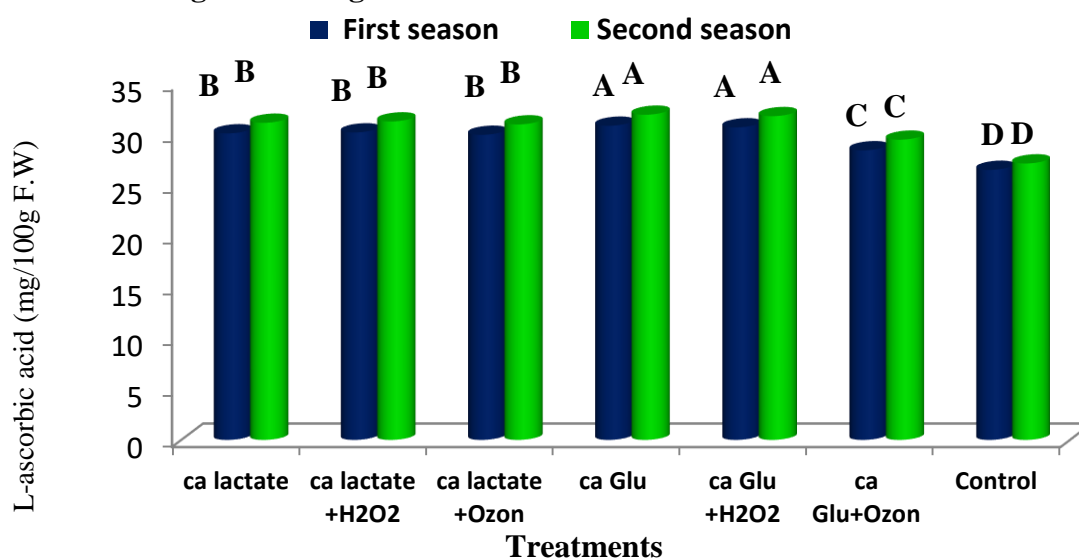
sugar, a precursor of ascorbic acid synthesis (Singh et al., 2005),

According to Erbaş and Koyuncu (2020), gluconic acid, a precursor in ascorbic acid production, may be responsible for the increase in total ascorbic acid observed with calcium gluconate therapy. Furthermore, 15 mM H<sub>2</sub>O<sub>2</sub> dramatically increased ascorbic acid levels during storage, according to Bayoumi (2008). The relationship between postharvest treatments and storage times was noteworthy, as **Figure (30)** illustrates. The ascorbic acid levels in the fruits were

lowest in the untreated group, while during a 28-day period at 5°C, the combination of calcium gluconate with H<sub>2</sub>O<sub>2</sub> and calcium gluconate alone demonstrated the greatest effectiveness in maintaining ascorbic acid levels, with no discernible differences between groups. Similarly, post-harvest application of calcium gluconate in the present study during storage was better in the retention of ascorbic acid compared to control, might be attributed to the slow rate of oxidation in the respiration process that delays the overall ripening and senescence (Deepthi et al., 2016).



**Fig. (28).** Effect of storage period on L-ascorbic acid (mg/100g F.W) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.



**Fig.(29).** Effect of calcium lactate and calcium gluconate treatments on L-ascorbic acid (mg/100g F.W) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

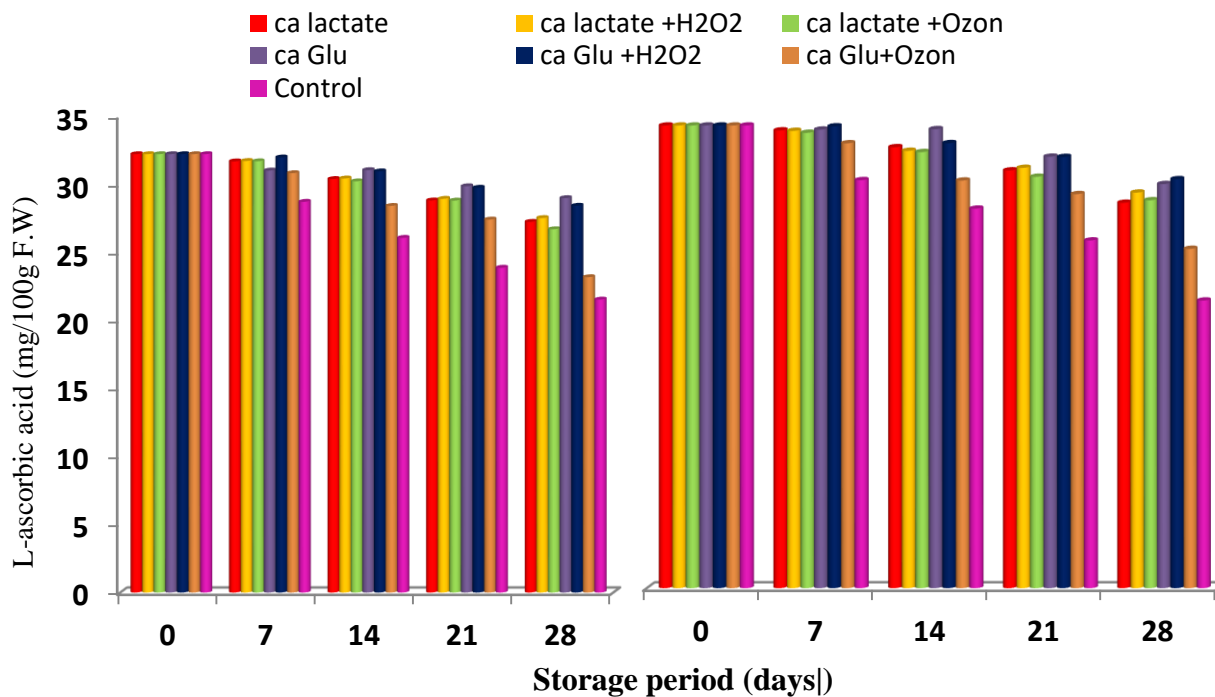


Fig (30). Interaction effect between postharvest treatments and storage periods on L-ascorbic acid (mg/100g F.W) of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

**11- Total sugar content:**

Analysis from **Figure (31)** highlighted the effects of calcium lactate and calcium gluconate treatments on the total sugar content in cantaloupe fruits. The results indicated a significant reduction in total

sugar percentage as storage time extended, in two seasons, corroborating findings by Hafez (2016) and Atrass and Attia (2011). According to Hafez (2016), this drop in total sugars is

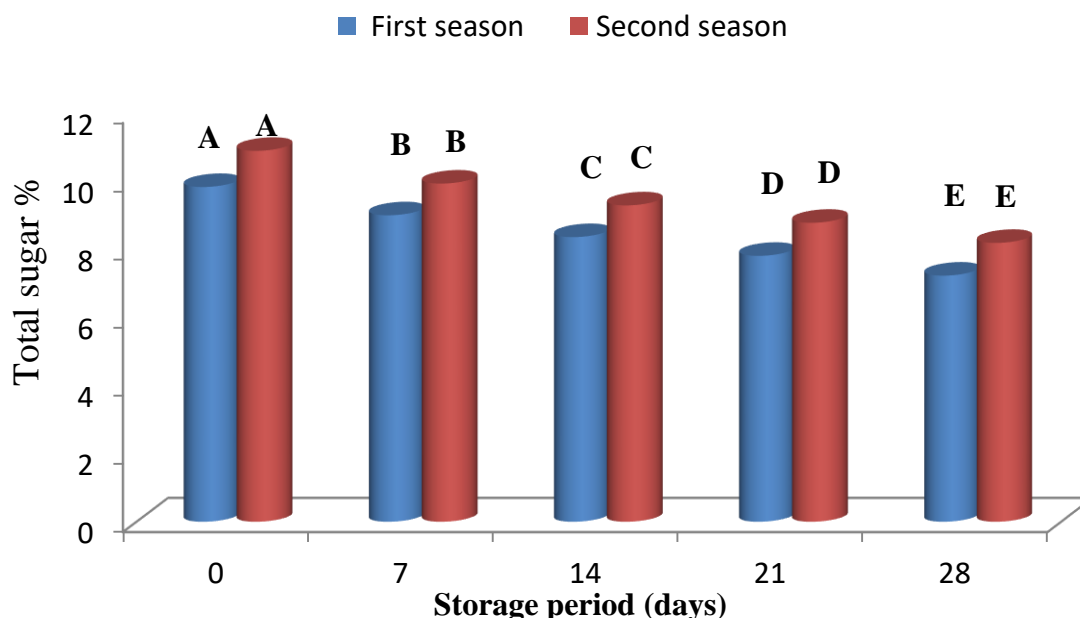


Fig. (31). Effect of storage period on total sugar % of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

Data from **Figure (32)** revealed that there were marked differences in total

sugar content between various postharvest treatments and the untreated control.



Treatments involving calcium gluconate plus H<sub>2</sub>O<sub>2</sub> were most effective at retaining sugar levels, closely followed by calcium gluconate alone, whereas probably the

result of their consumption during respiration and respiration's use of sugars may account for the drop in sugar levels during storage.

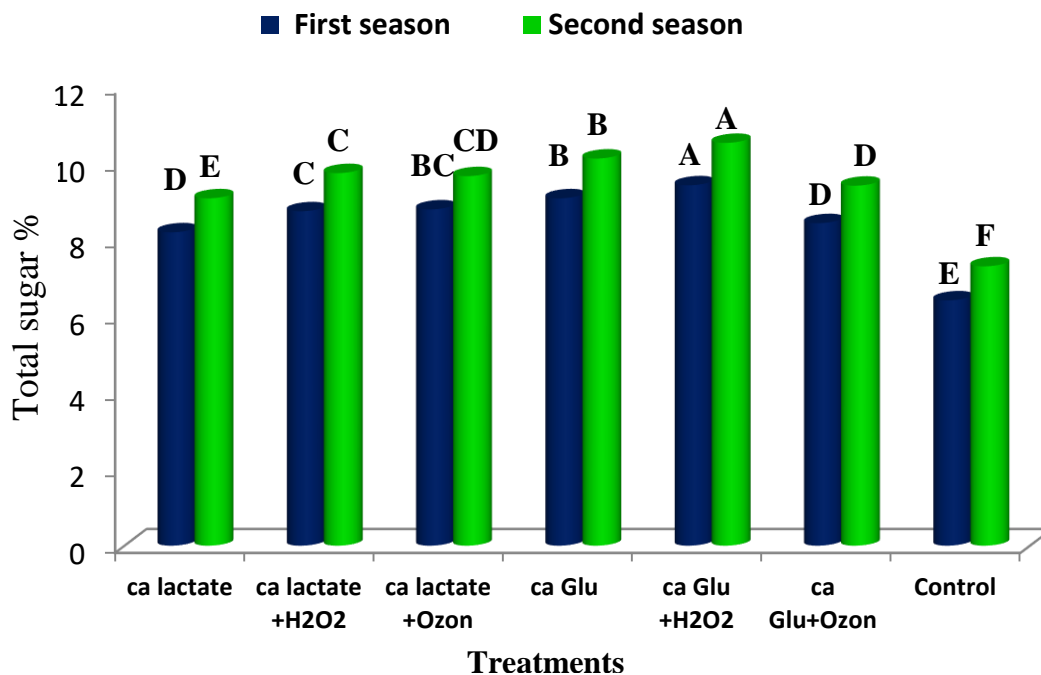


Fig.(32) Effect of calcium lactate and calcium gluconate treatments on total sugar % of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

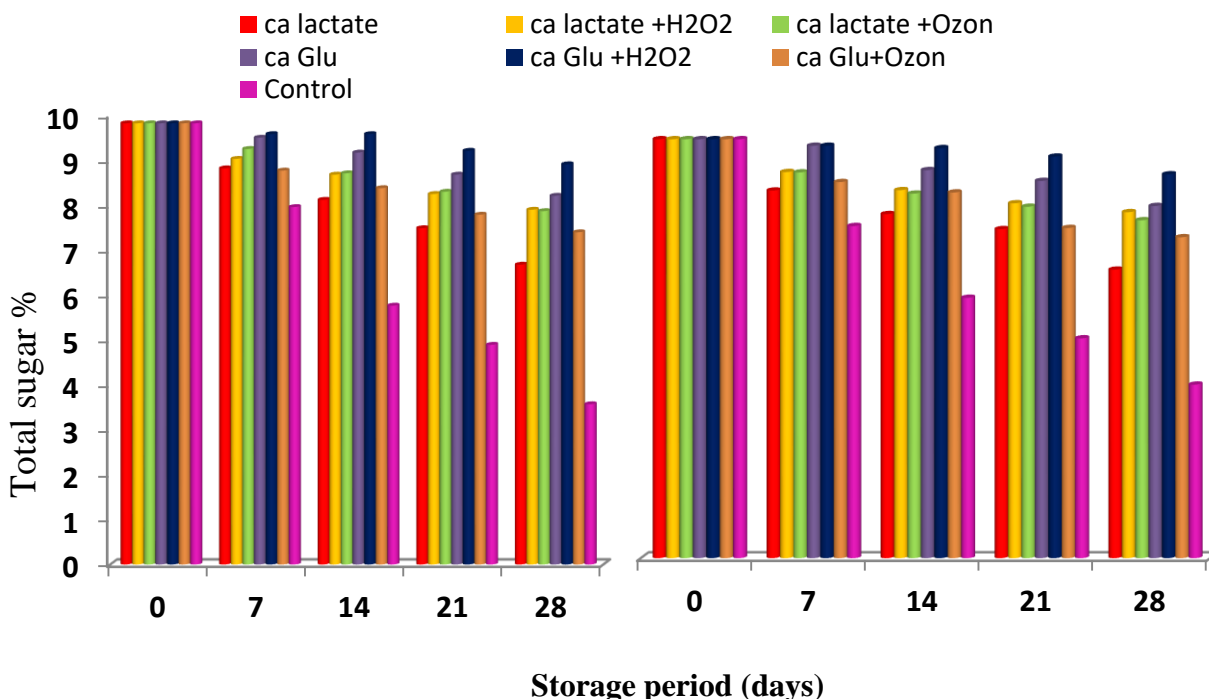


Fig. (33). Interaction effect between postharvest treatments and storage periods on total sugar % of cantaloupe fruits during cold storage at 5°C in the 2021 and 2022 seasons.

There were noticeable variations in the total sugar concentration between the

various postharvest treatments and the untreated control, according to data from



**Figure (32).** The fruits in the untreated control group had the least content of sugar, whereas the treatments using calcium gluconate plus  $H_2O_2$  were the most effective in maintaining sugar levels. These treatments were closely followed by calcium gluconate alone. These outcomes held true for the two studied seasons. According to Gharezi et al. (2012) there was an inverse association between fruit sugar content and calcium therapy, with calcium treatments tending to limit the growth in fruit sugar content.

The interaction between postharvest treatments and storage durations was significant across both seasons, particularly noticeable after 28 days of storage at  $5^\circ C$ . Cantaloupe fruits treated with calcium gluconate plus  $H_2O_2$  demonstrated superior efficacy in retaining

sugar content compared to other treatments. In contrast, untreated fruits showed the lowest sugar levels over the same period.

### CONCLUSIONS

Based on the findings, it is evident that the combination of calcium gluconate with  $H_2O_2$  proved to be the most effective treatment in reducing decay and weight loss, while also preserving the general appearance of the fruits. This treatment effectively maintained the firmness, color, total soluble solids, ascorbic acid levels, and sugar content of the cantaloupe fruits throughout the 28-day storage period at  $5^\circ C$ . These results underscore the efficacy of this treatment regimen in enhancing the overall quality and longevity of stored produce..

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## تأثير استخدام جلوكونات الكالسيوم ولاكتات الكالسيوم مع بعض المطهرات على صفات الجودة والقدرة التخزينية لثمار الكنتالوب

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اجريت هذه الدراسة خلال موسمي 2021 و 2022 على ثمار الكنتالوب صنف بريمال، طراز جاليا لدراسة تأثير معاملات ما بعد الحصاد لجلوكونات الكالسيوم ولاكتات الكالسيوم بمفردهما وبالمشاركة مع المطهرات مثل الأوزون وبيروكسيد الهيدروجين ( $H_2O_2$ )، وكذلك الماء المقطر كعامل مقارنة على الحفاظ على صفات الجودة والمظهر العام، الصلابة، اللون، تقليل التلف، تقليل فقد الوزن، وإطالة العمر التسويقي لثمار الكنتالوب أثناء التخزين علي درجة حرارة 5 درجة مئوية ورطوبة نسبية 95% لمدة 28 يوماً. أشارت النتائج إلى أن جميع معاملات ما بعد الحصاد تفوقت على معاملة الكنتالوب في انخفاض فقد الوزن والتلف والحفاظ على الصلابة واللون والمواد الصلبة الذائبة الكلية ومحتوى السكريات الكلية وحمض الأسكوربيك. كما أن معاملة ثمار الكنتالوب بجلوكونات الكالسيوم مع  $H_2O_2$  كانت الأكثر فعالية في الحفاظ على صفات الجودة وإعطاء الثمار مظهراً عاماً جيداً بعد 28 يوماً من التخزين علي درجة حرارة 5 درجة مئوية.