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RESEARCH ARTICLE

Maintenance of fresh-cut green onion quality and storability using some sanitizing treatments during cold storage

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Abstract

Fresh-cut green onions (*Allium cepa* L.) are highly perishable and deteriorate after harvesting due to rapidly undergoing biochemical and physiological changes in weight loss, general appearance, decay, relative chlorophyll content (SPAD), microbial count, and enzymatic spoilage. Therefore, the present study was conducted on green onions Photon cv. to study the effect of four sanitization treatments at concentration of sodium hypochlorite 100 mg/L for 2 min., peracetic acid 600 mg/L for 4 min., hydrogen peroxide 5% for 2 min., acetic acid 5% for 2 min. and control (distilled water) for 5 minutes on physical and chemical characters of fresh- cut green onions at (0˚C) with relative humidity of (90-95%) for twenty days during two successive seasons. The results obtained showed that treating green onions (fresh cut) with peracetic acid 600 mg/L was the most effective therapy for decreasing decay and weight loss. It maintained the general appearance, prevented root growth and leaf bending, and also reduced leaf expansion, maintaining chlorophyll and led to a decrease in polyphenol oxidase activity and microbial count, followed by hydrogen peroxide 5% compared with another treatment plants up to 20 days of cold storage. Hence peracetic acid 600 mg/L for 4 min. significantly proved to be a potential treatment to delay the deterioration and maintain the physical and chemical characteristics of fresh-cut green onions as compared to other treatments and control under cold storage conditions.

Keywords: Green onions; Sanitization; Quality attributes; Microbial count; Storage conditions

1. Introduction

Green onions (*Allium cepa* L.) are known for their distinctive aroma, pungency and flavour. It contains a high value of secondary components, such as macro- and micro-minerals and vitamins (B-carotene, folic acid, vitamins A and C). Bunching green onions, like most vegetables, present a significant difficulty as a minimally processed product since they quickly experience physiological and biochemical changes that impact their postharvest and shelf life. These changes include softening, weight loss, colour changes, and microbial and enzymatic spoiling. (Lwin *et al.*, 2013). Therefore, solutions to increase the marketability of bunching green onions that have undergone minimal processing must be developed.

Sterilize the surfaces of fresh products by washing and before packaging using physical or chemical methods, because they are effective in removing organisms from fresh cut products (Gil *et al.*, 2009).

Acetic acid and hydrogen peroxide are combined to create peracetic acid, also known as peroxyacetic acid. It was patented in 1950 to treat plant surfaces. Plant parts can be sprayed or dipped in it in the field or after harvest, to reduce decomposition caused by fungi and bacteria (Greenspan and Margulies, 1950). Food safety studies have been conducted on it, and it is available in appropriate solutions containing stabilizers. It is approved for use by the US Food

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and Drug Administration as a disinfectant for food contact surfaces and vegetable washing equipment. (FDA, 2017 a, b, c).

Peracetic acid has tremendous capabilities as a strong oxidant, so it is particularly used in the food industry. It does not produce harmful fruits and does not leave residues behind. It is also used in organic agricultural production. Valuable compounds used in chlorination can be replaced with this compound with fresh cut produce in disinfection and sanitation (Lo´pez-Ga´lvez *et al.,* 2009; Ho *et al.,* 2011; Pizzo *et al.,* 2023).

Hydrogen peroxide is a proposed alternative sterilization agent (Sao José and Vanetti 2015; Zhang and Yang 2017). It is antimicrobial and environmentally safe due to its low toxicity (Coswosck *et al.*, 2021). The organic acid acetic acid is also sterilized (Tian *et al.*, 2013; Valiolahi *et al.*, 2019; Kale *et al.,* 2021), these are natural components of fresh produce and are widely used as post-harvest additives. Hydrogen peroxide is generally considered safe (GRAS) and is commonly used for its antibacterial and antimicrobial activity (Park *et al.,* 2009).

Sodium hypochlorite is one the important used disinfectants due to its cost-effective use, broad-spectrum antimicrobial activity, and easy availability. Sodium hypochlorite has been used as a disinfecting agent to lower the amount of microbes on freshly cut and fresh vegetables (Santosh *et al.,* 2020).

This study aimed to investigate the effect of some sanitizing treatments of sodium hypochlorite, peracetic acid, hydrogen peroxide, and acetic acid on the extension of shelf life, maintaining quality attributes and reducing the decay of fresh-cut green onions at (0˚C) with relative humidity of (90-95%).

2. Material and methods

Using standard farming methods, green onions (*Allium cepa* L.) Photon cv. are grown on a private farm in El Khatatba District, El Monufia Governorate, Egypt. Plants were harvested during the third week of January in the first and second seasons of 2022 and 2023, respectively, when the bulb diameter was between 12 and 16 mm. Plants were transferred to the postharvest laboratory of the Vegetable Handling Department, Horticulture Research Center. directly under cooling (by refrigerated transport vehicle). Plants were selected after being pruned (leaf tips and roots cut), sorted into consistent sizes (25 cm length), and cleaned with tap water. Flawless plants (10 plants/bouquet) were grouped and tied using rubber bands, and dipped 5 cm from the white stem as follows: Dipping in the solution of sodium hypochlorite 100 mg/L for 2 min., peracetic acid 600 mg/L for 4 min., hydrogen peroxide 5% for 2 min., acetic acid 5% for 2 min. and five minutes of tap water served as the control.

Eighteen replicates of each treatment were placed inside cardboard boxes with dimensions (35 x 22 x 7 cm), three replicates were arranged in a completely randomized design and were stored at 0°C with 95% relative humidity, and the samples were examined. Every 4 days, a sample is taken for examination up to 20 days. The following measurements were recorded:

2.1. Weight Loss Percentage (%)

The weight reduction% was measured in accordance with the description of Zhan *et al.* (2013).

2.2. Decay Percentage (%)

At every sampling interval, the samples' surface appearance was visually inspected. Deteriorated samples included soft rot, discoloration flaws, or fungal development (Hong *et al.,* 2000).

2.3. General Appearance (GA)

General Appearance was assessed on a scale of 1 to 9, where plants with a rating of 5 or lower were deemed unsalable, and those with a score of 9 or better were judged excellent, 7 or good, 5 or fair, 3 or poor, and 1 or unsalable (the panel tests for general appearance, decay, and chilling injury, evaluated by seven researchers at the postharvest vegetable lab.).

2.4. Leaf extension growth

Leaf extension growth was measured as the distance from the cut surface of the green leaf base to the end of the greatest extended section during storage using a vernier caliper, accurate to the nearest 0.1 mm.

2.5. Root growth

Root growth was measured in undamaged green onions that had their roots cut using a vernier caliper. A score of 1 to 5 was employed, with 1 representing none, 2 representing 1 to 2 mm, 3 representing 3 to 5 mm, 4 representing 6 to 10 mm, and 5 representing 11 to 15 mm.

2.6. Leaf curvature

1 = none, 2 = curvature of stem or leaf up to 15° from the horizontal, 3 = 15 - 30°, 4 = 30 - 45°, and 5 > 45° from the horizontal were the possible scores (Hong *et al*., 2000).

2.7. Total chlorophyll

Total chlorophyll used the Minolta Chlorophyll Meter Spad, 502 to measure.

2.8. Enzyme Assay PPO Activity

With the following modification, the approach of Dogan *et al.* (2002) was used to measure PPO activity. The findings were presented as a percentage of the corresponding zero experiments' activity.

2.9. Total microbial count

Plate count agar medium was used to calculate the total number of plates. The plates were incubated for 48±2 hours at 35 ºC. (Andrews, 1992).

2.10. Statistical analysis

Three measurements were made for each parameter at each storage time. With SPSS (version 11.0), the gathered data were submitted for analysis of variance. The effect of treatments on measured parameters during storage was compared using a one-way ANOVA with a 0.05 confidence level and the least significant difference (LSD) test.

3. Results

3.1. Weight Loss (%)

Data in Fig. 1 demonstrated a rise in the weight loss% of a fresh cut green onion while stored. These results were consistent with Shehata *et al.* (2017) green onion and respiration, transpiration, and various other metabolic processes associated with senescence during storage are often the cause (Frezza *et al.*, 2011).

The results of the sterilization treatments revealed that the percentage of weight loss varied significantly amongst the treatments. However, all sterilization treatments resulted in lower weight loss compared to the untreated control. Plants immersed in a 600 mg/L peracetic acid solution for 4 minutes or 5% hydrogen peroxide for 2 minutes gave the lowest percentage of weight loss, with no significant differences between them in both seasons. The highest value of weight loss percentage was in untreated plants (control). Sterilization treatment reduced respiratory rates (Irakoze *et al.*, 2022). These results were consistent with those obtained (Saito *et al.*, 2021; Pizzo *et al.*, 2023).

The percentage of weight loss in untreated plants rose during the storage duration and reached a maximum loss at the end of storage (20 days), according to observations made about the interaction between the sterilizing treatments and the storage period. Compared to other treatments in both seasons, the percentage of weight loss was more inhibited in green onions dipped in a solution of peracetic acid 600 mg/L for 4 minutes or a solution of hydrogen peroxide 5% for 2 minutes and stored for 4 days.

3.2. Decay (%)

Data in Fig. 1 showed that the decay% started slowly and then gradually increased until the end of the storage period. These results consist of Hong *et al.* (2000) and Shehata *et al.* (2017). However, dipped green onion in all sanitizing

treatments was effective in reducing decay% compared with untreated plants (control) during storage. The most effective treatment was 600 mg/L of peracetic acid solution for 4 minutes. These results were consistent with (Saito *et al.*, 2021) which may be related to the washing of natural disease-causing germs from fruit surfaces. Conversely, the decay value was higher in the untreated control.

However, there was a substantial interaction between the storage period and the sanitizing treatments for green onion plants dipped in peracetic acid 600 mg/L for 4 min and did not show any decay till 16 days. The decay% was observed after 4 days of storage for untreated control.

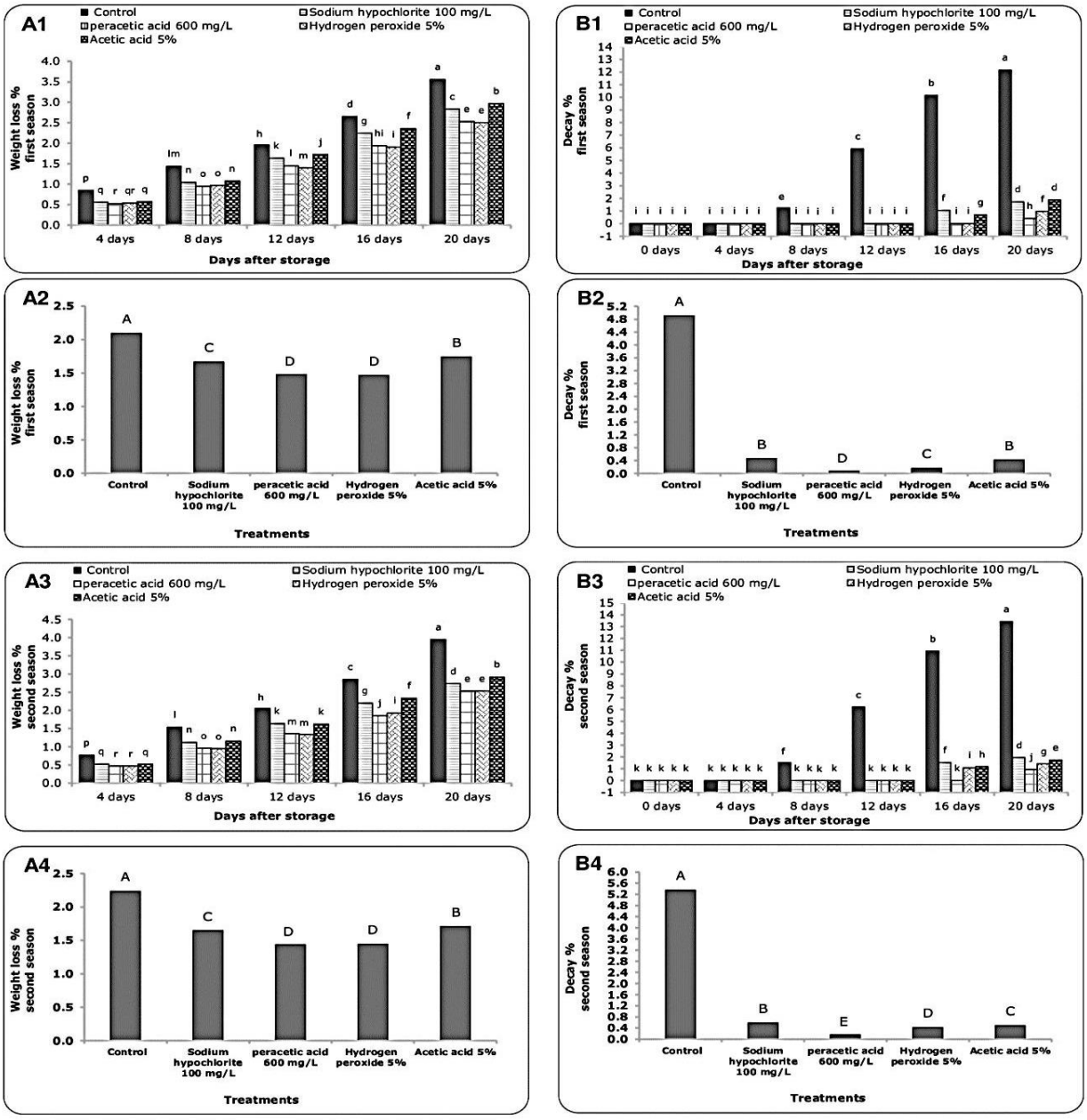

FIGURE 1

Effect of some sanitizing treatments on weight loss % (a1, 2, 3, 4) and decay % (b1, 2, 3, 4) of green onions during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

1

3.3. General Appearance (GA)

Results presented in Fig. 2 showed that the GA steadily reduced and that the overall appearance of fresh-cut green onions diminished till the conclusion of the storage period. Shehata *et al.* (2010); Frezza *et al.* (2011) found that the degradation (discoloration) of the outermost leaf, yellowing, leaf growth extension, and decay were the primary causes of GA loss in green onions.

On the other hand, fresh-cut green onions that were dipped in sanitizing treatments generally had good GA during cold storage, with notable variations between them and the untreated control. Maintaining GA was best achieved with either 5% hydrogen peroxide for 2 minutes or 600 mg/L peracetic acid for 4 minutes. These results were consistent with Shehata *et al.* (2010) and Shehata *et al.* (2017) on green onion.

As for the interaction, fresh cut green onion treated with peracetic acid 600 mg/L for 4 min or hydrogen peroxide 5% for 2 min had significantly preserved GA till 16 days in comparison to other treatments of storage at 0º C in the two seasons.

3.4. Leaf and root Extensions

The results in Fig. 2 and 3 reveal an increase in the growth and extension of fresh cut green onion leaves, as well as the growth of roots, as the growth and extension of leaves and roots reached 4.11 mm and 2.57 degrees (average of two seasons), respectively, till the end of storage. The augmentation of root and leaf growth has an adverse effect on the quality of the market (Shehata *et al.*, 2017). These results were correct in two seasons and agreed with (Hong *et al.*, 2000). However, the most successful treatments for inhibiting the growth of roots and leaf extension without causing obvious damage were fresh cut green onions that were dipped in 600 mg/L of peracetic acid for 4 min. Cantwell *et al.* (2001) Show that unless a green onion has additional flaws, a 5 mm leaf extension growth is not obvious enough to make it unmarketable. These results were correct in two seasons and agreed with Shehata *et al.* (2017).

In general, the interaction between treatments and storage period on growth of leaf and root extensions was significant during storage; While untreated treatment plants (control) recorded the highest value of leaf and root extension, plants dipped in a solution of peracetic acid 600 mg/L or hydrogen peroxide 5% proved to be the most efficient treatments in lowering such features during the storage period. These results were true in the both seasons and agreed with Hong *et al.*, (2000).

3.5. Leaf Curvature

A prevalent flaw in commercially available fresh cut green onions is curved leaves. Data in Fig. 3 suggested that the degree of leaf curvature was gradually increasing. After 8 days, the curve of the leaf emerged. When the leaves were stored for a full 20 days, the degree of curvature increased the most. These results were consisted with Shehata *et al.* (2017) on green onions during two seasons. However, fresh cut green onions dipped in peracetic acid 600 mg/L for 4 min. were highly effective in retarding curvature of leafs in two seasons (Shehata *et al.*, 2010).

However, fresh cut green onions treated with peracetic acid 600 mg/L for 4 min. and hydrogen peroxide 5% controlled the leaf curvature, while untreated treatment plants (control) recorded the lowest value of leaf curvature during storage. The interaction between treatments and storage period on leaf curvature was significant.

3.6. Chlorophyll content

Data presented in Fig. 4 demonstrate a steady and notable drop in the amount of chlorophyll. Freshly cut green onions typically turned a yellowish green color. The breakdown of chlorophyllase activity and the transformation of chloroplasts into chromoplasts (colorless) could be the cause of the drop in chlorophyll content.These results were consisted with Emam (2009), Shehata *et al.* (2010) and Frezza *et al.* (2011) on green onion in both seasons.

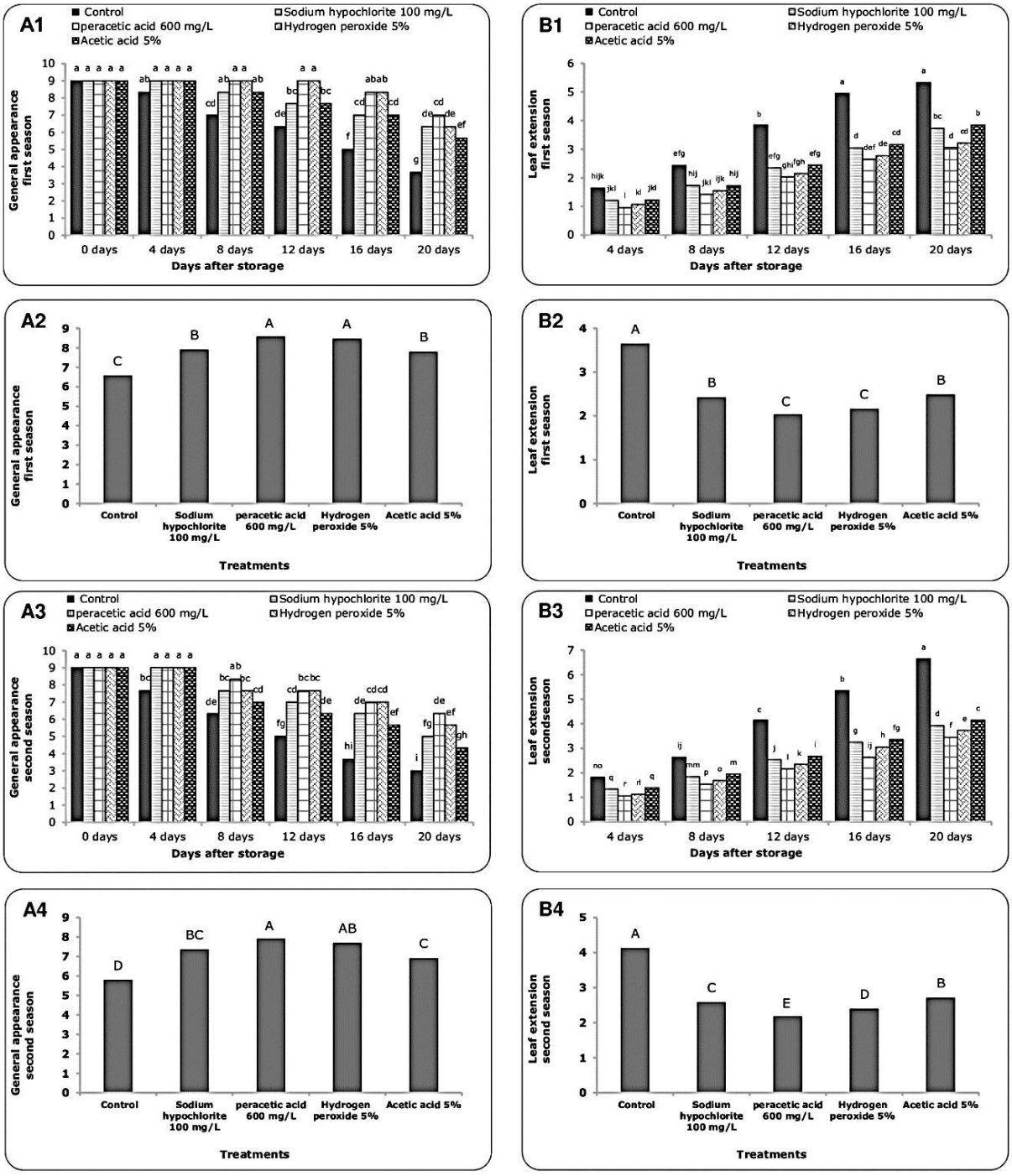

FIGURE 2

Effect of some sanitizing treatments on general appearance (a1, 2, 3, 4) and leaf extension (b1, 2, 3, 4) of green onions during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

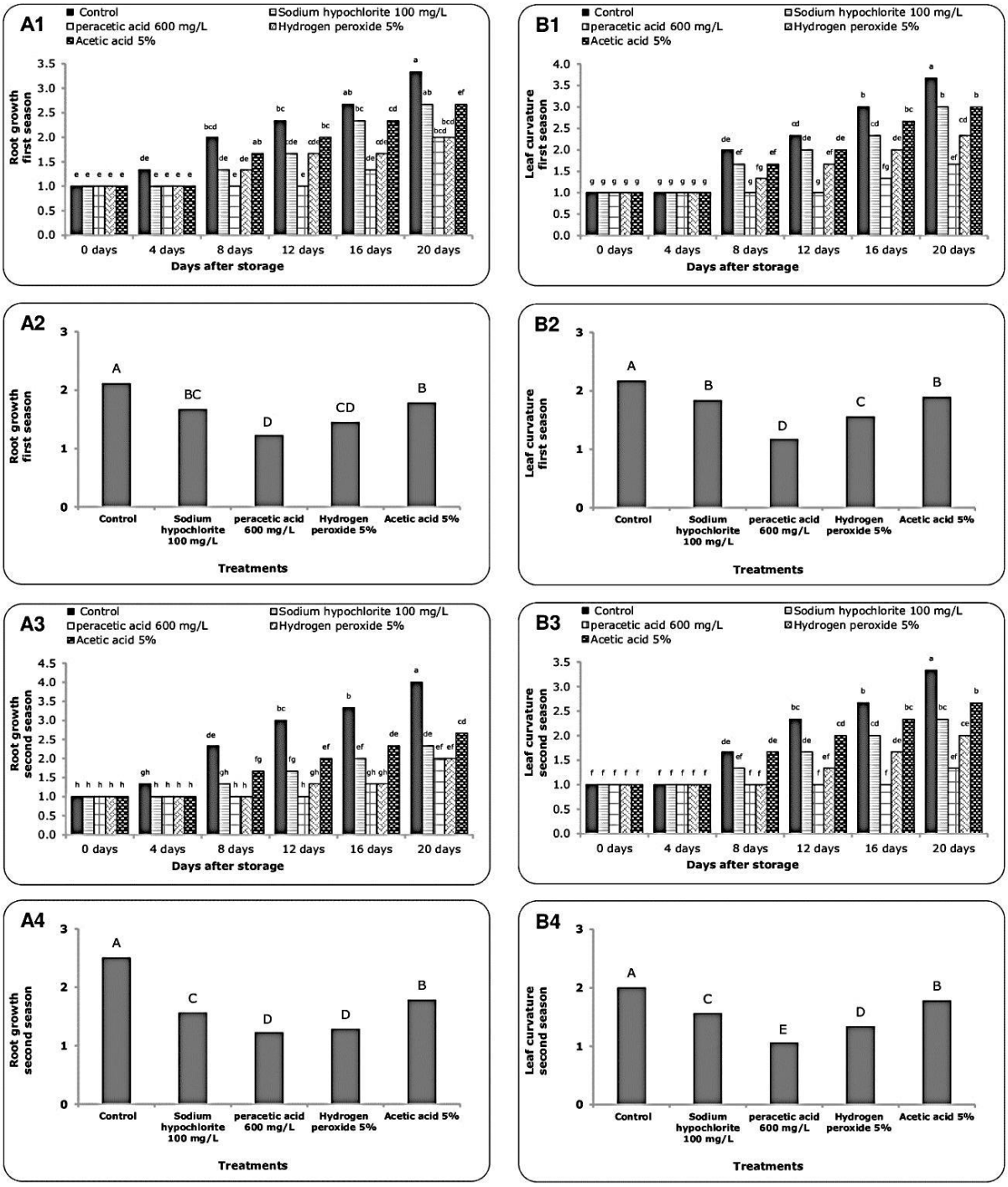

FIGURE 3

Effect of some sanitizing treatments on root growth (a1, 2, 3, 4) and Leaf curvature (b1, 2, 3, 4) of green onions during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

Regarding treatments, it is clear from the results that plants dipped in a solution of peracetic acid 600 mg/L for 4 min significantly reduced degradation of chlorophyll of fresh cut green onion compared with other treatments, in both seasons. In general, untreated green onion leaves (control) contained the lowest value in chlorophyll contents. These results were consisted with the findings of Shehata *et al.* (2017). On the chlorophyll measurement, there was a substantial interaction between the storage duration and the treatments. The most successful therapies, however, were fresh sliced green onions bathed in 600 mg/L of peracetic acid for 4 minutes, which preserved the chlorophyll. But during cold storage, the untreated control had the lowest value.

3.7. Polyphenolic oxidase activity (PPO)

Data in Fig. 4 shows a significant increase in PPO enzyme activity with extended storage period. The increased PPO activity in the control treatment is mainly due to the activation process from the latent form to the fully active form. As previously reported by Howard *et al.* (1994) and Jaramillo *et al.* (2022) involves wounding of tissue-embedded mineralization of cellular components with subsequent release of proteases involving a cascade of reactions leading to activation of the latent PPO.

Comparing peracetic acid to other treatments, treatment results indicated a considerable reduction in polyphenol oxidase activity. Green onions' polyphenol oxidase activity can be effectively delayed by acetic acid. These results are consistent with (Kocira *et al.*, 2021).

The interaction between all treatments and storage period, results indicated that dipped fresh cut onions in peracetic acid and stored for 20 days had effectiveness in detracting the activity of polyphenol oxidase compared with untreated plants. The direct effect of peracetic acid on polyphenol oxidase might be related to the direct denaturation of its protein (Kocira *et al.*, 2021).

3.8. Total microbial count

In Fig. 5, the total microbial count and storage period were shown to have a linear relationship, with an increase in storage length corresponding to a rise in total microbial count. These results were consisted with Lo´pez-Ga´lvez *et al.* (2009). Conversely, the best treatment for reducing the overall microbial count in both seasons was dipping peracetic acid, followed by 5% hydrogen peroxide. The same result was obtained by (Pizzo *et al.*, 2023) who reported that peracetic acid can provide ideal conditions for the growth of microorganisms, the use of hydrogen peroxide also prevents some of the microorganisms' growth (Martinez-Tellez *et al.*, 2009).

Significant differences were seen in the interaction between the treatments and the storage duration. It was observed that all treatments, particularly the application of peracetic acid during the storage period, had an impact on the quantity of microorganisms. Subsequently, as the storage duration lengthened in both seasons, a discernible rise in the overall microbial count was noted.

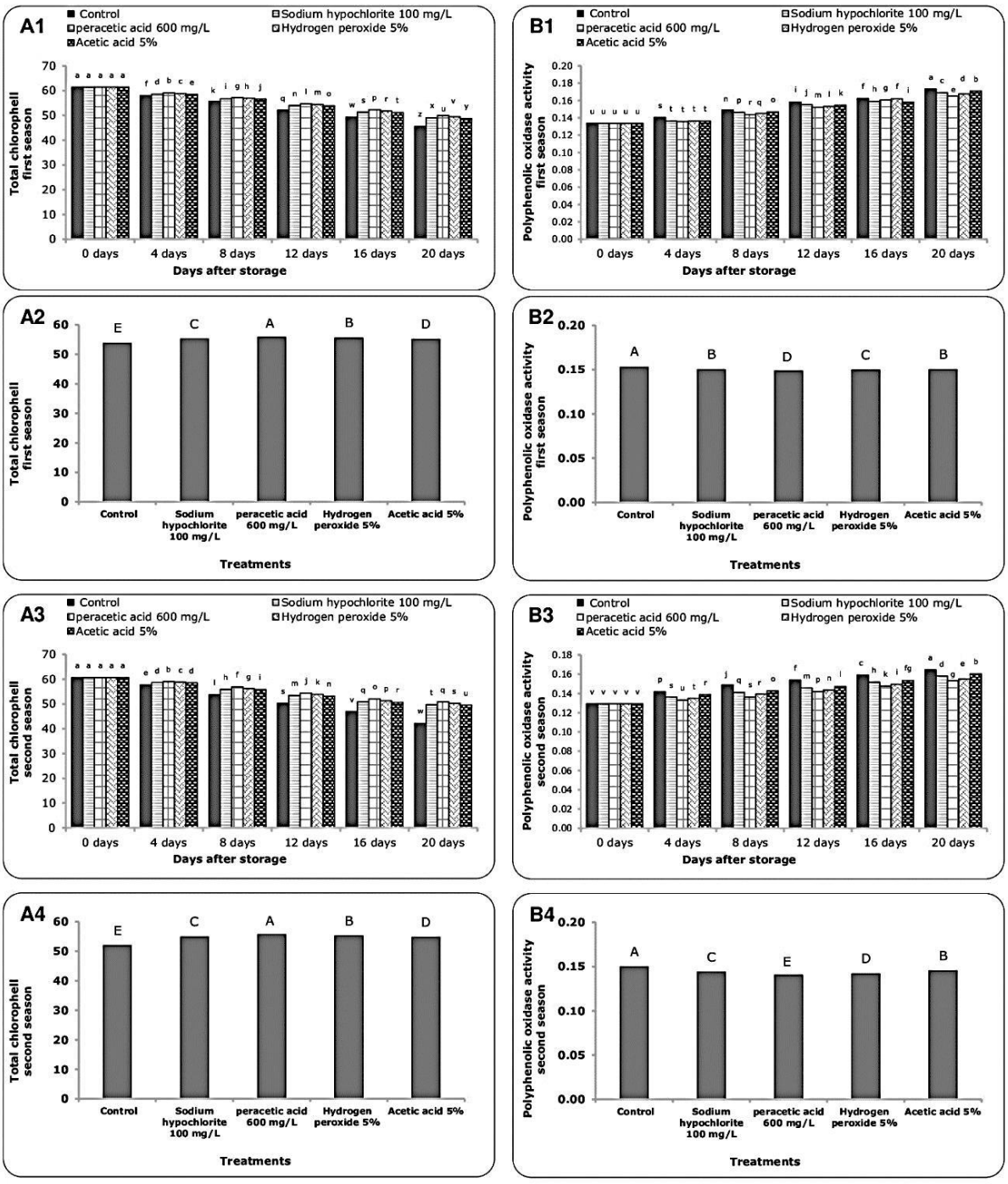

FIGURE 4

Effect of some sanitizing treatments on total chlorophell, (a1, 2, 3, 4) and polyphenolic oxidase activity (PPO) (b1, 2, 3, 4) of green onions during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

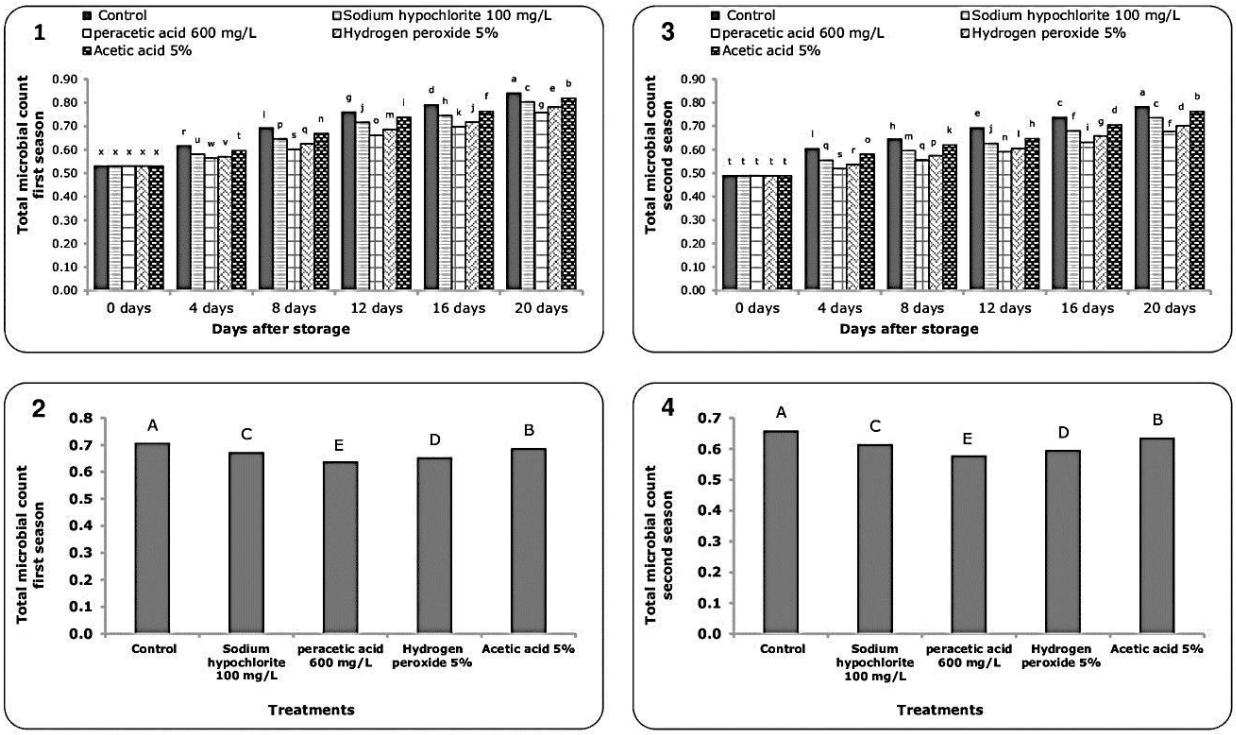

FIGURE 5

Effect of some sanitizing treatments on total microbial count (1, 2, 3, 4) of green onions during cold storage. Values followed by the same letter (s) are not significantly different at 5%.

4. Discussion

The purpose of this study was to examine the effects of sanitization treatments on the physical and chemical characteristics of fresh-cut green onions stored in the cold for 20 days throughout two consecutive seasons at 0˚C and 90–95% relative humidity **.**

The best treatment for preventing weight loss and deterioration was to treat fresh green onions with 600 mg/L of peracetic acid, according to the results. In comparison to another treatment plant, it preserved the overall appearance, inhibited root growth and leaf bending, and decreased leaf expansion while preserving chlorophyll. This was followed by a decrease in polyphenol oxidase activity and microbial count and a decrease in hydrogen peroxide 5% after 20 days of cold storage.

The findings demonstrated that cleaning fresh-cut green onions can protect them from post-harvest infections and stop them from deteriorating during storage. Concerning sanitization treatments, the food sector uses solutions of peracetic acid, which are particularly useful because of their potent oxidizing power (derived from hydrogen peroxide and acetic acid). It doesn't leave any residues or yield any dangerous fruits. According to Quan *et al.* (2008), H_2O_2 is involved in a variety of resistance mechanisms, including phytoalexin synthesis, plant cell wall fortification, and increased resistance to different stresses. Several phytopathogenic fungi and bacteria were shown

to be susceptible to the fungicidal and bactericidal effects of acetic acid. (Kang et *al.*, 2003).

The findings demonstrated that extending the storage period resulted in fresh-cut green onions turning yellowish green, increased deterioration, weight loss, and overall appearance. This gradual and significant decrease in chlorophyll content may have been caused by ongoing biochemical changes in fruits, such as increased respiration rates and the breakdown of complex compounds into simpler forms, which makes them more susceptible to fungal infection (Wills *et al.*, 1998). The breakdown of chlorophyllase activity and the transformation of chloroplasts into chromoplasts could be the cause of the drop in chlorophyll content. These results were consistent with Emam (2009), Shehata *et al.* (2010) and Frezza *et al.* (2011).

5. Conclusions

This study suggested that peracetic acid 600 mg/L for 4 min significantly proved to be a potential treatment to delay deterioration and maintain physical characteristics and chemical characteristics, such as reducing weight loss, decay percentage, leaf extension growth root growth, and leaf curvature, maintained of general appearance, chlorophyll, delaying polyphenol oxidase activity and reducing microbial count of fresh- cut green onions as compared to other treatments and control under cold storage conditions. Moreover, further research is required to increase the shelf-life of fresh-cut vegetables including green onions.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are included in this published study.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MAAA, and HAI conceived and designed the study. MAAA and SMA cultivation field experiment and laboratory tests during data collection. Data entry, cleaning, and analysis were carried out by HAI and SMA. The initial draft of the manuscript was prepared through collaboration among MAAA, HAI and SMA, with all authors contributing to the review and approval of the final manuscript. The integrity and accuracy of the data analysis are collectively assumed by all authors. The final manuscript underwent a thorough review and received approval from each author.

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