# Effect of Melatonin and Ascorbic Acid Application on Delay of Senescence and Keeping Quality of Fresh Broccoli Florets.

**Abou-Elwafa S. M. and Safaa Zakaria**

Postharvest and Handling of Vegetable Crops Dept., Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.

## ABSTRACT

Broccoli (*Brassica oleracea* L.) is rapidly perishable because of the loss of green color and the consequent yellowing of florets after harvest at ambient temperature. Therefore, the purpose of the study was to investigate the effects of melatonin (MT) solutions at 75, 100 and 125 µM and ascorbic acid (AA) solution at 0.5, 1 and 1.5% in addition to control on delay of senescence and quality attributes, and shelf life extending of fresh broccoli florets after harvest and during cold storage at 5˚C and 90-95% relative humidity for 16 days, during two successive seasons of 2024 and 2025. The obtained results revealed that the application of melatonin at 100 µM was notably effective in reducing weight loss. Moreover, giving a good general appearance (score) and retention of green color (high hue angle), maintained lightness after 16 days at 5°C and as well as maintained the total content of chlorophyll, photonic content and vitamin C. Whereas, ascorbic acid treatments were less effective in this concern in two tested seasons.

**Keywords:** Broccoli- Melatonin- Ascorbic Acid- Total Chlorophyll- Total Phenolic.

## INTRODUCTION

Broccoli (*Brassica oleracea* var. italica) is a Brassica genus vegetable used worldwide vegetable with high nutritional value and health benefits, due to its richness in vitamins, antioxidants, anti-carcinogenic substances and health-promoting phytochemicals such as glucosinolates (Yuan et al., 2010.) Epidemiological studies have shown an inverse association between the consumption of Brassica vegetables and the risk of cancer (Day et al., 1994).

Broccoli is a highly perishable vegetable that senesces quickly after harvest and thus its postharvest life is quite short due to yellowing, softening, water loss, decay and off-odor incidences a storage life of 3 to 4 weeks in 0 °C and 95% RH and 2 to 3 days at 20 °C (Vasconcelos and Almeida, 2003). Yellowing caused by either chlorophyll loss or blooming of the buds is a common problem intimately related to ethylene concentration and temperature of storage (Zhuang et al., 1995). During the postharvest period, inflorescences lose their green color, turn yellow and decrease their nutritional and quality, diminishing the concentration of proteins, sugars, ascorbic acid and glucosinolates (Jia et al., 2009).

Melatonin (N-acetyl-5-methoxytryptamine) is an endogenously produced indoleamine in all plant species, since fruits and vegetables are perishable goods, their shelf life and quality decline after they are harvested. It has been determined that melatonin is a signaling molecule that is involved in several physiological processes, including plant development, differentiation, ripening, and senescence, as well as protecting against different types of environmental stress (Reiter et al., 2015). Melatonin is also recognized as an abiotic and biotic anti-stress and has been found to function in delaying senescence and improving quality in plants (Arnao and Hernández, 2019). Exogenous melatonin (MT) improves the storage life and quality of broccoli, (Cano et al., 2022). Zhu et al. (2018) observed that melatonin delayed the senescence process of postharvest broccoli florets by regulating the respiratory metabolism and antioxidant activity. Total chlorophyll in melatonin-treated florets was 24.15% higher and the total respiration rate of postharvest broccoli florets by reducing the operating proportion of embden-meyerhof-parnas (EMP) tricarboxylic acid cycle (TCA) and phosphopentose pathway (PPP). It also ameliorates the buildup of reactive oxygen species and $H_2O_2$ compared to the control.

Ascorbic acid (AA) treatments in the preservation of horticultural crops are a biologically safe molecule that can be used to maintain post-harvest quality (Balouchi et al., 2012). Broccoli heads contain high levels of (AA), but it has been observed that this compound decreases rapidly in the postharvest period, especially during the shelf life (Nishikawa et al., 2003). During the senescence trend of broccoli, it was observed that the accumulation of active oxygen species increases and thus the antioxidant content, especially ascorbic acid, decreases. AA 1.5 % treatments lead to a delay in chlorophyll degradation and florets senescence in broccoli at 0°C (Balouchi et al., 2012).

Therefore, the main objectives of the present study were to investigate the effect of melatonin and ascorbic acid treatments as postharvest treatments to maintain the quality, delay yellowing and extend the shelf life of broccoli florets during refrigerated storage at 5°C and 95% RH.

# MATERIALS AND METHODS

Broccoli (*Brassica oleracea var. italic Imperial F1 hybrids)* , was harvested at the proper stage of marketing on the 1st and 2nd of January in the 2024 and 2025 winter seasons respectively, from Experimental Farm for Central Lab. for Agric. Climate in Giza Governorate, to study the effect of melatonin and ascorbic acid treatments on delay senescence, maintenance quality and extend the shelf life of fresh broccoli florets during cold storage. Broccoli Heads were placed in plastic boxes, with heads pointing upwards and no stacking and transported immediately within 30 minutes to the laboratory of the Department of Vegetable Handling and Postharvest Research Section, Horticultural Research Institute, Agriculture Research Center, Giza Governorate, Egypt. Fresh broccoli heads were selected for uniformity of size, color and being free from any visual defects and absence of physical damage and pests. Then, broccoli heads are separated into florets and stems. The florets were disinfected with sodium hypochlorite at the rate of 150 ppm for 10 min, followed by repeated washing with distilled water. The broccoli florets were divided into 7 groups and dipped for 10 min. in melatonin (MT), a solution of 75, 100 and 125 µM, ascorbic acid (AA) solution at 0.5, 1 and 1.5 % and distilled water represented as control. All treatments of broccoli florets were dried in a well-ventilated room under sterilized conditions and packed in trays sealed with a polyethylene film of 15µm thicknesses and each packed was approximately 200 g represented as an experimental unit (EU). Twelve EU were prepared for each treatment. Samples were arranged in a completely randomized design. All treatments were placed inside carton boxes (40 × 30 ×12.5 cm) and stored at 5°C and 95% RH, for 16 days. Samples of 3 replicates (EU) were randomly taken and examined immediately after treatment and at four days intervals (0- 4-8-12-16) days for the following properties:

**Physical analysis:**

- **Weight loss (%):** It was determined to harvest and every four days of storage, the weight of each sample from each of the three replications of each experimental unit was recorded. The percentage loss of the initial weight was used to describe cumulative weight losses **(**Lemoine et al., 2009)
- **General appearance:** It was determined according to the scale of the scoring

system 9: Excellent, 7: good, 5: fair, 3: poor and 1: unsalable, depending on morphological defects such as flower bud yellowing, texture (crisp to very soft) and pathological defects, (Gorny et al., 2002).

- **External surface color:** Color was evaluated by a color meter (Minolta model CR400, Konica Minolta, Tokyo, Japan), to measure the L* (lightness), and hue angle, (McGuire, 1992).

**Chemical composition:**

- **Total** chlorophyll **content:** The content of chlorophylls was measured according to (Moran, 1982).

**5. The total phenolic content (mg/100F.W.**): was determined according to Aaby et al. (2005).

**6. Vitamin C content (mg/100g FW):** was determined by the titration method using 2, 6, di phenol indophenols as described in A.O.A.C. (2000).

- **Statistical** Analysis**:** The experiment was factorial with 2 factors in a complete randomized design (CRD) with 3 replicates. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance. The statistical analysis was performed according to Snedecor and Cochran (1982).

## RESULTS AND DISCUSSION

**1. Weight loss percentage: -**

As shown in **Table (1),** the Data exhibited significant increases in weight loss percentage with the extension of the storage period during storage at 5°C the two seasons. The loss in weight may be attributed to respiration and other senescence-related metabolic processes Finger et al., (1999). Similar results were obtained by Jia et al., (2009), Pedro et al., (2013), Bilgin, (2021) on broccoli florets. The Weight loss percentage is one of the most important postharvest issues which have a direct impact on the marketability and quality of broccoli (Nath et al., 2011). Also, water loss is one of the main issues during broccoli storage, causing stalk hardening and bud-cluster turgidity loss (Serrano et al., 2006).

Concerning the effect of dipping of melatonin (MT) and AA treatments on weight loss % of fresh broccoli florets, results demonstrate that in **Table (1),** there were significant differences among treatments in weight loss percentage during storage. All treatments reduced weight loss % during storage as compared with untreated control. Furthermore, broccoli florets dipped in MT solution at 100 μM was the most effective treatment in reducing weight loss % during storage at 5 ℃ in both seasons, followed by dipped in MT solution at 125, 75 μM and AA 1.5%. Meanwhile, untreated control gave the highest values of weight loss in the two seasons. These results agreed with those reported by Cano et al., (2022). The MT treatments are related to its participation in the closing and opening of the stomata, (Wei et al., 2018). Accumulation of ROS and ethylene production during storage caused membrane degradation (Hodges, 2003). Furthermore, accompanied by changes in membrane permeability, changes in ability of cell soluble material preservation, increased leakage in cells and finally loss of weight, therefore possibly ascorbic acid (AA) treatments led to inhibition of ethylene production (Ieamtim et al., 2008) and cellular membrane destruction and reduce ROS level, had led to decreasing weight loss (Shalata and Neumann, 2001).

Regarding, the interactions between various postharvest treatments and storage periods in **Table (1).** Data conclusively show that significant effect on weight loss percentage after 14 days of storage at 5℃ and 95% RH, the lowest value of weight loss was recorded from the broccoli florets dipped in MT solution at 100 μM, while the highest ones were obtained from untreated control in both seasons. Melatonin treatments delayed the senescence process of postharvest broccoli florets by regulating respiratory metabolism and antioxidant activity. Also, ameliorates the buildup of reactive oxygen species and $H_2O_2$ compared to the control (Zhu et al., 2018).

**Table (1). Effect of melatonin, ascorbic acid and their interactions on weight loss percentage of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | 2024 | | | | | |
| **Melatonin (75 µM)** | 0.00q | 1.53ko | 1.63jn | 1.83jk | 2.20hi | **1.44E** |
| **Melatonin (100 µM)** | 0.00q | 1.00p | 1.26op | 1.47lo | 1.80jl | **1.11F** |
| **Melatonin (125 µM)** | 0.00q | 1.30np | 1.38mo | 1.77jl | 2.37fh | **1.36E** |
| **Ascorbic Acid (0.5%)** | 0.00q | 1.90ij | 2.30gh | 2.60eg | 3.53c | **2.07B** |
| **Ascorbic Acid (1%)** | 0.00q | 1.70jm | 1.93ij | 2.37fh | 2.93de | **1.79C** |
| **Ascorbic Acid (1.5 %)** | 0.00q | 1.60jn | 1.80jl | 2.20hi | 2.67df | **1.65D** |
| **Control** | 0.00q | 2.67df | 3.00d | 4.00b | 4.83a | **2.90A** |
| **Mean** | **0.00 E** | **1.67D** | **1.90C** | **2.32B** | **2.90A** | |
| | 2025 | | | | | |
| **Melatonin (75 µM)** | 0.00t | 1.60oq | 1.77mp | 2.07jm | 2.60fh | **1.61E** |
| **Melatonin (100 µM)** | 0.00t | 1.08s | 1.19rs | 1.30qs | 1.70np | **1.05G** |
| **Melatonin (125 µM)** | 0.00t | 1.47pr | 1.63op | 1.87lo | 2.33hj | **1.46F** |
| **Ascorbic Acid (0.5%)** | 0.00t | 2.10jl | 2.67eg | 2.97de | 3.40c | **2.23B** |
| **Ascorbic Acid (1%)** | 0.00t | 1.90ko | 2.20ik | 2.43gi | 2.90ef | **1.89C** |
| **Ascorbic Acid (1.5 %)** | 0.00t | 1.73np | 2.00kn | 2.16il | 2.93de | **1.77D** |
| **Control** | 0.00t | 2.57gh | 3.23cd | 4.10b | 4.70a | **2.92A** |
| **Mean** | **0.00E** | **1.78D** | **2.10C** | **2.41B** | **2.94A** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

## 2. General Appearance (Score): -

As depicted in **Table. (2)** general appearance (score) of broccoli florets was decreased with the prolongation of the storage period. These results were in agreement with those obtained by Feng et al. (2018) and Liyang et al. (2020). The decreases in general appearance during storage might be due to the degradation of chlorophyll (Page et al., 2001). Branchless and florets lose turgor and become flaccid if water loss is excessive, (Brennan and Shewfelt, 1989). Decay commonly occurs on florets, primarily during advanced stages of senescence.

The broccoli florets treated with MT and AA had significantly the highest score of appearance as compared with untreated control. The broccoli florets dipped in MT solution at 100 μM, were the most effective treatment for maintaining general appearance during storage at 5 ℃ and 95% RH, followed by those dipped in MT solution at 125, 75 μM and AA 1.5%. Whereas untreated control recorded the lowest value of general appearance. These results agree with Liyang et al. (2020) and on broccoli florets. Bilgin et al. (2021) indicated that MT is important for the physiological regulation of cellular homeostasis. In addition, MT helps maintain the morphology of the chloroplast and thylakoid membranes. Thus, the yellowing process of the MT-treated broccoli samples was remarkably delayed, ( Feng et al., 2018). Also, Liyang et al. (2020) reported that melatonin treatment was effective in retaining the green color and fresh weight of fresh-cut broccoli during cold storage.

The effect of interaction between postharvest treatments and storage periods at 5℃ and 95% RH on general appearance (score). The broccoli florets dipped in MT solution at 100 µM, gave a good appearance at the end of the storage period of 16 days at 5° C and 95% RH. On the other hand, untreated control had an unsalable appearance at the end of the storage period in both seasons. The MT treatments lead to maintaining the visual quality and health-promoting properties of broccoli florets during cold storage, by substantially inhibiting the protection against chlorophyll degradation of chlorophyll which is important in the retention of green color in broccoli.

**Table (2). Effect of melatonin, ascorbic acid and their interactions on general appearance (score) of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | **0** | **4** | **8** | **12** | **16** | **Mean** |
| | | | **2024** | | | |
| **Melatonin (75 µM)** | 9.00a | 9.00a | 7.00 | 6.33be | 4.33eg | **7.13BC** |
| **Melatonin (100 µM)** | 9.00a | 9.00a | 9.00a | 9.00a | 7.00ad | 8.60A |
| **Melatonin (125 µM)** | 9.00a | 9.00a | 8.33ab | 6.33be | 5.00df | 7.53B |
| **Ascorbic Acid (0.5%)** | 9.00a | 7.67ad | 5.00df | 4.33eg | 1.67h | 5.53E |
| **Ascorbic Acid (1%)** | 9.00a | 8.33ab | 6.33be | 5.67ce | 2.33gh | 6.33D |
| **Ascorbic Acid (1.5 %)** | 9.00a | 9.00a | 6.33be | 5.67ce | 3.00fh | 6.60CD |
| **Control** | 9.00a | 7.00ad | 5.00df | 3.00fh | 1.00h | 5.00E |
| **Mean** | **9.00A** | **8.43A** | **6.71B** | **5.76C** | **3.48D** | |
| | | | **2025** | | | |
| **Melatonin (75 µM)** | 9.00a | 9.00a | 7.00 | 7.67ac | 4.33eg | **7.40B** |
| **Melatonin (100 µM)** | 9.00a | 9.00a | 9.00a | 8.33ab | 7.00ad | **8.47A** |
| **Melatonin (125 µM)** | 9.00a | 9.00a | 8.33ab | 7.00ad | 5.00df | **7.67B** |
| **Ascorbic Acid (0.5%)** | 9.00a | 7.67ac | 5.00df | 5.00df | 1.67 | **5.67D** |
| **Ascorbic Acid (1%)** | 9.00a | 8.33ab | 6.33be | 5.00df | 2.33gh | **6.20CD** |
| **Ascorbic Acid (1.5 %)** | 9.00a | 9.00a | 6.33be | 5.67ce | 3.00fh | **6.60C** |
| **Control** | 9.00a | 7.00ad | 4.33eg | 3.00fh | 1.00h | **4.87E** |
| **Mean** | **9.00A** | **8.43A** | **6.62B** | **5.95C** | **3.48D** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

### 3. Color (hue angle h° value): -

As shown in **Table (3).** There's a significant hue angle value of broccoli florets with the prolongation of the storage period at 5℃ and 95% RH during both seasons. The loss of green color in broccoli florets occurs due to chlorophyll breakdown and this is stimulated by exogenously applied and endogenously produced ethylene (Tain et al., 1996). These results agree with those obtained by Perini et al. (2017) and Liyang et al. (2020). Yellowing is a reflection of to decline in the hue angle of the flower buds. As well the increase in yellowing rates and the decrease in chlorophyll concentrations during storage are very important factors to the storage life of broccoli (Dong et al., 2004). Hue angel decreased significantly during storage at 4 °C reflecting the transition from a green color to yellow (Fadhel et al., 2018). Yellowness is generally related to senescence which is characterized by chlorophyll degradation during storage (Vasconcelos and Almeida, 2003).

Concerning the effect of melatonin and ascorbic acid treatments on hue angle value as shown in **Table (3)** there was a significant difference between treatments during storage periods at 5℃ and 95% RH in two seasons. The broccoli florets which dipped in MT solution at 100 µM were the most effective in retention of green color (high hue angle) which is an indicator of greenness during storage, followed by dipping in MT solution at 125, 75 µM and AA 1.5% were less effective in this concern. While the untreated control recorded the lowest value in both seasons. These results agreed with Jiajun et al. (2023). 100 µM MT treatment was most effective in keeping the green color of florets among all treatments. Also, 100 µM MT treatment showed significantly higher H values and slowed down the reduction rate of chlorophyll content when compared with other treatments and control. Moreover, MT treatment significantly delayed the degradation of chlorophyll, while POD activity was decreased during storage, (Liyang et al., (2020). MT treatment can keep the chloroplasts intact as well as inhibit the expression of genes and the activity of enzymes involved in chlorophyll degradation (Wu et al., 2021). Ascorbic acid treatments delayed chlorophyll degradation. This delay might be attributed to efficient scavenging of ROS by antioxidants compounds like AA, that would have destroyed the lipid membrane and chlorophyll pigments (Farouk, 2011).

As for the interaction between the interaction between postharvest treatments and storage periods at 5℃ and 95% RH on hue angle value, demonstrated in **Table (3),** the broccoli florets dipped in melatonin solution at 100 µM were the most effective in retention of green color (high hue angle) after 16 days of storage in the two seasons.

**Table (3). Effect of melatonin, ascorbic acid and their interactions on the huge angle (h° value) of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | | | 2024 | | | |
| **Melatonin (75 µM)** | 130.20a | 127.67cd | 126.33df | 121.00kl | 119.07mn | **124.85C** |
| **Melatonin (100 µM)** | 130.20a | 129.90ab | 129.12ac | 126.33df | 123.50hi | **127.81A** |
| **Melatonin (125 µM)** | 130.20a | 128.67bc | 127.67cd | 124.60gh | 121.83jl | **126.59B** |
| **Ascorbic Acid (0.5%)** | 130.20a | 125.10fg | 123.33hj | 118.33no | 116.33p | **122.66F** |
| **Ascorbic Acid (1%)** | 130.20a | 126.00eg | 124.77gh | 119.37mn | 117.33op | **123.53E** |
| **Ascorbic Acid (1.5 %)** | 130.20a | 126.80de | 125.40eg | 120.40lm | 118.20q | **124.20D** |
| **Control** | 130.20a | 122.00ik | 116.33p | 112.33q | 109.50r | **118.07G** |
| **Mean** | **130.20A** | **126.59B** | **124.71C** | **120.34D** | **117.97E** | |
| | | | 2025 | | | |
| **Melatonin (75 µM)** | 131.10ab | 129.67cd | 128.00ef | 124.17ij | 120.30no | **126.65C** |
| **Melatonin (100 µM)** | 131.10ab | 132.33a | 130.93bc | 127.60eg | 123.83jk | **129.16A** |
| **Melatonin (125 µM)** | 131.10ab | 130.83bc | 129.53d | 126.40gh | 122.77kl | **128.13B** |
| **Ascorbic Acid (0.5%)** | 131.10ab | 127.17fg | 125.17hi | 121.03mn | 117.10q | **124.31F** |
| **Ascorbic Acid (1%)** | 131.10ab | 128.00ef | 126.40gh | 122.07lm | 118.17pq | **125.15E** |
| **Ascorbic Acid (1.5 %)** | 131.10ab | 128.80de | 127.40fg | 123.13jl | 119.13op | **125.91D** |
| **Control** | 131.10ab | 123.37jk | 119.50o | 115.63r | 113.00s | **120.52G** |
| **Mean** | **131.10A** | **128.60B** | **126.70C** | **122.86D** | **119.19E** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

**4. Color (lightness L. Value): -**

As shown in **Table (4).** There's a significant increase in lightness loss of broccoli florets with the prolongation of the storage period at 5℃ and 95% RH during the two seasons. These results agree with those obtained by Liyang et al. (2020) and Jiajun et al. (2023) in broccoli. The deterioration of color during the postharvest storage of broccoli is a result of losses in total chlorophyll (Serrano et al., 2006).

Regarding, the effect of dipping heads in MT and AA treatments on lightness value, there were significant differences between treatments during storage periods at 5℃ and 95% RH in the two tested seasons. The broccoli florets which dipped in MT solution at 100 μM was the most effective in reducing the increases of lightness loss during storage, Meanwhile the untreated control recorded the highest mean value. These results were achieved in the two seasons and were in agreement with those reported by Jiajun et al. (2023) and Liyang et al. (2020). The L* parameter indicates the brightness or luminosity of the broccoli surface. Generally, it is desirable that it remains constant (Cano et al., 2022). 100 μM MT treatment obviously inhibited the increase of L* value. Furthermore, 100 Mm MT treatment significantly reduced chlorophyll content when compared with control and other treatments and confirmed those of Wei et al. (2018).

Concerning the interaction between postharvest treatments and storage periods on color (lightness L* Value) of fresh broccoli florets **(Table 4).** The broccoli florets dipped in MT solution at 100 μM was the most effective treatment in reducing the increases of lightness loss after 16 days of storage.

**Table (4). Effect of melatonin, ascorbic acid and their interactions on Lightness (L* Value) of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | | | 2024 | | | |
| **Melatonin (75 μM)** | 35.87n | 39.43k | 40.10j | 42.47g | 44.23e | **40.42E** |
| **Melatonin (100 μM)** | 35.87n | 36.33n | 37.07m | 38.17l | 39.00k | **37.29G** |
| **Melatonin (125 μM)** | 35.87n | 38.33l | 39.00k | 41.83h | 42.60fg | **39.53F** |
| **Ascorbic Acid (0.5%)** | 35.87n | 42.10gh | 43.80e | 45.10d | 47.63b | **42.90B** |
| **Ascorbic Acid (1%)** | 35.87n | 41.07i | 42.13gh | 44.10e | 46.17c | **41.87C** |
| **Ascorbic Acid (1.5 %)** | 35.87n | 40.27j | 41.17i | 43.00f | 45.03d | **41.07D** |
| **Control** | 35.87n | 44.07e | 45.67c | 47.17b | 48.67a | **44.29A** |
| **Mean** | **35.87E** | **40.23D** | **41.28C** | **43.12B** | **44.76A** | |
| | | | 2025 | | | |
| **Melatonin (75 μM)** | 37.10a | 39.93m | 41.13l | 42.43j | 43.60h | **40.84E** |
| **Melatonin (100 μM)** | 37.10a | 37.50a | 38.17o | 39.30n | 40.00m | **38.41G** |
| **Melatonin (125 μM)** | 37.10a | 38.40o | 39.99m | 40.73l | 41.70k | **39.58F** |
| **Ascorbic Acid (0.5%)** | 37.10a | 43.10i | 44.77f | 46.03d | 47.47c | **43.69B** |
| **Ascorbic Acid (1%)** | 37.10a | 42.03jk | 43.10i | 45.10ef | 46.33d | **42.73C** |
| **Ascorbic Acid (1.5 %)** | 37.10a | 41.10l | 42.07jk | 43.43hi | 44.10g | **41.56D** |
| **Control** | 37.10a | 45.23e | 47.07c | 48.13b | 49.40a | **45.39A** |
| **Mean** | **37.10E** | **41.04D** | **42.33C** | **43.60B** | **44.66A** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

## 5. Total chlorophyll content: -

As shown in **Table (5),** the total chlorophyll content of broccoli florets decreased and gradually deteriorated during storage at 5℃ and 95% RH with the extension of the storage period in both seasons. These results agree with those obtained by Liyang et al. (2020) on broccoli florets. Chlorophyll degradation is the most obvious visual change, and this is accompanied by losses in membrane lipids and proteins eventually resulting in cell death, (Page et al., 2001). The decrease and gradual deterioration could be attributed to the gradual increase of destruction by chlorophyll degrading peroxidase POD activity, which is the transformation of chloroplasts to chromoplasts, (Dong et al., 2004).

**Table (5).Effect of melatonin, ascorbic acid and their interactions on total chlorophyll content (mg/100g F.W) of Fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | 2024 | | | | | |
| **Melatonin (75 µM)** | 99.40a | 97.03cd | 95.27hi | 94.30km | 93.00n | **96.58C** |
| **Melatonin (100 µM)** | 99.40a | 99.10a | 97.97b | 97.50bc | 96.97ce | **98.19A** |
| **Melatonin (125 µM)** | 99.40a | 98.10b | 96.77de | 96.03fg | 94.98ik | **97.06B** |
| **Ascorbic Acid (0.5%)** | 99.40a | 95.87gh | 94.53jl | 93.13n | 92.27o | **95.04F** |
| **Ascorbic Acid (1%)** | 99.40a | 96.60df | 95.73gh | 95.03ij | 93.63mn | **96.08D** |
| **Ascorbic Acid (1.5 %)** | 99.40a | 97.53bc | 96.30eg | 95.67gi | 94.00lm | **95.80E** |
| **Control** | 99.40a | 95.00ij | 93.17n | 92.13o | 90.00p | **93.94G** |
| **Mean** | **99.40A** | **97.03B** | **95.68C** | **94.83D** | **93.55E** | |
| | 2025 | | | | | |
| **Melatonin (75 µM)** | 100.10a | 97.90cd | 96.83fg | 95.17j | 93.00n | **97.52C** |
| **Melatonin (100 µM)** | 100.10a | 99.93a | 99.63a | 99.10b | 97.28ef | **99.21A** |
| **Melatonin (125 µM)** | 100.10a | 99.00b | 98.13c | 97.57de | 96.53gi | **98.27B** |
| **Ascorbic Acid (0.5%)** | 100.10a | 96.57gh | 95.30j | 93.60lm | 92.13o | **95.54F** |
| **Ascorbic Acid (1%)** | 100.10a | 97.47de | 96.07i | 94.20k | 93.97kl | **96.36E** |
| **Ascorbic Acid (1.5 %)** | 100.10a | 98.67b | 97.50de | 96.27hi | 95.07j | **96.60D** |
| **Control** | 100.10a | 95.43j | 93.33mn | 92.10o | 90.40p | **94.27G** |
| **Mean** | **100.10A** | **97.85B** | **96.69C** | **95.43D** | **94.05E** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

Regarding the effect of dipping of melatonin and ascorbic acid treatments on the total chlorophyll content (mg/100g F.W) of fresh broccoli florets, there were significant differences between all used treatments. The broccoli florets dipped in MT solution at 100 µM, exhibited the lowest deterioration and retained more total chlorophyll content during storage periods, followed by dipping in MT solution at 125, 75 µM and ascorbic acid (AA) 1.5% which were less effective in this concern. Whereas the untreated control recorded the lowest mean value in both seasons. These results agreed with Cano et al. (2022) and Balouchi et al. (2012). MT treatment may keep chloroplasts intact as well as inhibit the expression of genes and the activity of enzymes involved in chlorophyll degradation (Wu et al., 2021). In addition, MT may prevent chlorophyll from degrading (Di et al., 2022). AA treatments delayed chlorophyll degradation. This delay might be attributed to the efficient scavenging of ROS by antioxidant compounds like AA, which would have destroyed the lipid membrane and chlorophyll pigments (Farouk, 2011). Moreover, it has been proposed that AA may retard senescence either by inhibiting ethylene production or decreasing respiration (Ieamtim et al., 2008).

As for the interaction between postharvest treatments and storage periods on total chlorophyll content of fresh broccoli florets during cold storage, results showed that the broccoli florets dipped in MT solution at 100 μM was more retained and reduced the decline of total chlorophyll content after 16 days of storage at 5℃ in two seasons. Zhu et al. (2018) observed that MT delayed the senescence process of postharvest broccoli Florets by regulating respiratory metabolism and antioxidant activity.

**6. Vitamin C content:**

Vitamin C content of broccoli florets decreased with extending storage period in both seasons as shown in **Table (6).** These results agree with those obtained by Rybarczyk-Plonska et al. (2014) and Liyang et al. (2020). This decrease in vitamin C could be due to oxidation or enzymatic degradation, which occur during storage (Kibar et al., 2023). It was previously reported that this decrease may be attributed to respiration and other senescence-related metabolic processes, (Finger et al., 1999).

**Table (6). Effect of melatonin, ascorbic acid and their interactions on vitamin C content (mg/100g F.W.) of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons.**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | 2024 | | | | | |
| **Melatonin (75 µM)** | 48.73a | 46.63df | 46.13dg | 44.30hi | 42.10ln | **45.58C** |
| **Melatonin (100 µM)** | 48.73a | 48.57a | 48.10ab | 47.87ac | 46.87ce | **48.03A** |
| **Melatonin (125 µM)** | 48.73a | 47.83ac | 47.17bd | 45.90eg | 43.70ik | **46.67B** |
| **Ascorbic Acid (0.5%)** | 48.73a | 44.33hi | 43.50ik | 40.37o | 38.23p | **43.03F** |
| **Ascorbic Acid (1%)** | 48.73a | 45.60fg | 44.17hj | 41.70mn | 39.87o | **44.01E** |
| **Ascorbic Acid (1.5 %)** | 48.73a | 46.60df | 45.03gh | 42.63km | 41.03no | **44.81D** |
| **Control** | 48.73a | 43.10jl | 40.10o | 38.10p | 36.60q | **41.33G** |
| **Mean** | **48.73A** | **46.10B** | **44.89C** | **42.98D** | **41.20E** | |
| | 2025 | | | | | |
| **Melatonin (75 µM)** | 47.70a | 45.20ce | 43.43gh | 41.60k | 40.13mn | **43.61C** |
| **Melatonin (100 µM)** | 47.70a | 47.50a | 47.07ab | 46.20bc | 45.70cd | **46.83A** |
| **Melatonin (125 µM)** | 47.70a | 46.17bc | 44.70df | 43.37hi | 42.20jk | **44.83B** |
| **Ascorbic Acid (0.5%)** | 47.70a | 43.07hj | 40.23m | 38.27o | 37.10pq | **41.27F** |
| **Ascorbic Acid (1%)** | 47.70a | 43.83fh | 41.43kl | 39.73mn | 38.03op | **42.15E** |
| **Ascorbic Acid (1.5 %)** | 47.70a | 44.47eg | 42.13jk | 40.40lm | 39.10no | **42.76D** |
| **Control** | 47.70a | 42.30ik | 38.50o | 36.67q | 34.27r | **39.89G** |
| **Mean** | **47.70A** | **44.65B** | **42.50C** | **40.89D** | **39.50F** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

Concerning the effect of dipping melatonin and ascorbic acid treatments on vitamin C content of fresh broccoli florets, (**Table 6).** There were significant differences between treatments in vitamin C content. All treatments inhibited clear decrease in vitamin C content during storage as compared with untreated control. Furthermore, broccoli florets dipped in MT solution at 100 μM was the most effective treatment in deterioration inhibitor and more retention of vitamin C content during storage at 5 ℃ in both seasons. These results agreed with those obtained by Liyang et al. (2020). MT treatments inhibited the decrease in vitamin C content due to the effective inhibition of oxidation and scavenging of free radicals by MT. Besides, the effect of MT was indirectly demonstrated by the increase in DPPH in broccoli (Feng et al., 2018). The exogenous MT treatment slowed a clear deterioration of vitamin C and reduced the active oxygen content, respiration intensity and ethylene production, also reduced the oxidative damage to cells and maintained more complete cell structure during storage (Xin et al., 2017).

The interaction between postharvest treatments and storage periods on vitamin C content of fresh broccoli florets during cold storage, was shown in **Table (6).** The broccoli florets dipped in MT solution at 100 μM reduced the decline of vitamin C content after 16 days of storage at 5℃ in two seasons.

**7. Total phenolic content**:

The total phenolic content of broccoli florets decreased significantly throughout cold storage at 5°C for 16 days in both seasons, **(Table. 7).** These findings were in line with those of Liu et al. (2018) and Di et al. (2022). Vegetables have a lot of enzymes that can oxidize and degradation of phenolic compounds and are caused by the loss of integrity of the cell membrane. PPO and POD were the main agents responsible for the degradation of phenols in plants (Baltacig et al., 2011). Loss of the integrity of the membrane results in the barriers and allowing enzymes to act on their substrates, the decrease in phenolic content on broccoli florets is probably due to the oxidation of the PPO enzyme to give the colored quinones and quinone was oxidized directly by PPO (Zhang et al., 2015).

As shown in **Table (7).** The phenolic componds were significantly higher in all treatments. The broccoli florets dipped in MT solution at 100 μM, were the most effectively treated on maintained total phenols during storage as compared with untreated control in both seasons. Following by those dipped in MT solution at 125, 75 μM and AA 1.5%, which were less effective in this concern. While the untreated control recorded the lowest value in both seasons. Similar results were previously reported in broccoli, Melatonin significantly increased the total phenols and total flavonoid contents (Liyang et al., 2020). The increase in total phenols might be explained by a higher phenylalanine ammonia-lyase (PAL) enzyme activity induced by the MT treatment leading to an accumulation of phenols (Aghdam and Fard, 2017). During the long period of storage, cells gradually lose the integrity of the membrane system, which allows enzymes to act on their substrates (Zhang et al., 2015). AA treatment causes increased total phenolic content (Balouchi et al., 2012). AA is extensively used to avoid enzymatic browning of fruit which caused by the reduction of the o-quinones, generated by the action of the PPO, back to the phenolic substrates (Lamikanra and Watson, 2001).

The interaction between postharvest treatments and storage periods on Total phenolic content of fresh broccoli florets during cold storage at 5°C. The broccoli florets dipped in MT solution at 100 μM were retained with the highest value of total phenolic content compared by other treatments. While untreated florets (control) gave the lowest value in this concern in both seasons.

**Table (7). Effect of melatonin, ascorbic acid and their interactions on Total phenols content (mg/100g F.W.) of fresh broccoli florets during cold storage at 5°C and RH 90-95% during 2024 and 2025 seasons**

| Treatments | Storage periods (per day) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | 16 | Mean |
| | | | 2024 | | | |
| **Melatonin (75 µM)** | 26.40a | 25.03c | 23.60e | 22.50f | 20.70i | **23.65C** |
| **Melatonin (100 µM)** | 26.40a | 26.20a | 25.70b | 25.10c | 24.30e | **25.54A** |
| **Melatonin (125 µM)** | 26.40a | 25.57b | 24.40d | 23.77d | 22.70f | **24.57B** |
| **Ascorbic Acid (0.5%)** | 26.40a | 22.50f | 20.23j | 19.03l | 17.40o | **21.11F** |
| **Ascorbic Acid (1%)** | 26.40a | 23.50e | 21.90g | 20.10j | 18.63m | **22.11E** |
| **Ascorbic Acid (1.5 %)** | 26.40a | 24.60d | 22.50f | 21.40h | 19.70k | **22.92D** |
| **Control** | 26.40a | 21.97g | 19.23l | 18.07n | 15.17p | **20.17G** |
| **Mean** | **26.40A** | **24.20B** | **22.51C** | **21.42D** | **19.80E** | |
| | | | 2025 | | | |
| **Melatonin (75 µM)** | 25.73a | 23.10e | 20.77h | 19.63i | 17.97l | **21.44C** |
| **Melatonin (100 µM)** | 25.73a | 25.40a | 24.83b | 24.13c | 23.63d | **24.75A** |
| **Melatonin (125 µM)** | 25.73a | 24.54b | 23.40de | 22.70f | 21.67g | **23.61B** |
| **Ascorbic Acid (0.5%)** | 25.73a | 20.47h | 17.60l | 16.63m | 14.60p | **19.01F** |
| **Ascorbic Acid (1%)** | 25.73a | 21.40g | 18.90j | 17.87l | 15.76o | **19.93E** |
| **Ascorbic Acid (1.5 %)** | 25.73a | 22.43f | 19.60i | 18.50k | 16.87m | **20.63D** |
| **Control** | 25.73a | 19.17j | 16.17n | 14.63p | 12.90q | **17.72G** |
| **Mean** | **25.73A** | **22.36B** | **20.18C** | **19.16D** | **17.63E** | |

Values with the same letters in the same column and capital letters the same row are not statistically different, at 0.05 level according to Duncan's. Small letters for interactions.

## CONCLUSION

From the previous results, it could be concluded that MT treatments at 100 µM was the most effective treatment in reducing weight loss, giving a good general appearance (score) and retention of green color (high hue angle) and lightness, Moreover, maintained the total content of chlorophyll, photonic content and vitamin C. during storage at 5˚C for 16 Days. Therefore, 100 µM melatonin recommended selected as the best and used to further maintain postharvest attributes.

## REFERENCES


Aaby, K., Skrede, G. and Wrolstad, R.E. (2005). Phenolic composition and antioxidant activities in flesh and achenes of strawberries (*Fragraria ananassa*). Journal of Agricultural and Food Chemistry, 3: 4032-4040.

Aghdam M.S. and Fard, J.R. (2017). Melatonin treatment attenuates postharvest decay and maintains nutritional quality of strawberry fruits (*Fragaria x anannasa* cv. Selva*)* by enhancing GABA shunt activity*.* Food Chemistry, 221: 1650–1657.

AOAC. (2000).Ascorbic acid in vitamin preparation and juices. In Official Method of Analysis, 17th ed. Gaithersburg, MD: Association of Official Analytical Chemists.

Arnao, M. B. and Hernández-Ruiz, J. (2019). Melatonin: A New Plant Hormone and/or a Plant Master Regulator. Trends and plant science, 24(1) ;38-48.

Balouchi, Z., Peyvast, G., Ghasemnezhad, M. and Dadi, M. (2012). Effects Of Ascorbic Acid in Delaying Florets Senescence of Broccoli During Post-

Harvest Storage. South-Western Journal of Horticulture Biology and Environment, 3(2):167-183.

Baltacig, C., Veliog, S. and Karacabey, E. (2011). Changes in total phenolic and flavonoid contents of rowanberry fruit during postharvest storage. Food Quality, 34: 278–283.

Bilgin, J. (2021). The Effects of Salicylic, Folic and Ascorbic Acid Treatment on Shelf-Life Quality of Broccoli Florets. Journal of Agricultural Production, 2(1): 7-15.

Brennan, P.S. and Shewfelt, R.L. (1989). Effect of cooling delay at harvest on broccoli quality during postharvest storage. J. Food Quality, 12:13– 22.

Cano, A., Giraldo-Acosta, M., García-Sánchez, S., Hernández-Ruiz, J. and Arnao, M. B. (2022). Effect of Melatonin in Broccoli Postharvest and Possible Melatonin Ingestion Level. Plants, 11(2000):1-15.

Day, G. L., Shore, R. E., Blot, W. J. ,McLaughlin, J. K., Austin, D. F. and Greenberg, R. S. (1994). Dietary factors and second primary cancers: A follow-up of oral and pharyngeal cancer patients. Nutr. Cancer, 21: 223–232.

Di, H., Li, Z., Wang, Y., Zhang, Y., Bian, J., Xu, J., Zheng, Y., Gong, R., Li, H., Zhang, F. and Sun, B. (2022). Melatonin Treatment Delays Senescence and Maintains the Postharvest Quality of Baby Mustard (*Brassica juncea var. gemmifera*). Plant Sci., 12:817861.

Dong, H., Y. Jiang, Y. Wang, R. Liu, and H. Guan, (2004). Effects of hot water immersion on storage quality of fresh broccoli heads. Food Technol. Biotechnol., 42(2):135-139.

Fadhel, Y., Ben., N., Ziane, S., Salmieri, S., and Lacroix1,M. (2018). Combined post-harvest treatments for improving quality and extending shelf-life of minimally processed broccoli florets (*Brassica oleracea* var. italica). Food Bioproc. Tech., 11(1): 84-95.

Farouk, S. (2011). Ascorbic acid and α-tocopherol minimize salt-induced wheat leaf senescence. Stress Physiology & Biochemistry, 7(3): 58-79.

Feng, L., Cai, J., Zhang, X., Tao, D., Zhou, X., Zhou, Q., Zhao, Y., Wei, B., Cheng, S. and Ji, S. (2018) Effects of methyl jasmonate and melatonin treatments on the sensory quality and bioactive compounds of harvested broccoli RSC Adv., 8: 41422–41431.

Finger, F.L., Endres, L. P., Mosquim R. and Puiatti, M. (1999). Physiological changes duringpostharvest senescence of broccoli. Pesqui. Agropecu. Bras., 34(9):1565-1569.

Gorny, J. Hess-Pierce, R. B. and Cifuentes, R. A. (2002). Quality changes in fresh-cut pear slices as affected by controlled atmospheres and chemical preservatives. Postharvest Biol.Technol., 24: 271–278.

Hodges, D.M. (2003). Postharvest oxidative stress in horticultural crops. New York Food, book; 1st Edition.

Kibar, H., Kibar, B. and Turfan, N. (2023). Exogenous citric acid, salicylic acid, and putrescine treatments preserve the postharvest quality and physicochemical properties of broccoli (*Brassica oleracea* L. var. italica) during cold storage. Food Sci Nutr.,12:1686–1705.

Ieamtim, P., Buanong, M. and Kanlayanarat, S. (2008). Role of ascorbic acid on vase life red ginger (*Alpinia purpurata* (Vieill.) K. Schum). Acta Horticulture, 804: 287-290.

Jia, C. G, Xu, J., Wei, J. , Yuan, J., Yuan, G. F. and Wang, B. L. (2009). Effect of modified atmosphere packaging on visual quality and glucosinolates of broccoli florets. Food Chem., 114(1): 28-37.

Jiajun, L., Wu, C. ,Wang, H., Cao, S., Wei, Y., Chen, Y., Jiang, S., Shao X. and Xu, F. (2023). Melatonin treatment delays postharvest senescence of broccoli with regulation of carotenoid metabolism. Food Chemistry, 408: 135185.

Lamikanra, O. and Watson, M. A. (2001). Effects of ascorbic acid on peroxidase and polyphenoloxidase activities in fresh-cut cantaloupe melon. Food science, 66(9): 1283-1284.

Lemoine, M.L., Civello, P., Chaves, A. and Martıinez, G.A. (2009). Hot air treatment delays senescence and maintains quality of fresh-cut broccoli florets during refrigerated storage. Food Sci. Technol., 42: 1076–1081.

Liu, C, Zheng, H., Sheng, K., Liua, W. and Zheng, L. (2018). Effects of melatonin treatment on the postharvest quality of strawberry fruit. Postharvest Biology and Technology, 139: 47–55.

Liyang, W., Changhong , L., Jinjin, W., Shoaib, Y., Huanhuan, Z. and Lei, Z. (2020). Melatonin immersion affects the quality of fresh-cut broccoli (*Brassica oleracea* L.*)* during cold storage: Focus on the antioxidant system J Food Process Preserv, 4691.

McGuire, R.G. (1992). Reporting of objective color measurement. HortScience, 27: 1254 –1255.

Moran, R. (1982). Formulae for Determination of Chlorophyllous Pigments Extracted with N, N-Dimethylformamide. Plant Physiol., 69: 1376 –1381.

Nath, A., Bagchi, B., Misra, L.K. and Deka, B. C. (2011). Changes in post-harvest phytochemical qualities of broccoli florets during ambient and refrigerated storage Food Chem., 127: 1510 –1514.

Nishikawa, F., Kato, M., Hyodo, H. , Ikoma, Y. , Sugiura, M. and Yano, M. (2003). Ascorbate metabolism in harvested broccoli. Journal of Experimental Botany, 54(392): 2439-2448.

Page, T., Griffiths, G. and Buchanan-Wollaston, V. (2001). Molecular and biochemical characterization of postharvest senescence in broccoli. Plant Physiol., 125(2):718 -727.

Pedro, J. Z., Tucker, G. A., Valero, D. and Serrano, M. (2013). Quality parameters and antioxidant properties in organic and conventionally grown broccoli after pre-storage hot water treatment. J Sci. Food Agric., 93: 1140–1146.

Perini, M. A., Sin, I. N. , Jara, A. M. R., Lobato, M. E. G. , Civello P. M. and Martinez, G. A. (2017). Hot water treatments performed in the base of the broccoli stem reduce postharvest senescence of broccoli (*Brassica oleracea* L. Varitalic) heads stored at 20 ℃. Food Sci. Technol., 77: 314 -322.

Reiter, R.J., Tan, D.X., Zhou, Z., Cruz, M.H.C., Fuentes-Broto, L. and Galano, A. (2015). Phytomelatonin: Assisting plants to survive and thrive. Molecules, 20: 7396-7437.

Rybarczyk-Plonska, A., Hansen, M. K. Wold, A. Hagen, S. F. Borge, G. I. A.and Bengtsson, G. B. (2014). Vitamin C in broccoli (*Brassica oleracea* L. var. italica) flower buds as affected by postharvest light, UV-B irradiation and temperature. Postharvest Biology and Technology, 98: 82-89.

Serrano, M, Martinez-Romero, D. Guill-en, Castillo, S. and Valero, D. (2006). Maintenance of broccoli quality and functional properties during cold storage as affected by modified atmosphere packaging. Postharvest Biol. Technol., 39:61–68.

Shalata, A. and Neumann, P. M. (2001). Exogenouse ascorbic acid (vitamin C) increases resistance to sait stress and reduced lipid peroxidation. Experimental botany, 52(346):2207.

Snedecor, C.W. and W.G. Cochran, (1982). Statistical Methods.7 Ed. The Iowa State Univ. Press. Ames. Iowa, USA.

Tian, M. S., Woolf, A. B. Bowen, J. H. and Ferguson, I. B. (1996). Changes in color and chlorophyll fluorescence of broccoli florets following hot water treatment. J. Amer. Soc. Hort.Sci., 121: 310–313.

Vasconcelos, I. and Almeida, D. (2003). treatment with 1-methylcyclopropene complements temperature management in maintaining postharvest quality of broccoli. Postharvest Hortic., 628: 227–232.

Wei, J., Li, D., Zhang, J., Shan, C. , Rengel, Z. , Song, Z. and Chen, Q. (2018). Phytomelatonin receptor PMTR1-mediated signaling regulates stomatal closure in Arabidopsis thaliana. J. Pineal Res., 65, e12500.

Wu, X., Ren, J., Huang, X. Q., Zheng, X. Z. Tian, Y. C. and Shi, L. (2021). Melatonin: Biosynthesis, content, and function in horticultural plants and potential application. Sci. Hortic. 288:110392.

Xin, D.D., Si, J.J. and Kou, L.P. (2017). Post-harvest exogenous melatonin enhances quality and delays the senescence of cucumber. Acta Horticulturae Sinica, 44: 891-901.

Yuan, G., Sun, B., Yuan J. and Wang, Q. (2010). Effect of 1-methylcyclopropene on shelf life, visual quality, antioxidant enzymes and health-promoting compounds in broccoli florets. Food Chem., 118: 774−781

Zhang, Z., Huber, D. J. , Qu, H., Yun, Z. Wang, H. ,Huang ,Z. and Jiang, Y. (2015). Enzymatic brown-ing and antioxidant activities in harvested litchi fruit as influenced by apple polyphenols.Food Chemistry, 171:191–199.

Zhu, L., H. Hu, S. Luo, Z. Wu, and P. Li, (2018). Melatonin delaying the senescence of postharvest broccoli by regulating respiratory metabolism and antioxidant activity. Transactions of the Chinese Society of Agricultural Engineering. 34: 300-307.

Zhuang, H., Hildebrand, D. F. and Barth, M. M. (1995). Senescence of broccoli buds is related to changes in lipid peroxidation. J. agri. food chem., 43(10): 2585–2591

## الملخص العربي

## تأثير معاملات الملاتونين وحامض الاسكوربيك علي تأخير الشيخوخة والمحافظة علي جودة ما بعد الحصاد في البركولي الطازج المجزأ

**صالح محمد أبو الوفا و صفاء زكريا**

قسم بحوث تداول الخضر- معهد بحوث البساتين- مركز البحوث الزراعيه

البروكلي (*Brassica oleracea* L) من النباتات سريعة التلف بعد الحصاد بسبب فقدان اللون الأخضر و اصفرار البراعم لذلك كان الهدف من البحث هو التحقق من معرفة تأثير المعاملات من االميلاتونين (MT) عند 75 و 100 و 125 ميكرومول وحمض الأسكوربيك AA عند 0.5 و 1 و 1.5٪ علي تأخير الشيخوخة و المحافظة علي خصائص الجودة، وإطالة العمر التسويقي للبروكلي الطازجة المقطع جزئيا خلال التخزين المبرد عند 5° م ورطوبة نسبية 90-95٪ لمدة 16 يومًا، خلال موسمي 2024 و 2025. أظهرت النتائج المتحصل عليها أن المعاملة بالميلاتونين عند تركيز 100 ميكرومول كان الاكثر فاعلية في تقليل الفقد في الوزن و إعطاء مظهر عام جيد والاحتفاظ باللون الأخضر والبريق بعد 16 يومًا من التخزين علي درجة 5° م وكذلك الحفاظ على المحتوى الكلي من الكلوروفيل والفينولات وفيتامين سي بينما كانت معاملات حمض الأسكوربيك أقل فعالية في هذا الشأن في كلا موسمين.