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Improving postharvest quality and increasing the storage life of 'March Early' orange using melatonin

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ABSTRACT

Melatonin, a natural hormone with antioxidant properties and growth-regulating effects, has recently gained attention as an effective agent for maintaining the postharvest quality of fruits. The present study aimed to investigate the role of melatonin on the postharvest characteristics of orange fruit during storage through a factorial experiment with a completely randomized design, including three replications, conducted at the Horticultural Science Laboratory, University of Hormozgan, in 2023-2024. After treatment with melatonin at concentrations of 200, 400, and 600 µM, the fruits were stored in a cold chamber at 5 ± 1 °C and 90 ± 5% relative humidity for 90 days. Sampling was conducted every 30 days to evaluate parameters such as weight loss, titratable acidity, ascorbic acid, firmness, total soluble solids, total antioxidant activity, and phenolic compounds. The results showed that fruits treated with 400 µM melatonin experienced significantly less weight loss (35.80%) compared to other treatments and the control group. Additionally, these fruits exhibited higher levels of phenolic compounds (354.8 µg g^{-1} FW), firmness (49.75 N), ascorbic acid (61.73 mg 100 g^{-1} FW), total antioxidant activity (37.76%), and titratable acidity (1.03%). The fruits treated with 400 µM melatonin also had the lowest soluble solids content (13.21 °Brix). The combination of melatonin demonstrated strong antioxidant properties and the ability to act as a protective agent, inhibiting free radicals. This study revealed that a 400 µM concentration of melatonin effectively extended the shelf life of orange fruit by preserving antioxidant properties and enhancing quality.

1- INTRODUCTION

Citrus belongs to the family *Rutaceae*, subfamily *Aurantioideae*, and is mainly classified under the genus *Citrus*. Citrus fruits are among the most popular fruit crops worldwide and are well suited for cultivation in Mediterranean countries, China, the United States, and Brazil. The total area allocated to citrus production is approximately 9.93 million hectares. The global production of oranges, mandarins, lemons and limes, and grapefruit in 2021 was about 75.7, 41.95, 20.83, and 9.56 million tons, respectively [1]. Citrus fruits are rich in nutrients, antioxidant activity, ascorbic acid, phenolic compounds, and other bioactive substances that are considered highly beneficial for human health [2]. Citrus fruits are among the most important commodities in global fruit trade (import/export), and their demand worldwide is largely due to their scientifically recognized health benefits, high antioxidant activity, and high ascorbic acid content. However, citrus production faces numerous pre- and postharvest challenges, including pests, diseases, weeds, fruit cracking, yield problems, and postharvest quality deterioration. Orange (*Citrus sinensis*) is the most widely cultivated tree fruit in the world [3]. Due to its susceptibility to fungal diseases, a considerable portion of the produced fruits is lost each year during postharvest handling and storage. The long interval between harvest and consumption often leads to significant losses caused by fungal, bacterial, and physiological disorders. Water loss (shrinkage) during storage is also a major challenge for marketing and export, as it reduces fruit quality.

After harvest, fruits and vegetables continue to undergo biological processes such as respiration and transpiration, resulting in the loss of water and nutrients, which consequently reduces the quality of fresh produce during storage. To maintain fruit quality and extend shelf life, various physical and/or chemical techniques have been developed and applied during postharvest handling. These include hot electrolyzed water dipping [4], nitric oxide fumigation [5], and treatments with anti-senescence plant growth regulators (e.g., 2,4-dichlorophenoxyacetic acid and its analogs, gibberellins, 24-epibrassinolide, 1-MCP, etc.) [6,7].

Melatonin (*N*-acetyl-5-methoxytryptamine) is a non-toxic signaling molecule with multiple physiological functions and is widely found in various plant species [8]. Initially, melatonin was discovered in animals, but later studies demonstrated its presence in plants as well [5], where it plays a role in plant growth and seed development [9]. Improvements in seed germination, photosynthesis, biomass production, circadian rhythm, redox homeostasis, membrane integrity, root growth, delay of leaf senescence, osmotic regulation, and tolerance to abiotic stresses have all been associated with melatonin.

In recent years, researchers have found that melatonin helps preserve postharvest fruits by inhibiting ethylene synthesis, reducing respiration rate [10], scavenging free radicals, and enhancing antioxidant capacity [5]. Fan et al. [11] immersed papaya fruits in melatonin solutions at different concentrations (100, 400, and 800 µM) and found that melatonin improved papaya fruit quality by enhancing antioxidant and defense-related systems. Treatment of guava fruits with 600 µM melatonin for 2 hours significantly increased the activity of catalase, superoxide dismutase, ascorbate peroxidase, and glutathione reductase while simultaneously reducing the levels of O_2^-, H_2O_2, and malondialdehyde (MDA). These changes improved the antioxidant and defense systems of guava fruit, helping maintain fruit quality and increasing resistance to diseases [11]. Tan et al. [12]

reported that application of 100 µM melatonin inhibited the expression of respiratory burst oxidase homolog (RBOH) genes, which enhanced the scavenging capacity of O_2^- and DPPH radicals and increased peroxidase and superoxide dismutase activities as well as their gene expression.

Various studies have also shown that melatonin significantly delays postharvest ripening, increases antioxidant enzyme activity, and slows down the senescence process in horticultural crops such as litchi [13], peach [14], and apple [15]. In a study conducted by Rastgar et al. [16] on Orlando tangelo, melatonin application improved antioxidant properties and increased total phenols, flavonoids, and the activities of catalase and peroxidase enzymes. Melatonin can stimulate hydrogen peroxide signaling and activate the transcription of enzymatic and non-enzymatic antioxidant synthesis [17].

Considering that limited studies have investigated the effect of melatonin treatment on the postharvest quality of citrus fruits, the present study was carried out to evaluate the effects of different concentrations of melatonin on the quality characteristics of orange fruit during three months of storage.

2- Materials and Methods

In this study, mature fruits of 'Mars Early' orange were harvested from the research orchard of Jiroft Agro-Industry and transferred to the Horticultural Sciences Laboratory of the University of Hormozgan. The fruits were then selected for uniformity in shape and size and inspected to ensure they were free from pests, diseases, and visible damage. Only healthy fruits without any signs of infestation or injury were selected for the experiment. The fruits were disinfected by immersing them in a 0.5% sodium hypochlorite solution for 1 minute and were subsequently rinsed with distilled water for 30 minutes.

For treatment, the orange fruits were divided into four groups and immersed for 30 minutes in distilled water (control) or melatonin solutions prepared at concentrations of 200, 400, and 600 µM. The treated fruits were placed in a ventilated environment for surface drying and were then packed in polyethylene bags (50 × 40 cm). Distilled water treatment was used as the control group. The fruits were transferred to cold storage and kept at 5 ± 1 °C with 90 ± 5% relative humidity. At 30-day intervals during the storage period, several parameters were evaluated, including weight loss, total soluble solids, ascorbic acid, titratable acidity, and juice pH.

2.1 Fruit Weight Loss

Selected fruits were weighed at the beginning of the experiment and during the storage period, and the percentage of weight loss was calculated. Fruit weight before storage and after removal from storage on sampling days was measured using a digital balance with a precision of 0.001 g. Fruit weight loss was calculated using the following formula [18].

Weight loss (%) = [(Initial weight − Final weight) / Initial weight] × 100

2.2. Total Soluble Solids (TSS) Measurement

Total soluble solids (TSS) content was measured as °Brix using a digital refractometer (DBR95, Taiwan). For this purpose, the juice was first extracted using a manual juicer and then filtered through filter paper. A few drops of the extract were

placed on the prism surface of the device, and the TSS value was recorded [18].

2.3. Titratable Acidity (TA)

Titratable acidity was determined using titration with 0.1 N sodium hydroxide (NaOH) solution. For this purpose, 5 mL of fruit juice was poured into a 100 mL Erlenmeyer flask, and 45 mL of distilled water was added. The solution was then titrated using a 50 mL burette with 0.1 N NaOH until reaching a pH of 8.1. The amount of titratable acidity was reported as a percentage of citric acid (the predominant acid in orange fruit) [19].

2.4. Ascorbic Acid

Ascorbic acid content was measured using a colorimetric method based on the L-ascorbic acid standard curve. Initially, 0.1 mL of fruit juice was added to 10 mL of metaphosphoric acid (1%) and shaken vigorously using a vortex mixer. Subsequently, 1 mL of this solution was added to 9 mL of 2,6-dichlorophenol-indophenol solution (0.0025%) and shaken again. The absorbance of the samples was then read at a wavelength of 510 nm using a microplate reader (Epoch 2; Bio-Tek, USA). The ascorbic acid content was expressed as milligrams of ascorbic acid per 100 g of fresh tissue [19].

2.5. Fruit Firmness

Fruit firmness was measured using a penetrometer (Model 53205, Turoni, Italy) with an 8 mm diameter probe. Measurements were taken at two opposite points in the equatorial region of the fruit, and the results were expressed in Newtons (N) [18].

2.6. Total Phenolic Content

The total phenolic content of the samples was determined using the Folin-Ciocalteu reagent. First, 0.5 g of plant tissue was ground in 3 mL of 85% methanol to obtain a homogeneous solution. The samples were then centrifuged at 12,000 rpm for 20 minutes. Subsequently, 300 µL of the supernatant was mixed with 1.5 mL of 10% Folin-Ciocalteu reagent. After 5 minutes, 1.2 mL of 7% sodium carbonate was added. The final solution was placed on a shaker in the dark for 1.5 hours, and the absorbance was measured at 760 nm using a microplate reader (Epoch 2; Bio-Tek, USA). The total phenolic content was calculated using a the gallic acid standard curve and expressed as micrograms of gallic acid per gram of fresh weight [20].

2.7. Antioxidant Activity

Antioxidant activity was determined using the free radical scavenging method based on 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical inhibition by fruit antioxidant compounds.

In this method, 30 µL of the methanolic extract was mixed with 270 µL of 0.1 mM DPPH solution. The mixture was vortexed thoroughly and then incubated in the dark for 30 minutes. The absorbance of the samples was measured at 517 nm using a microplate reader. Antioxidant activity was calculated using the following equation [20]:

Antioxidant activity (%) = ((Absorbance of control − Absorbance of sample) / Absorbance of control) × 100

2.8. Experimental Design

The experiment was conducted as a factorial arrangement based on a completely randomized design (CRD) with three replications and five fruits per replicate. The first factor consisted of four treatment levels, while the second factor included four storage duration levels. Statistical analysis of the data was performed using SAS software (version

9.4), and the figures were prepared using Microsoft Excel.

3- Results and Discussion

3.1. Weight Loss

The results of the analysis of variance (Table 1) indicated that treatment, storage time, and their interaction had a significant effect on the weight loss of orange fruit at the 1% probability level. During storage, water loss and fruit weight loss showed an increasing trend. The highest weight loss (7.15 ± 0.45%) was observed in the control treatment after 90 days of storage, while the lowest weight loss (4.59 ± 0.20%) at the end of storage period was recorded in fruits treated with 400 µM melatonin. In addition, the results indicated that there was no significant difference among the different melatonin concentrations after 90 days of storage (Fig. 1).

Changes occurring in fruits during storage are closely related to variations in firmness and weight loss [21]. Water loss and subsequent weight reduction during storage are natural processes caused by evaporation of water from the fruit surface. The disruption of the fruit's water connection with the parent plant and increased transpiration from the fruit surface are two major factors contributing to water loss and weight reduction during storage.

Melatonin, as a safe and environmentally friendly compound, has been reported to play an important role in maintaining water content and delaying fruit weight loss during storage, as well as delaying the ripening process in climacteric fruits (such as apples) and non-climacteric fruits (such as grapes) [22,23]. Shang et al. [24] reported that treatment with 0.05 mM melatonin effectively extended the storage period of blueberry fruits up to 42 days. In the present study, melatonin treatment delayed weight loss in orange fruits. These results are consistent with findings reported for banana [25], pear [26], and tomato [27].

Overall, these results indicate that melatonin treatment effectively delays fruit weight loss due to its anti-senescence and antioxidant effects. By reducing respiration rate, transpiration, and peel permeability, melatonin treatment minimizes weight loss and consequently improves the quality of orange fruits during storage.

Table 1. Analysis of variance (mean of squares) of quality traits of orange fruits

Sources of variation	df	TSS	Ascorbic acid	Firmness	Total phenol	Weight loss	Titratable acidity	Total antioxidants
time	3	12.72**	349.237**	365.721**	**920.511	60.22**	2.147**	161.451**
Treatment	3	4.5272**	139.936**	87.057**	6288.521**	6.952**	0.062**	39.002**
Repetition	2	0.322^{ns}	6.349^{ns}	0.098^{ns}	85.151^{ns}	0.242^{ns}	0.001ns	0.52^{ns}
Treatment×time	9	1.092**	23.160**	*19.55	2788.926**	1.054**	0.033**	8.162**
Error	31	0.0470	2.39	98.531	66.874	0.217	0.055	0.615
Total	48	-	–	–	–	–	-	-

^{ns}, *, ** Not-significant, significant at 5% and 1% levels of probability, respectively.

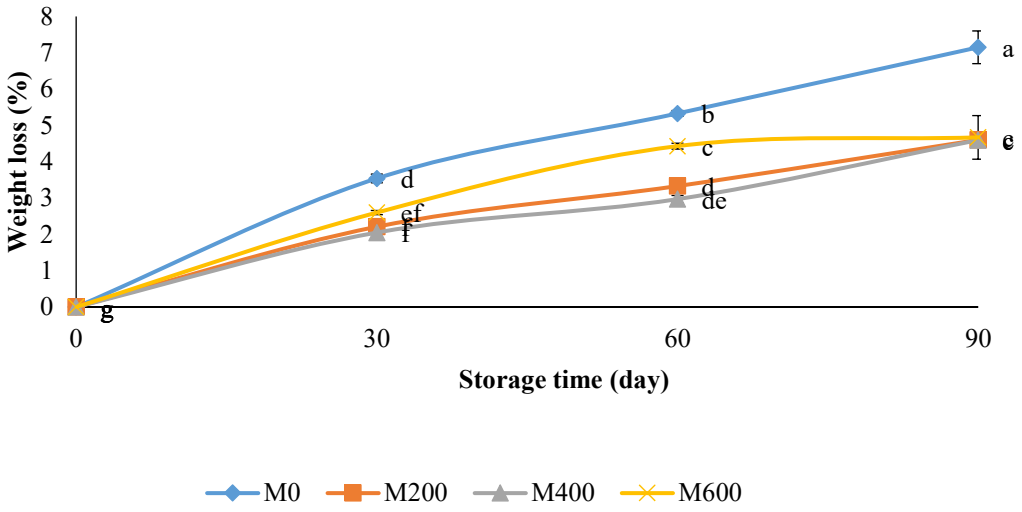

Fig. 1. Changes in the weight loss of orange fruit treated with different concentrations of melatonin during storage. Different letters on each day indicate significant differences between the data ($p<0.05$).
M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.2. Firmness

The analysis of variance showed a significant difference at the 1% probability level between the control fruits and those treated with melatonin in terms of firmness (Table 1). The mean comparison of data related to the effects of treatment and storage time on orange fruit firmness indicated that melatonin treatment better preserved fruit firmness during storage.

With the progression of the storage period, firmness decreased in all treatments. After 90 days of storage, the control treatment exhibited the lowest tissue firmness, whereas the highest firmness (49.75 N) was observed in fruits treated with 400 µM melatonin. Firmness is an important indicator for evaluating fruit ripening and overall quality, and its loss in fresh fruits results from the degradation of cell wall components such as pectin and other structural polysaccharides [28]. Application of melatonin reduces the activity of cell wall-degrading enzymes. The reduction in firmness is mainly attributed to the breakdown of structural polysaccharides, particularly hemicellulose and pectin's [11].

Results from similar studies have shown that melatonin application helps maintain fruit firmness during storage [29,30]. In agreement with Carrion-Antoli et al. [31] and Bal et al. [32], firmness of both melatonin-treated and untreated cherry fruits decreased during storage. However, the decrease in firmness was delayed in melatonin-treated fruits. In the present study, melatonin application delayed the onset and progression of softening in orange fruits through synergistic effects. Previous studies have indicated that melatonin preserves membrane stability by delaying oxidative stress and consequently preventing membrane lipid peroxidation [33], which may further contribute to maintaining fruit firmness during storage.

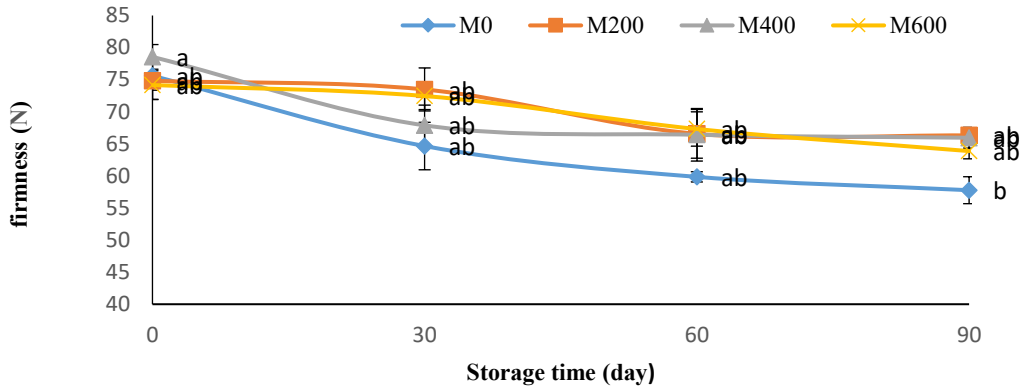

Figure 2. Changes in firmness of orange fruit treated with different concentrations of melatonin during storage (percentage)

Different letters on each day indicate significant differences between the data ($p<0.05$).

M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.3. Ascorbic Acid

According to the results (Fig. 3), during the storage period, the ascorbic acid content of melatonin-treated fruits initially decreased and then remained relatively stable, whereas in the control treatment, a gradual decreasing trend was observed until the end of the storage period. A significant difference was observed between the melatonin treatments and the control. The lowest ascorbic acid content (45.23 mg 100 g–1 FW) was recorded in the control treatment after 90 days of storage, while the highest value (61.73 mg 100 g–1 FW) was observed in fruits treated with 400 µM melatonin.

Ascorbic acid is both an essential nutrient and an important antioxidant [34]. Glutathione and ascorbic acid can directly scavenge free radicals and reactive oxygen species, increase the antioxidant capacity of fruit cells, and protect total phenols and flavonoids from degradation [35]. Generally, the amount of ascorbic acid decreases over the storage period, as was also observed in the present study. This reduction is consistent with the findings of Nair et al. [36] in guava fruit. The decrease in vitamin C during storage may be due to increased oxidation resulting from water loss, reduced activity of ascorbic acid oxidase, and auto-oxidation of ascorbic acid [37]. The results of this study indicated that melatonin effectively enhanced antioxidant activity, minimized the accumulation of H2O2, and increased the levels of phenolic compounds and ascorbic acid. Wang et al. (2019) also reported that melatonin treatment increased ascorbic acid content while reducing the accumulation of H2O2 and MDA as well as relative membrane permeability in cherry fruits [38].

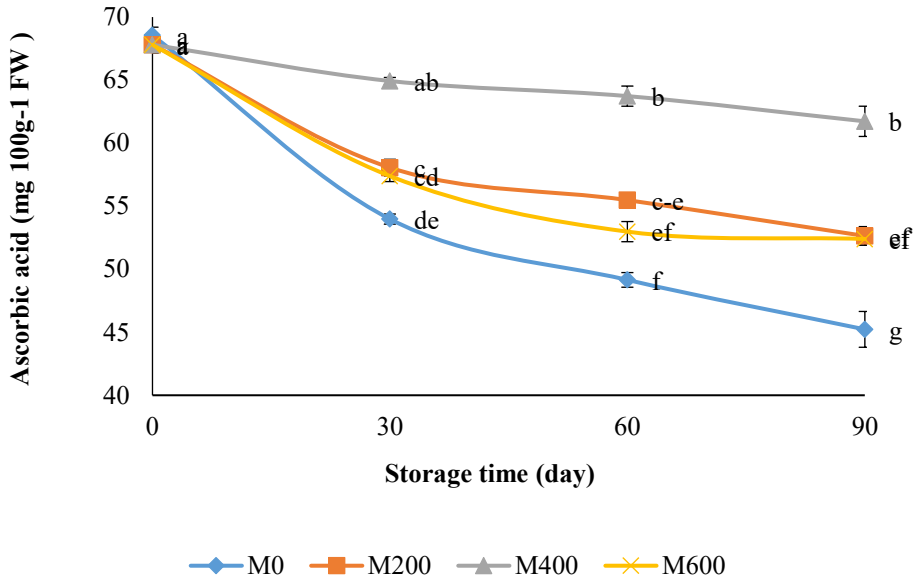

Fig. 3. Changes in ascorbic acid of orange fruit treated with different concentrations of melatonin during storage. Different letters on each day indicate significant differences between the data ($p<0.05$).
M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.4. Total Soluble Solids

The TSS content of orange fruit showed a gradual increasing trend during the storage period. According to the results of the analysis of variance, the interaction effect of melatonin treatment × storage time on TSS was significant at the 1% probability level (Table 1). Fruits treated with 400 µM melatonin exhibited the lowest TSS value (13.21 °Brix), whereas the control fruits showed the highest TSS value (15.86 °Brix) during the storage period.

Hamdani et al. [39] reported that the TSS content of Moro blood orange decreased during 75 days of storage, which was attributed to its utilization in respiration and energy-requiring metabolic processes. In line with the present study, Liu et al. [40] reported that treatment with 0.5 mM melatonin effectively delayed changes in mango ripening characteristics such as fruit firmness, pulp color, β-carotene content, TSS, and titratable acidity.

In contrast to our results, other studies have shown that foliar application of melatonin to strawberries induces the biosynthesis of endogenous melatonin-related genes, thereby maintaining fruit quality during storage and increasing sugar content.

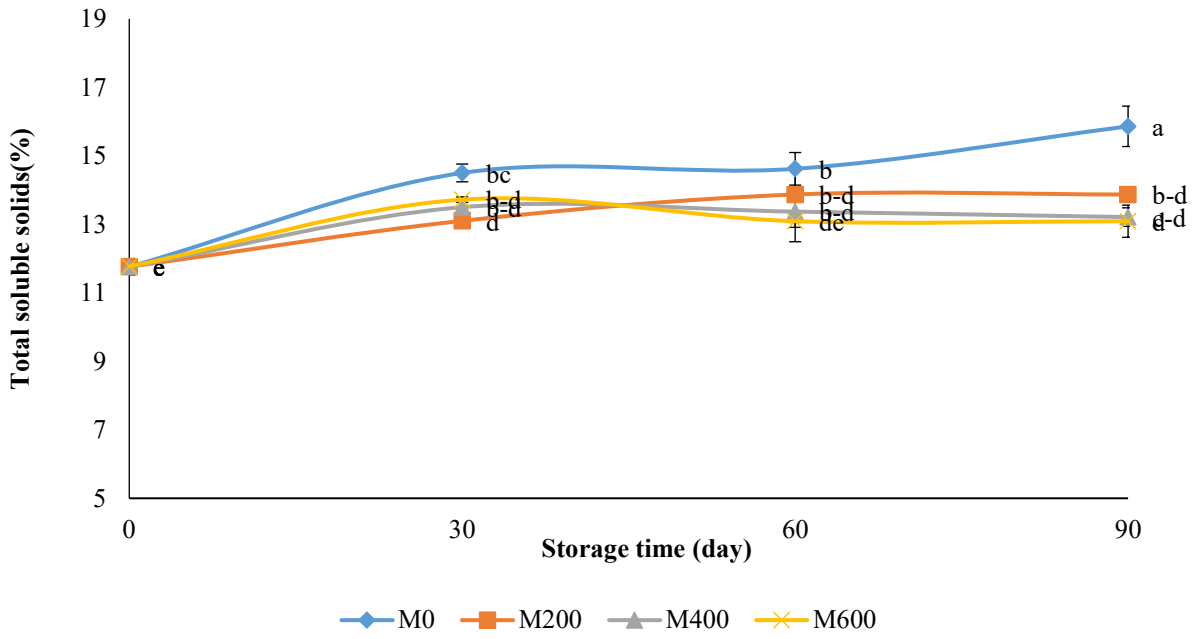

Fig. 4. Changes in soluble solids of orange fruit treated with different concentrations of melatonin during storage.
Different letters on each day indicate significant differences between the data ($p<0.05$). M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.5. Titratable Acidity

The organic acid content in the control fruits decreased significantly during the storage period. The lowest titratable acidity (0.54%) was observed in the control treatment on the 90th day of storage. Melatonin treatments largely preserved the organic acids of the fruit during storage. The highest titratable acidity at the end of the storage period was recorded in fruits treated with 400 µM melatonin (1.03%). No significant difference was observed between the 400 and 600 µM melatonin treatments in terms of titratable acidity on the 90th day, and both were placed in the same statistical group (Fig. 5).

The reduction in titratable acidity observed in the treatments is consistent with the findings of Hussain et al. [41], who reported that during cold storage of oranges, acid content decreases while sugar content increases over the storage period. The higher acidity observed in melatonin-treated fruits is in agreement with the results of Shi et al. [4] in peach and Liu et al. [40] in strawberry. These researchers reported that melatonin indirectly prevents the reduction of organic acids and enhances the protective capacity of fruit soluble solids, thereby improving the storage life of the fruit.

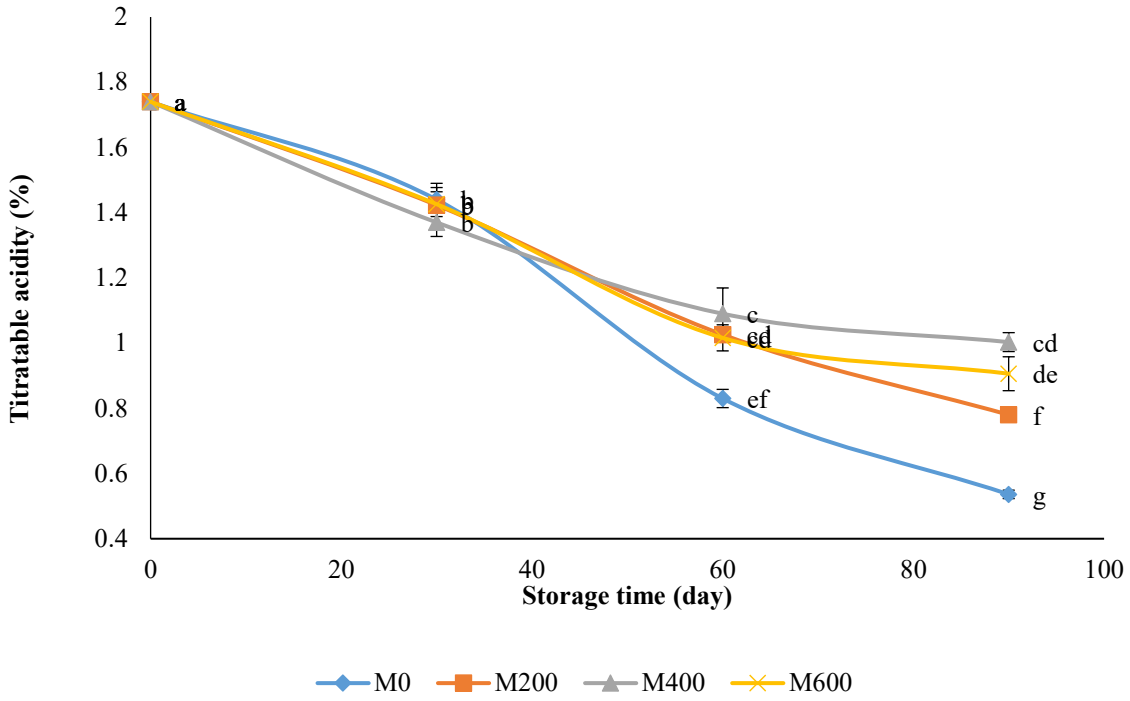

Fig. 5. Changes in total phenolic content of orange fruit treated with different concentrations of melatonin during storage (micrograms/kg fresh weight). Different letters on each day indicate significant differences between the data ($p<0.05$). M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.6. Total Phenolic Content

Phenolic compounds are important plant metabolites synthesized through the shikimic acid pathway and play a significant role in scavenging free radicals. The results of the analysis of variance indicated that melatonin treatment had a significant effect on the phenolic content of fruit compared to the control at harvest time. The concentrations of 400, 600, and 200 µM melatonin showed the highest phenolic contents (354.8, 339.33, and 322.43 µg g^{-1} fresh weight, respectively) compared with the control treatment on the 90th day of storage (Fig. 6). In agreement with the present study, Sun et al. [42] reported that melatonin promotes the accumulation of total phenols and flavonoids by positively regulating the expression of key genes involved in the phenylpropanoid biosynthesis pathway, such as PAL, CHS1, and CHS2. It has also been reported that nectarine fruits treated with 1000 µM melatonin maintained higher levels of total phenolic compounds and showed lower losses of ascorbic acid and flavonoids during storage [32].

Similar results were reported by Bhardwaj et al. [43], where soaking mango fruits for 120 minutes in 100 µM melatonin reduced the loss of ascorbic acid and maintained higher levels of total phenols and total flavonoids. Postharvest application of melatonin has also been shown to preserve fruit quality and phenolic compound content in peach during cold storage. Melatonin reduced decay incidence and weight loss while maintaining total phenolic content, antioxidant capacity, and fruit firmness. In cherries, melatonin treatments at concentrations of 50, 100, and 150 µM showed that 150 µM was more effective than other doses in maintaining higher total antioxidant activity and total phenolic content during storage. This improvement enhanced the fruit's ability to cope with oxidative damage and ultimately delayed postharvest senescence [38].

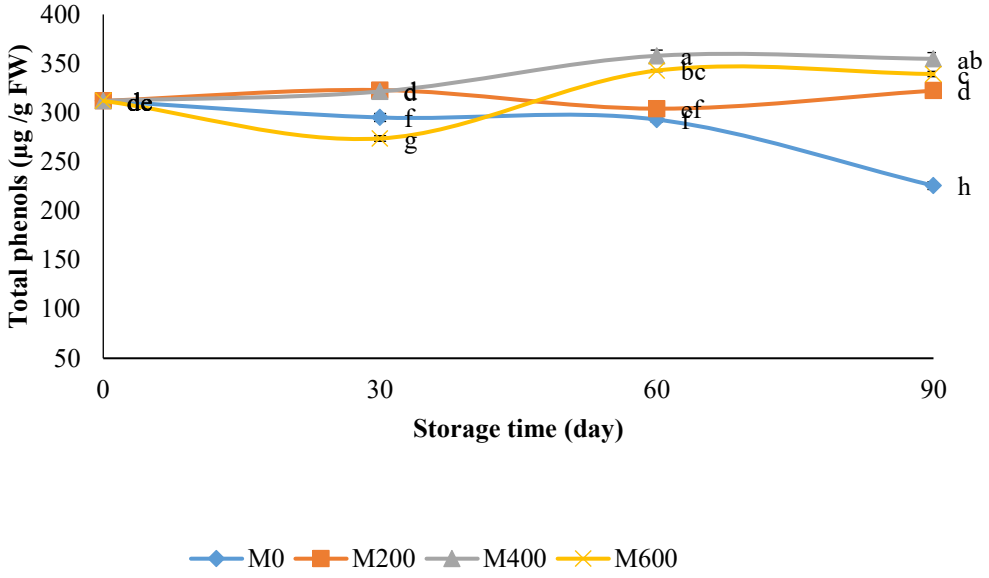

Fig. 6. Changes in total phenolic content of orange fruit treated with different concentrations of melatonin during storage (micrograms/g FW). Different letters on each day indicate significant differences between the data ($p<0.05$).
M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

3.7. Total Antioxidant Activity

The results of the analysis of variance indicated that melatonin treatment significantly affected the free radical scavenging capacity of the orange fruit during storage. Examination of the data showed that the total antioxidant activity of the fruit decreased over time. Comparison of mean values under the interaction effect of treatment × storage time demonstrated that the percentage of total antioxidant activity significantly declined throughout storage in all treatments. At the end of the cold storage period, the highest and lowest total antioxidant activity were observed in fruits treated with 400 µM melatonin (37.76%) and in the control (28.95%), respectively. No significant difference was observed between the 400 µM melatonin treatment and the control on the 60th day of storage in terms of total antioxidant activity ($P > 0.05$), and both were placed in the same statistical group (Fig. 7). Melatonin is recognized as a potent free radical scavenger and therefore exhibits high antioxidant activity. Due to its antioxidant properties, melatonin has been widely used in postharvest fruit preservation [44]. Moreover, as a biodegradable and safe biomolecule, melatonin does not adversely affect food safety. In agreement with the present study, Ge et al. [45] reported that melatonin increased DPPH radical scavenging activity in strawberry during cold storage by enhancing anthocyanin, phenolic, and flavonoid contents. Similarly, Cao et al. [46] reported that melatonin treatment of peach fruit enhanced antioxidant synthesis during storage through increased activity of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), and ascorbate peroxidase (APX), which is consistent with the findings of the present study.

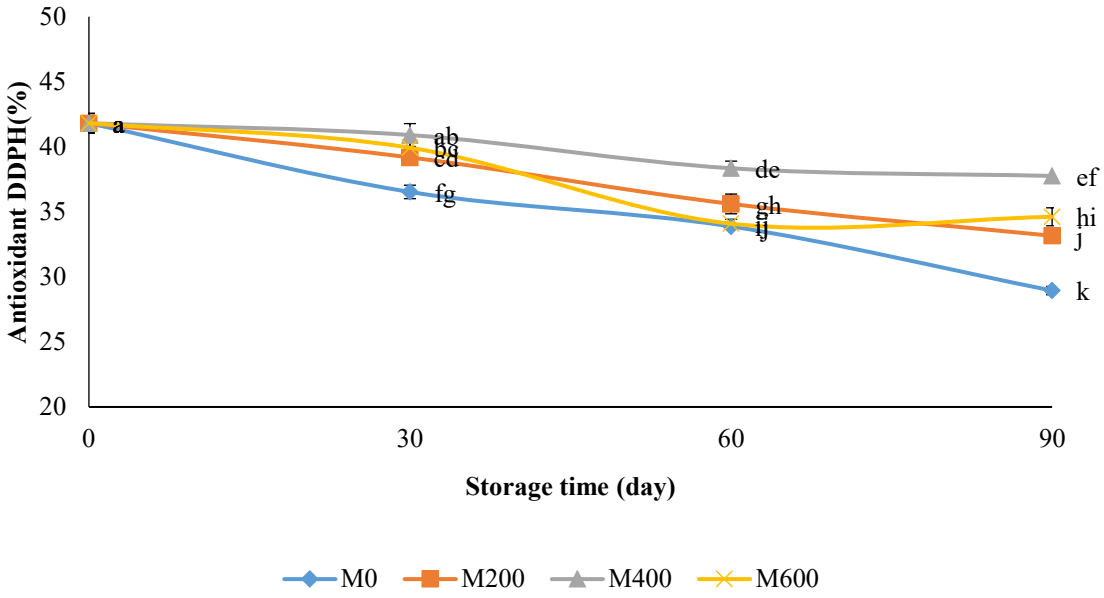

Fig. 7. Changes in total antioxidant content of orange fruit treated with different concentrations of melatonin during storage (%). Different letters on each day indicate significant differences between the data ($p<0.05$). M0: control, M200: containing 200 µmol/L melatonin, M400: containing 200 µmol/L melatonin, M600: containing 600 µmol/L melatonin

4-Conclusion

Postharvest melatonin treatments applied via fruit immersion had a positive effect on maintaining postharvest quality for longer periods by delaying ripening in orange fruits. Melatonin treatment reduced fruit weight loss, maintained firmness, preserved ascorbic acid content, and titratable acidity during storage. Furthermore, the treatment increased total antioxidant activity and total phenolic content, compared to the control, and reduced total soluble solids. Among the tested concentrations, 400 µM melatonin was the most effective dose and yielded to superior results compared to other treatments. Therefore, the application of melatonin at this concentration is recommended as an effective strategy to extend the storage life and maintain the postharvest quality in orange fruits.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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Author Contributions

All authors contributed to the design, analysis, writing, and approval of the final version of this manuscript. Mohammad Pour Ebrahimi: Data collection and drafting of the initial manuscript. Leila Jafari: Supervised the thesis, revised and finalized the content. Abdolmajid Mirzaalian Dastjerdi: Supervised the thesis, revised and finalized the content.

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چکیده

ملاتونین، یک هورمون طبیعی با خاصیت آنتی‌اکسیدانی و تنظیم کنندگی رشد، اخیراً به عنوان یک عامل مؤثر در حفظ کیفیت پس از برداشت میوه‌ها مورد توجه قرار گرفته است. تحقیق حاضر به‌منظور بررسی نقش ملاتونین بر خصوصیات پس از برداشت میوه پرتقال طی دوره انبارمانی به‌صورت آزمایش فاکتوریل در قالب طرح کاملا تصادفی با سه تکرار، در آزمایشگاه علوم باغبانی دانشگاه هرمزگان، در سال ۱۴۰۳-۱۴۰۲ انجام شد. میوه‌ها پس از تیماردهی با ملاتونین در غلظت‌های ۲۰۰، ۴۰۰ و ۶۰۰ میکرومولار به‌مدت ۹۰ روز در سردخانه با دمای ۱ ± ۵ درجه سانتی‌گراد و رطوبت نسبی ۵ ±۹۰ درصد قرار داده شده و با نمونه‌گیری به فاصله هر ۳۰ روز پارامترهایی نظیر کاهش‌وزن، اسید قابل تیتراسیون، اسید آسکوربیک، سفتی، مواد جامد محلول، آنتی‌اکسیدان کل و ترکیبات فنلی ارزیابی شدند. نتایج نشان داد میوه‌های تیمار شده با ملاتونین در غلظت ۴۰۰ میکرومولار نسبت به سایر تیمارها و شاهد، میزان (۳۵/۸۰ درصد) کاهش وزن کمتری داشتند و همچنین در این میوه‌ها میزان ترکیبات فنلی (۳۵۴/۸ میکروگرم در هر گرم وزن تازه)، سفتی (۴۹/۷۵ نیوتن)، اسید آسکوربیک (۶۱/۷۳ میلی‌گرم در ۱۰۰ گرم وزن تر)، آنتی‌اکسیدان کل (۳۷/۷۶ درصد)، اسید قابل تیتراسیون (۱/۰۳ درصد) افزایش یافتند. میوه‌های تیمار شده با ملاتونین در غلظت ۴۰۰ میکرومولار کمترین میزان مواد جامد قابل حل (۱۳/۲۱ درصد بریکس) را نشان دادند. ترکیب ملاتونین خاصیت آنتی‌اکسیدانی بالایی داشته و قادر است مانند یک ترکیب محافظت کننده عمل کرده و رادیکال‌های آزاد را مهار نماید. در این پژوهش دیده شد غلظت ۴۰۰ میکرومولار توانسته است عمر انبارمانی میوه پرتقال را با حفظ خواص آنتی‌اکسیدانی افزایش دهد و کیفیت را بهبود بخشد.