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AN OVERVIEW OF THE EFFECT OF MELATONIN ON MAINTAINING THE QUALITY OF ORNAMENTAL PLANTS BY INFLUENCING ANTIOXIDANT RESPONSES

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ABSTRACT

In plants, melatonin can regulate the life cycle, growth, and responses to environmental stress. It has been shown that in ornamental plants, melatonin regulates physiological processes. including growth, delays aging, and alleviates stress. The objective of this review is to provide information on the role of melatonin as a hormonal compound in ornamental plants, the significance of endogenous melatonin levels, and the its application in ornamental plant production and marketing. Several studies have reported that both exogenous and endogenous melatonin influence the lifespan of flowering potted plants, cut flowers, and foliage ornamentals, as well as their postharvest quality. Melatonin shows potential for maintaining the quality of ornamental plants. It acts as a growth regulator, preservative, and antimicrobial agent, thereby contributing to extended shelf life. This overview provides a comprehensive summary of melatonin biosynthesis in plants, endogenous melatonin content in various species, and its effects on cut flowers, potted plants, and ornamental foliage plants, as well as their postharvest quality. It also addresses the effects of exogenous melatonin application on ornamental plant cultivation.

Key words: hormonal compound, endogenous melatonin, exogenous melatonin

INTRODUCTION

Melatonin (MLT) has been identified as a potential agent for maintaining the quality of ornamental plants due to its various effects as a plant growth regulator, preservative, and antimicrobial agent (Gao et al. 2022). In most plant species, roots, seeds, leaves, bulbs, and flowers serve as rich sources of melatonin (Arnao & Hernández-Ruiz 2014). This compound can regulate the growth of roots, shoots, and explants, activate seed germination, and delay leaf aging (Arnao & Hernández-Ruiz 2014). In horticultural plants, melatonin has been reported to play a role in seed germination, root development, flowering, fruit formation and ripening (Gao et al. 2022). Additionally, melatonin acts as a potent antioxidant, enhancing plant resistance to various environmental stressors, while also supporting root growth, leaf morphology, chlorophyll preservation, and fruit development (Ahmad et al. 2023).

Ornamental plants are an important part of the horticultural market. However, their production and marketing are hindered by various obstacles due to biotic and abiotic factors. Stress caused by these factors reduces the profitability of ornamental plant sales and can negatively affect their quality. Therefore, it is necessary to develop new methods to improve and maintain quality. One way to enhance the quality of ornamental plants is through the application of melatonin.

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Numerous studies indicate that exogenous melatonin significantly affects the shelf life of cut flowers, including carnations (Lezoul et al. 2022) and tuberoses (Zulfiqar et al. 2023). This review presents melatonin as a novel hormonal compound, highlighting its occurrence in various ornamental plants and its impact on cut flowers, flowering potted plants, and foliage ornamentals. In this context, this article explores the potential of melatonin as a new agent for maintaining the quality of ornamental plants.

MELATONIN AS A HORMONAL COMPOUND IN PLANTS

In 1958, Lerner and his colleagues discovered melatonin (N-acetyl-5-methoxytryptamine) in the pineal glands of cattle (Arnao & Hernández-Ruiz 2019). Melatonin plays a significant role in physiological processes in animals, influencing circadian rhythms, sleep patterns, body temperature, appetite, sexual behavior, and the immune system (Carrillo-Vico et al. 2013). It acts as a signal of darkness, providing the brain and peripheral organs with the information necessary to synchronize the endogenous rhythms of physiological functions (Dubbels et al. 1995). Over the decades, the scope of research on melatonin has expanded. In 1995, it was detected in plant cells (Kanwar et al. 2018). This discovery laid the foundation for understanding the role of melatonin in plants – a compound called phytomelatonin.

Melatonin occurs in plants in small amounts, and its concentration varies depending on the species (Table 1). The highest concentrations are typically found in reproductive tissues, such as flowers and seeds. Melatonin production in plants is influenced by environmental factors such as light, temperature, and stress (Afreen et al. 2006). Melatonin serves a range of functions in plants, including the regulation of physiological processes (such as growth and cell differentiation), the inhibition of chlorophyll loss and the aging process, and counteracting the effects of stress (Mubarok et al. 2023).

ENDOGENOUS MELATONIN CONTENT IN VARIOUS ORNAMENTAL PLANTS

Endogenous melatonin is reported to play a crucial role in regulating growth across various plant species (Arnao & Hernández-Ruiz 2018). Its content varies between species and among different plant parts, such as flowers, leaves, fruits, and seeds (Çalişkan et al. 2017). A range of factors influence endogenous melatonin levels in plants, including arsenic (Kapoor et al. 2023) and lignin content as well as stem strength. Plants with stronger stems, such as *Paeonia lactiflora*, typically exhibit higher levels of this compound (Zhao et al. 2022). Other factors influencing this parameter include light deficiency (Wolf et al. 2001) and environmental conditions, e.g. abiotic stress from industrial pollution can increase endogenous melatonin content (Abbas et al. 2023), and cold stress causes an increase in melatonin content in young flower buds (Murch et al. 2009).

Table 1. Endogenous melatonin content in various ornamental plants

Scientific name	Common name	Endogenous melatonin content	Reference
Forsythia suspensa	weeping forsythia, golden-bell	45 $ng \cdot g^{-1}$	Chen et al. 2003
Helianthus annuus	sunflower	29 $ng \cdot g^{-1}$	Manchester et al. 2000
Lantana camara	wild sage	389 $pg \cdot g^{-1}$	Zohar et al. 2011
Laurus nobilis	bay laurel	8831 $pg \cdot g^{-1}$	Zohar et al. 2011
Lonicera etrusca	Etruscan honeysuckle	521 $pg \cdot g^{-1}$	Zohar et al. 2011
Lonicera japonica	Japanese honeysuckle	140 $ng \cdot g^{-1}$	Chen et al. 2003
Lupinus albus	white lupin	$1.28 \pm 0{,}06$ $ng \cdot g^{-1}$	Hernández-Ruiz and Arnao 2008
Myrtus communis	myrtle	291 $pg \cdot g^{-1}$	Zohar et al. 2011
Paeonia lactiflora	Chinese peony	62.61 ± 3.23 $ng \cdot g^{-1}$	Zhao et al. 2018
Phillyrea latifolia	green olive tree, mock privet	6337 $pg \cdot g^{-1}$	Zohar et al. 2011
Phyla nodiflora	lippia, frogfruit	27.48 ± 0.05 U per mg of protein	Abbas et al. 2023
Portulaca oleracea	pursley	19,000 $pg \cdot g^{-1}$	Simopoulos et al. 2005
Rehmannia glutinosa	Chinese foxglove	97 $ng \cdot g^{-1}$	Chen et al. 2003
Ruscus aculeatus	butcher's broom	954 $pg \cdot g^{-1}$	Zohar et al. 2011
Viburnum tinus	laurustinus	613 $pg \cdot g^{-1}$	Zohar et al. 2011

THE EFFECT OF MELATONIN ON CUT FLOWERS

The vase life of cut flowers is a key quality factor affecting farmers' profit margins in both domestic and international markets (Zulfiqar et al. 2023). Following harvest, metabolic activity persists within the flower cells, involving essential processes that utilize substrates stored in the tissues (Jhanji et al. 2023). Extending vase life and delaying aging can be achieved by maintaining carbohydrate levels, improving water absorption, and reducing oxidative stress caused by the excessive reactive oxygen species (ROS) formation (Zulfiqar et al. 2023). Following postharvest damage, the level of ROS rises significantly, accompanied by an increase in antioxidant activity. High levels of ROS can accelerate flower aging, directly affecting the quality and shelf life of cut flowers (Hatamzadeh et al. 2012).

Various postharvest treatments utilizing plant growth regulators (PGRs), signaling molecules, and biostimulants can inhibit postharvest aging and extend vase life (Zulfiqar et al. 2020). However, research on the preharvest application of these substances to enhance the postharvest performance of cut flowers remains limited (Zulfiqar et al. 2023). Preharvest application of biostimulants and potassium has been shown to improve the postharvest performance of gladiolus and statice by reducing oxidative stress during aging (Zulfiqar et al. 2020, 2023). Melatonin can prevent oxidative stress in plants due to its antioxidant properties (Altaf et al. 2021a, b).

Based on the findings of Lezoul et al. (2022), melatonin extended the vase life of cut carnations (*Dianthus caryophyllus* L.) by up to 10 days compared with the untreated control. Another study demonstrated that melatonin prolonged the vase life of tuberose flowers (Asparagaceae) by enhancing leaf gas exchange and soluble sugar content, while reducing proline, hydrogen peroxide (H_2O_2), and malondialdehyde (MDA) content (Zulfiqar et al. 2023).

THE EFFECT OF MELATONIN ON FOLIAGE ORNAMENTAL PLANTS

The aging of foliage ornamental plants can pose a significant challenge, especially when insufficient lighting leads to plant stress. This constraint can notably limit the quality of such plants, reducing their visual appeal and aesthetic value (Ferrante et al. 2015).

Several recent studies have shown that melatonin delays leaf aging induced by abiotic stressors, including drought and darkness (Byeon et al. 2012). Such stress conditions can trigger ethylene production (Irigoyen et al. 1992), which results in leaf aging and shedding, as well as other physiological disruptions, such as epinasty (Ferrante et al. 2015).

A study by Xiang et al. (2020a) evaluated the efficacy of melatonin in mitigating dark-induced plant damage in three *Pilea* species: *P. cadierei*, *P. involucrata*, and *P. mollis*. These plants are susceptible to damage, especially during long-distance transport, which can lead to the yellowing of leaves. The results showed that the application of melatonin at different concentrations (50, 100, 150, and 200 $\mu mol \cdot L^{-1}$) can reduce darkness-induced damage in all three species. Table 2 presents the results of exogenous melatonin application in various ornamental plants.

Table 2. Effect of melatonin application on ornamental plants

Scientific name	Common name	Plant organ	Application method	Optimal concentration	Effect	Reference
Anthurium	anthurium	flower	dipping the flower stem	100 µM	Melatonin mitigates chilling injury by reducing electrolyte leakage and maintaining lower malondialdehyde concentrations during storage under cold conditions	Aghdam et al. 2019
Antirrhinum majus	snapdragon	flower	spraying	200 µmol per L	Melatonin extends the vase life of cut flowers by increasing the length of the flowers and stems, as well as the number and size of flower buds, it also reduces postharvest decay by inhibiting ethylene biosynthesis and gene expression associated with ethylene biosynthesis, and exogenous melatonin can inhibit bacterial, viral, and parasitic infections by upregulating pathogenesis-related genes (such as nitric oxide and salicylic acid), thereby enhancing the postharvest quality of fruits and vegetables	Xiang et al. 2020b
Chrysanthemum morifolium	chrysanthemum	flower	spraying	100 µM	Melatonin enhances the physiological resistance of flowers to drought by enhancing photosynthetic capacity and antioxidant defense, and additionally reduces membrane damage and the accumulation of reactive oxygen species	Luo et al. 2023
Davidia involucrata	dove tree	flower	spraying	100 µM	Melatonin is associated with complex coordination of multiple signaling pathways and phytohormone synthesis, as well as the activation of phenylpropanoid biosynthesis, glutathione metabolism, and calcium signaling, contributing to the alleviation of drought stress	Liu et al. 2021
Dianthus caryophyllus	carnation	flower	spraying	0.1 mM	Melatonin extends the vase life of flowers, helping to maintain their initial fresh weight, membrane stability index, bioactive compounds, and antioxidant activity for a longer period	Lezoul et al. 2022
Gardenia jasminoides	gardenia	leaf	dipping the flower stem	1.0 mM	Melatonin delays the senescence of leaves and mitigates physiological stress by increasing glutamine synthetase activity, increasing water and protein content, reducing cell death under darkness, increasing endogenous melatonin levels, and enhancing the activity of superoxide dismutase and catalase	Zhao et al. 2017
Hedychium coronarium	white ginger lily	flower	dipping the flower stem	100 µM	Melatonin increases the production of flower aroma by altering the expression levels of genes involved in the flower aroma biosynthesis pathway	Abbas et al. 2021
Hibiscus syriacus	rose of Sharon	flower	spraying	100 µmol per L	Exogenous melatonin enhances the drought resistance by regulating the photosynthetic system, antioxidant enzyme activity, and drought-related genes	Yan et al. 2024
Hippeastrum hybridum	amaryllis	flower	dipping the flower stem	0.01 mM	Melatonin ensures the stability of flower stem mass, delays the degradation of anthocyanin and flavonoid pigments, and preserves the stability of phenolic compounds and total carbohydrates for 14 days	Lourêdo de Brito et al. 2023
Lilium	lily	bulb	dipping	20 µM	Melatonin regulates bulb development by downregulating LoRAV and upregulating LoBPM3 during the early stages of growth	Sun et al. 2022
Limonium bicolor	statice	leaf	spraying	5 µM	Melatonin improves salt tolerance by enhancing photosynthesis and improving cellular redox homeostasis under salt stress	Li et al. 2022
Malva parviflora	mallow	leaf	dipping	15 µM, 50 µM	Melatonin alleviates cadmium-induced stress by increasing the relative water content and stomatal conductance of plants, causing a significant increase in the activity of catalase, superoxide dismutase, and guaiacol peroxidase, while also stimulating the production of phenols, and increased activity of antioxidant enzymes reduces electrolyte leakage, lipid peroxidation, and hydrogen peroxide levels	Tousi et al. 2020
Paeonia lactiflora	garden peony	stem	spraying	0.5 mM	Melatonin increases stem strength by raising lignin content and regulating the expression of genes involved in lignin biosynthesis, improving the S/G lignin	Zhao et al. 2022

Scientific name	Common name	Plant organ	Application method	Optimal concentration	Effect	Reference
					composition ratio	
Pilea cadierei, *P. involucrata*, *P. mollis*	pilea	leaves	spraying	50–200 µmol per L	Melatonin mitigates plant damage caused by darkness by increasing stem height, leaf area, chlorophyll and anthocyanin content, and Fv/Fm values	Xiang et. al 2020a
Polianthes tuberosa	tuberose	flower	spraying	0.07 mM, 1.00 mM	Melatonin delays the aging of night-scented flowers by improving gas exchange in the leaves and increasing the content of soluble proteins and soluble sugars, it also lowers the levels of proline, hydrogen peroxide, and malondialdehyde, while enhancing the activity of superoxide dismutase and catalase, thereby reducing oxidative stress	Zulfiqar et al. 2023
Primula forbesii	baby primrose	flower	spraying	100 µmol per L	Melatonin mitigates growth inhibition induced by cadmium stress, improving morphology, growth index, and ornamental value	Jia et al. 2023
Ranunculus asiaticus	Persian buttercup	leaf	spraying	200 µM	Melatonin mitigates salt stress by increasing relative water content and photosynthetic pigments, while reducing the accumulation of sodium ions in the leaves, which improves vegetative parameters and promotes plant growth	Eisa et al. 2023
Rhododendron	rhododendron	leaf	spraying	200 µmol per L	Melatonin can increase tolerance to heat stress by enhancing the efficiency of photosynthetic electron transport, boosting the activity of Calvin cycle enzymes, stimulating the production of adenosine triphosphate, and improving the efficiency of photosynthesis and carbon dioxide assimilation through the regulation of the expression of specific genes, including RhRbsA	Xu et al. 2023
Rosa hybrida	rose	flower	dipping the flower stem	0.2 mM	Melatonin extends the vase life by reducing stomatal opening on the lower epidermis, increasing phenol and glutathione content, and enhancing the activity of catalase, ascorbate peroxidase, and glutathione reductase, it also reduces hydrogen peroxide production and lipid peroxidation, which contributes to membrane stability	Mazrou et al. 2022
Salvia nemorosa	woodland sage	flower	spraying	100 µM	Melatonin enhances antioxidant defense by increasing essential oil production, especially under mild water stress	Bidabadi et al. 2020

CONCLUSIONS

The application of melatonin to ornamental plants offers advantages as a biostimulant by enhancing their tolerance to various abiotic stressors, including extreme temperatures, drought, osmotic stress, heavy metals, and ultraviolet (UV) radiation. Melatonin plays a crucial role in regulating reactive oxygen species (ROS) and other free radicals, influences both primary and secondary plant metabolism, regulates stress-related enzyme transcription and transcription factors, and interacts with other hormones under diverse environmental conditions. Future research should further explore the functions of and mechanisms of action of melatonin in ornamental plant cultivation.

Author contribution statement

SM – A – Research concept and design, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

HM – B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article

AD – C – Data analysis and interpretation, D – Writing the article, F – Final approval of the article

NP – C – Data analysis and interpretation, E – Critical revision of the article

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Declarations
The authors declare no competing interests.

REFERENCES

Abbas T., Ahmad I., Khan Z.I., Okla M.K., Saleh I.A., Abdelgawad H.R. 2023. Comparative physiological adaptations to industrial pollution stress mediated by melatonin in riparian vegetation and *Phyla nodiflora* an ornamental plant. Scientia Horticulturae 321; 112367. DOI: 10.1016/j.scienta.2023.112367.

Abbas F., Zhou Y., He J., Ke Y., Qin W., Yu R., Fan Y. 2021. Metabolite and transcriptome profiling analysis revealed that melatonin positively regulates floral scent production in *Hedychium coronarium*. Frontiers in Plant Science 12; 808899; 18 p. DOI: 10.3389/fpls.2021.808899.

Afreen F., Zobayed S.M., Kozai T. 2006. Melatonin in *Glycyrrhiza uralensis*: response of plant roots to spectral quality of light and UV-B radiation. Journal of Pineal Research 41(2): 108–115. DOI: 10.1111/j.1600-079x.2006.00337.x.

Aghdam M.S., Jannatizadeh A., Nojadeh M.S., Ebrahimzadeh A. 2019. Exogenous melatonin ameliorates chilling injury in cut anthurium flowers during low temperature storage. Postharvest Biology and Technology 148: 184–191. DOI: 10.1016/j.postharvbio.2018.11.008.

Ahmad S., Wang F., Ahmad A., Ercisli S., Chen J., Guan Y. et al. 2023. Suggesting a prospect for melatonin-mediated orchid flowering under extreme conditions. Scientia Horticulturae 321; 112340; 10 p. DOI: 10.1016/j.scienta.2023.112340.

Altaf M.A., Shahid R., Ren M.X. Altaf M.M., Khan L.U., Shahid S., Jahan M.S. 2021a. Melatonin alleviates salt damage in tomato seedling: a root architecture system, photosynthetic capacity, ion homeostasis, and antioxidant enzymes analysis. Scientia Horticulturae 285; 110145; 10 p. DOI: 10.1016/j.scienta.2021.110145.

Altaf M.A., Shahid R., Ren M.X., Mora-Poblete F., Arnao M.B., Naz S. et al. 2021b. Phytomelatonin: An overview of the importance and mediating functions of melatonin against environmental stresses. Physiologia Plantarum 172(2): 820–846. DOI: 10.1111/ppl.13262.

Arnao M.B., Hernández-Ruiz J. 2014. Melatonin: plant growth regulator and/or biostimulator during stress? Trends in Plant Science 19(12): 789–797. DOI: 10.1016/j.tplants.2014.07.006.

Arnao M.B., Hernández-Ruiz J. 2018. Melatonin and its relationship to plant hormones. Annals of Botany 121(2): 195–207. DOI: 10.1093/aob/mcx114.

Arnao M.B., Hernández-Ruiz J. 2019. Melatonin: a new plant hormone and/or a plant master regulator? Trends in Plant Science 24(1): 38–48. DOI: 10.1016/j.tplants.2018.10.010.

Bidabadi S.S., VanderWeide J., Sabbatini P. 2020. Exogenous melatonin improves glutathione content, redox state and increases essential oil production in two *Salvia* species under drought stress. Scientific Reports 10; 6883; 12 p. DOI: 10.1038/s41598-020-63986-6.

de Brito F.A., de Mello N.R., Martins L.D., Martim M.B., da Silva L.F., Guerra T.M., Simões A.N. 2023. Application of melatonin and sucrose in prolonging the vase life of amaryllis cut flowers (*Hippeastrum hybridum* Herb). Ornamental Horticulture 29(4): 489–499. DOI: 10.1590/2447-536x.v29i4.2670.

Byeon Y., Park S., Kim Y.S., Park D.H., Lee S., Back K. 2012. Light-regulated melatonin biosynthesis in rice during the senescence process in detached leaves. Journal of Pineal Research 53(1): 107–111. DOI: 10.1111/j.1600-079x.2012.00976.x.

Carrillo-Vico A., Lardone P.J., Álvarez-Sánchez N., Rodríguez-Rodríguez A., Guerrero J.M. 2013. Melatonin: buffering the immune system. International Journal of Molecular Sciences 14(4): 8638–8683. DOI: 10.3390/ijms14048638.

Chen G., Huo Y., Tan D.X., Liang Z., Zhang W., Zhang Y. 2003. Melatonin in Chinese medicinal herbs. Life Sciences 73(1): 19–26. DOI: 10.1016/s0024-3205(03)00252-2.

Dubbels R., Reiter R.J., Klenke E., Goebel A., Schnakenberg E., Ehlers C. et al. 1995. Melatonin in edible plants identified by radioimmunoassay and by high performance liquid chromatography-mass spectrometry. Journal of Pineal Research 18(1): 28–31. DOI: 10.1111/j.1600-079x.1995.tb00136.x.

Eisa E.A., Honfi P., Tilly-Mándy A., Mirmazloum I. 2023. Exogenous melatonin application induced morpho-physiological and biochemical regulations conferring salt tolerance in *Ranunculus asiaticus* L. Horticulturae 9(2); 228; 16 p. DOI: 10.3390/horticulturae9020228.

Ferrante A., Trivellini A., Scuderi D., Romano D., Vernieri P. 2015. Post-production physiology and handling of ornamental potted plants. Postharvest Biology and Technology 100: 99–108. DOI: 10.1016/j.postharvbio.2014.09.005.

Gao T., Liu X., Tan K., Zhang D., Zhu B., Ma F., Li C. 2022. Introducing melatonin to the horticultural industry: physiological roles, potential applications, and challenges. Horticulture Research 9; uhac094; 18 p. DOI: 10.1093/hr/uhac094.

Hatamzadeh A., Hatami M., Ghasemnezhad M. 2012. Efficiency of salicylic acid delay petal senescence and extended quality of cut spikes of *Gladiolus grandiflora* cv 'wing's sensation'. African Journal of Agricultural Research 7(4): 540–545. DOI: 10.5897/ajar11.962.

Hernández-Ruiz J., Arnao M.B. 2008. Melatonin stimulates the expansion of etiolated lupin cotyledons. Plant Growth Regulation 55(1): 29–34. DOI: 10.1007/s10725-008-9254-y.

Irigoyen J.J., Emerich D.W., Sánchez-Díaz M. 1992. Alfalfa leaf senescence induced by drought stress: photosynthesis, hydrogen peroxide metabolism, lipid peroxidation and ethylene evolution. Physiologia Plantarum 84(1): 67–72. DOI: 10.1111/j.1399-3054.1992.tb08766.x.

Jia Y., Yin X., Zhao J., Pan Y., Jiang B., Liu Q. et al. 2023. Effects of 24-Epibrassinolide, melatonin and their combined effect on cadmium tolerance in *Primula forbesii* Franch. Ecotoxicology and Environmental Safety 262; 115217; 10 p. DOI: 10.1016/j.ecoenv.2023.115217.

Jhanji S., Kaur G., Kaur R., Dhatt U.K. 2023. Physiological and biochemical changes during flower development and senescence in Chrysanthemum and Gladiolus. Acta Physiologiae Plantarum 45(1); 14; 13 p. DOI: 10.1007/s11738-022-03486-4.

Kanwar M.K., Yu J., Zhou J. 2018. Phytomelatonin: recent advances and future prospects. Journal of Pineal Research 65(4); e12526; 19 p. DOI: 10.1111/jpi.12526.

Kapoor B., Kumar P., Gill N.S., Sharma R., Thakur N., Irfan M. 2023. Molecular mechanisms underpinning the silicon-selenium (Si-Se) interactome and crosstalk in stress-induced plant responses. Plant and Soil 486(1–2): 45–68. DOI: 10.1007/s11104-022-05482-6.

Koca Çalişkan U., Aka C., Bor E. 2017. Melatonin in edible and non-edible plants. Turkish Journal of Pharmaceutical Sciences 14(1): 75–83. DOI: 10.4274/tjps.33043.

Li J., Liu Y., Zhang M., Xu H., Ning K., Wang B., Chen M. 2022. Melatonin increases growth and salt tolerance of *Limonium bicolor* by improving photosynthetic and antioxidant capacity. BMC Plant Biology 22(1); 16; 14 p. DOI: 10.1186/s12870-021-03402-x.

Liu Q., Feng Z., Xu W., Vetukuri R.R., Xu X. 2021. Exogenous melatonin-stimulated transcriptomic alterations of *Davidia involucrata* seedlings under drought stress. Trees 35(3): 1025–1038. DOI: 10.1007/s00468-021-02099-7.

Lezoul N.E., Serrano M., Ruiz-Aracil M.C., Belkadi M., Castillo S., Valero D., Guillén F. 2022. Melatonin as a new postharvest treatment for increasing cut carnation (*Dianthus caryophyllus* L.) vase life. Postharvest Biology and Technology 184; 111759; 8 p. DOI: 10.1016/j.postharvbio.2021.111759.

Luo Y., Hu T., Huo Y., Wang L., Zhang L., Yan R. 2023. Effects of exogenous melatonin on *Chrysanthemum* physiological characteristics and photosynthesis under drought stress. Horticulturae 9(1); 106; 13 p. DOI: 10.3390/horticulturae9010106.

Manchester L.C., Tan D.X., Reiter R.J., Park W., Monis K., Qi W. 2000. High levels of melatonin in the seeds of edible plants: possible function in germ tissue protection. Life Sciences 67(25): 3023–3029. DOI: 10.1016/s0024-3205(00)00896-1.

Mazrou R.M., Hassan S., Yang M., Hassan F.A. 2022. Melatonin preserves the postharvest quality of cut roses through enhancing the antioxidant system. Plants 11(20); 2713; 14 p. DOI: 10.3390/plants11202713.

Mubarok S., Suminar E., Abidat A.H., Setyawati C.A., Setiawan E., Buswar A.S. 2023. Overview of melatonin's impact on postharvest physiology and quality of fruits. Horticulturae 9(5); 586; 15 p. DOI: 10.3390/horticulturae9050586.

Murch S.J., Alan A.R., Cao J., Saxena P.K. 2009. Melatonin and serotonin in flowers and fruits of *Datura metel* L. Journal of Pineal Research 47(3): 277–283. DOI: 10.1111/j.1600-079x.2009.00711.x.

Simopoulos A.P., Tan D.X., Manchester L.C., Reiter R.J. 2005. Purslane: a plant source of omega-3 fatty acids and melatonin. Journal of Pineal Research 39(3): 331–332. DOI: 10.1111/j.1600-079x.2005.00269.x.

Sun L., Song S.L., Yang Y., Sun H.M. 2022. Melatonin regulates lily bulblet development through the *LoBPM3-LoRAV* module. Ornamental Plant Research 2; 12; 11 p. DOI: 10.48130/opr-2022-0012.

Tousi S., Zoufan P., Ghahfarrokhie A.R. 2020. Alleviation of cadmium-induced phytotoxicity and growth improvement by exogenous melatonin pretreatment in mallow (*Malva parviflora*) plants. Ecotoxicology and Environmental Safety 206; 111403; 10 p. DOI: 10.1016/j.ecoenv.2020.111403.

Wolf K., Kolář J., Witters E., van Dongen W., van Onckelen H., Macháčková I. 2001. Daily profile of melatonin levels in *Chenopodium rubrum* L. depends on photoperiod. Journal of Plant Physiology 158(11): 1491–1493. DOI: 10.1078/0176-1617-00561.

Xiang D., Nguyen C.D., Opgenorth J., Clark D., Huo H. 2020a. Effects of melatonin and AVG on plant growth of three *Pilea* species in darkness. The Horticulture Journal 89(5): 609–618. DOI: 10.2503/hortj.utd-208.

Xiang D., Nguyen C.D., Felter L., Clark D., Huo H. 2020b. The effects of preharvest LED light, melatonin and AVG treatments on the quality of postharvest snapdragon and vase life. Journal of Floriculture and Landscaping 6: 14–19. DOI: 10.25081/jfcls.2020.v6.6236.

Xu Y.X., Zhang J., Wan Z.Y., Huang S.X., Di H.C., He Y., Jin S.H. 2023. Physiological and transcriptome analyses provide new insights into the mechanism mediating the enhanced tolerance of melatonin-treated rhododendron plants to heat stress. Journal of Integrative Agriculture 22(8): 2397–2411. DOI: 10.1016/j.jia.2023.07.005.

Yan R., Liu J., Zhang S., Guo J. 2024. Exogenous melatonin and salicylic acid enhance the drought resistance of hibiscus (*Hibiscus syriacus* L.) by regulating photosynthesis and antioxidant system. Journal of Soil Science and Plant Nutrition 24(1): 497–511. DOI: 10.1007/s42729-023-01560-5.

Zhao D., Wang R., Liu D., Wu Y., Sun J., Tao J. 2018. Melatonin and expression of tryptophan decarboxylase gene (*TDC*) in herbaceous peony (*Paeonia lactiflora* Pall.) flowers. Molecules 23(5); 1164; 11 p. DOI: 10.3390/molecules23051164.

Zhao D., Luan Y., Shi W., Tang Y., Huang X., Tao J. 2022. Melatonin enhances stem strength by increasing lignin content and secondary cell wall thickness in herbaceous peony. Journal of Experimental Botany 73(17): 5974–5991. DOI: 10.1093/jxb/erac165.

Zhao D., Wang R., Meng J., Li Z., Wu Y., Tao J. 2017. Ameliorative effects of melatonin on dark-induced leaf senescence in gardenia (*Gardenia jasminoides* Ellis): leaf morphology, anatomy, physiology and transcriptome. Scientific Reports 7(1); 10423; 19 p. DOI: 10.1038/s41598-017-10799-9.

Zohar R., Izhaki I., Koplovich A., Ben-Shlomo R. 2011. Phytomelatonin in the leaves and fruits of wild perennial plants. Phytochemistry Letters 4(3): 222–226. DOI: 10.1016/j.phytol.2011.04.002.

Zulfiqar F., Younis A., Finnegan P.M., Ferrante A. 2020. Comparison of soaking corms with moringa leaf extract alone or in combination with synthetic plant growth regulators on the growth, physiology and vase life of sword lily. Plants 9(11); 1590; 9 p. DOI: 10.3390/plants9111590.

Zulfiqar F., Moosa A., Darras A., Nafees M., Ferrante A., Siddique K.H. 2023. Preharvest melatonin foliar treatments enhance postharvest longevity of cut tuberose *via* altering physio-biochemical traits. Frontiers in Plant Science 14; 1151722; 7 p. DOI: 10.3389/fpls.2023.1151722.