Effect of plant extracts on postharvest conservation of cut flowers

Callejas-Utrera, Ángela[1]; Adame-García, Jacel[2]; Fernández-Viveros, José Antonio[2]; Torres-Pelayo, Vianey del Rocío[3]; Alvarado-Castillo, Gerardo[1*]

[1] Universidad Veracruzana, Facultad de Ciencias Agrícolas, Doctorado en Ciencias Agropecuarias. Xalapa, Xalapa-Enríquez, Veracruz, México. C. P. 91090.
[2] Tecnologico Nacional de México, Instituto Tecnológico de Úrsulo Galván. Úrsulo Galván, Úrsulo Galván, Veracruz, México. C. P. 91667.
[3] Universidad Veracruzana, Facultad de Biología. Xalapa, Xalapa-Enríquez, Veracruz, México. C. P. 91090.
* Correspondence: gealvarado@uv.mx

ABSTRACT

Objective: To evaluate the effect of plant extracts on the postharvest preservation of cut flowers.

Methodology: Seven extraction methods were employed to obtain active compounds from fresh and dry plant material, using *Azadirachta indica* as a reference and rose as the model flower. With the extraction method defined, five plants with medicinal and antimicrobial properties (*Azadirachta indica*, *Piper auritum*, *Equisetum arvense*, *Hamelia patens*, and *Solanum nigrum*) were evaluated on five cut flowers species (rose, gerbera, carnation, gladiolus, and chrysanthemum) at three concentrations (25, 50, and 75 ppm), alongside a standard (Floralife®) and control. The experimental design was completely randomized in a factorial arrangement with three replications.

Results: Significant differences were observed (Tukey $P \leq 0.05$) among flower types, plant extracts, and concentrations, indicating a significant delay in floral senescence.

Limitations on study: Further studies are required to validate these findings, particularly regarding the metabolites present in the evaluated extracts.

Conclusions: Plant extracts are proposed as an effective and natural strategy to enhance cut flower preservation.

Keywords: Vase life, natural preservatives, floral senescence, flower quality.

Citation: Callejas-Utrera, Á., Adame-García, J., Fernández-Viveros, J. A., Torres-Pelayo, V. del R., & Alvarado-Castillo, G. (2025). Effect of plant extracts on postharvest conservation of cut flowers. *Agro Productividad*. https://doi.org/10.32854/agrop.v18i2.3249

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: November 17, 2024.
Accepted: January 28, 2025.
Published on-line: March XX, 2025.

Agro Productividad, 18(2). February. 2025. pp: 115-124.

INTRODUCTION

Worldwide, floriculture is a highly relevant commercial activity for both local markets and exportation. In addition to its economic importance, flowers hold aesthetic, symbolic, and emotional value in many societies (Tejeda-Sartorius & Arévalo-Galarza, 2012). In Mexico, this agro-industrial activity is one of the most important, as it generates employment and foreign exchange, contributing significantly to the economic and social development of various regions. Among the most commonly traded crops internationally are roses (*Rosa*

spp.), carnations (*Dianthus caryophyllus*), chrysanthemums (*Chrysanthemum* spp.), gerberas (*Gerbera* spp.), and gladiolus (*Gladiolus* spp.), among other species (Meza-García *et al.*, 2017; Valencia-Sandoval & Guerrero-Morales, 2018).

To prolong the vase life of flowers and maximize product profitability, various preservation techniques are employed (Nguyen & Lim, 2021). These methods aim to extend the sales period, increase availability, facilitate long-distance transportation, and meet market demand (Thakur, 2020). These techniques include refrigeration, floral preservatives, pulsing, controlled atmospheres, UV radiation, and their combinations.

Refrigeration is the most widely used technique at the industrial level (Debnath *et al.*, 2019; Thakur, 2020), as it helps reduce the respiration rate and slows down senescence. However, the temperature and duration of cold storage may vary depending on the species and variety of the flower. Additionally, relative humidity and ventilation are critical factors that must be carefully controlled during refrigeration (Debnath *et al.*, 2019). Despite its effectiveness, refrigeration has drawbacks such as high initial investment costs, significant energy consumption, and condensation issues that can promote the proliferation of microorganisms (Juárez *et al.*, 2008). Similarly, storage conditions are specific to each type of flower (Debnath *et al.*, 2019); for instance, some flowers are cold-sensitive and cannot be stored below 10 to 13 °C, such as bird of paradise, heliconia, orchids, and anthuriums (Soleimani *et al.*, 2016; Nascimento *et al.*, 2018).

Similarly, the use of floral preservatives is particularly important for small-scale producers who lack adequate infrastructure and in situations where flowers need to be transported and stored for extended periods before their sale or use in floral arrangements. These preservatives are widely available on the market and are used by most florists and flower distributors, as they are easy to obtain, cost-effective, and do not require specialized infrastructure for their application. However, the use of commercial chemical preservatives may pose a risk to public health and have a negative environmental impact.

In this regard, sustainable alternatives based on bioactive agents, such as plant extracts, have the potential to improve the quality and extend the vase life of flowers. These agents may possess antimicrobial, antioxidant, and anti-ethylene properties (Cerna *et al.*, 2019; Nguyen & Lim, 2021). Some species with potential chemical defense properties that could replace fungicides and bactericides include neem (*Azadirachta indica*), hoja santa (*Piper* spp.), and moringa (*Moringa oleifera*), among others (Hassan & Fetouh, 2019). These plants contain natural metabolites that could provide an alternative in the search for new treatments to extend the shelf life of flowers, foliage, and fruits (Cerna *et al.*, 2019). Therefore, the objective of this research was to evaluate the effect of plant extracts on the postharvest preservation of cut flowers.

MATERIALS AND METHODS

Selection of Plant Material

Plants with medicinal, antiseptic, and antimicrobial properties were selected for the preparation of extracts. The species *Azadirachta indica*, *Piper auritum*, *Equisetum arvense*, *Hamelia patens*, and *Solanum nigrum* were chosen for their potential to produce secondary metabolites that act as chemical defenses and crop protection agents. The flowers evaluated

in the study were rose, gerbera, carnation, gladiolus, and chrysanthemum, due to their commercial importance in Mexico.

Method for the Extraction of Plant Extracts

Tests were conducted to determine the most efficient method for extracting plant compounds, using various techniques. The experiment focused on the senescence time of a model flower (rose), using *Azadirachta indica*, a plant known for its properties, as a reference. Seven extraction methods were tested: 1) Soxhlet with 100% ethanol (SE), 2) Soxhlet combined with 60% water and 40% ethanol (SWE), 3) reflux (RE), 4) infusion (IN), 5) hydrolysis (HY), 6) steam distillation (SD), and 7) pretreatment (PT).

The plant material used was collected fresh (fresh material) and previously dehydrated in an oven at 105 °C until a constant weight was achieved (dry material). A 250 g sample and 1250 mL of distilled water were used as the extraction solution, following the AOAC procedure 936.15 (1990). Once the extract was obtained, it was purified at 45 °C using a rotary evaporator for three hours and stored at 4 °C in amber bottles inside a kraft paper bag to prevent light exposure. Fourteen treatments were obtained (seven methods applied to two types of material), plus one standard (commercial preservative, in this case, citric acid salts and dextrose, known in the market as Floralife® or "oasis") and one control (no treatment). Each treatment was applied at a concentration of 50 ppm in a 500 mL floral solution of water.

Evaluation of Senescence

Once the most efficient extraction method was identified, it was used to obtain the extracts from the five selected plants with phytochemical properties. The extracts were applied through absorption to five cut flowers of economic importance in Mexico (rose, gerbera, carnation, gladiolus, and chrysanthemum) to determine which extract was most effective in prolonging vase life (senescence). Three different concentrations were tested (25 ppm, 50 ppm, and 75 ppm), along with a control (no treatment) and a standard (Floralife®), with no change of the aqueous solution. The experimental design was completely randomized, with five replications. Senescence was evaluated based on bent neck symptoms or "drooping," which occurs when the floral xylem is blocked by microorganisms, preventing water uptake and reducing the flower's lifespan (Nguyen & Lim, 2021).

Data Analysis

The data obtained were analyzed using analysis of variance (ANOVA) and a multiple comparison of means test (Tukey $P \leq 0.05$), using the STATISTICA® program.

RESULTS AND DISCUSSION

Method for Obtaining Plant Extracts

Plant metabolites possess unique properties and structures, which require the application of different extraction methods depending on their solubility, whether in water or in organic solvents such as ethanol or chloroform. To achieve optimal extraction, it is

necessary to evaluate several methods based on the type of metabolite (Puri & Chawla, 2012). In this study, significant differences were found in the days to senescence (Tukey P≤0.05) between the evaluated techniques: control (3.20b), standard (3.40b), PT (3.50b), RE (3.60b), HY (3.90b), SWE (4.00b), IN (4.30b), SE (4.70b), and SD (7.60a).

The substrates used (control=3.20a, standard=3.40a, dry material=4.17a, and fresh material=4.85a) did not show significant statistical differences (Tukey P≤0.05). Regarding the interactions, the best statistical group (Tukey P≤0.05) included: SE with dry material (4.60ab), SE with fresh material (4.80ab), IN with fresh material (5.00ab), SD with dry material (6.80ab), and SD with fresh material (8.40a) (Figure 1).

It is observed that the most efficient technique was SD, likely due to its ability to extract volatile and essential compounds, which preserve the antimicrobial and antioxidant properties of the extracts. Additionally, this method reduces the direct exposure of the compounds to high temperatures, minimizing their thermal degradation and preserving their biological activity (Bakkali *et al.*, 2008). As a result, it produces relatively pure extracts with fewer contaminants and residues, as the steam carries away the volatile components, leaving behind less volatile materials (Burt, 2004). Finally, this method is scalable and can be applied both in the laboratory and in industrial production, making it suitable for the floriculture industry and other commercial applications (Dutta, 2015).

Regarding the type of plant material used (fresh and dry material), although no statistically significant differences were observed, it is estimated that for the purposes of this experiment, fresh material is more suitable, as it is more representative of the plant in its natural state. This could better reflect the chemical composition and properties of the compounds of interest, which may be altered or lost during the drying process. In addition, fresh material does not require prior preparation, which considerably reduces the time and resources needed for processing. This aspect is reflected in the interactions between both

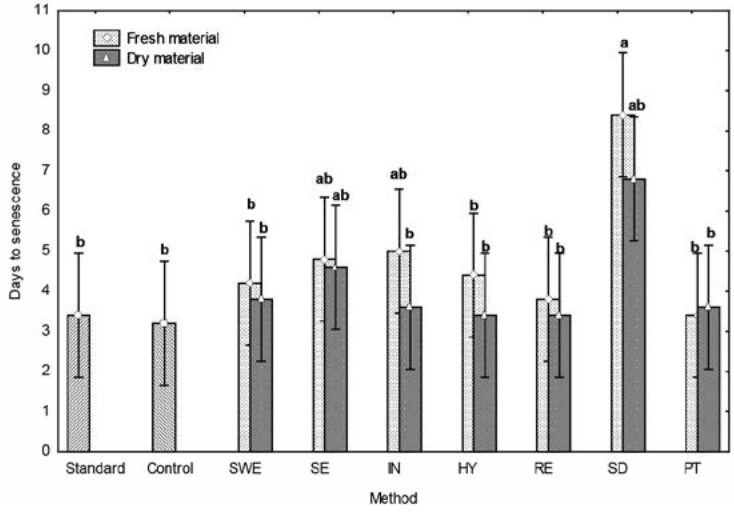

Figure 1. Days to senescence of rose according to different extraction techniques and substrates. Different letters indicate statistically significant differences (Tukey P≤0.05). SE=Soxhlet with 100% ethanol, SWE=Soxhlet combined with 60% water and 40% ethanol, RE=reflux, IN=infusion, HY=hydrolysis, SD=steam distillation, and PT=pre-treatment.

factors, highlighting the SD with fresh material group as the most outstanding (Figure 1), which aligns with the findings of Bakkali *et al.* (2008). Despite the results, future studies should consider the genetic variability of the plants and environmental conditions to validate and expand the current findings.

Senescence Evaluation

Significant differences (Tukey P≤0.05) were found between the different types of flowers: gladiolus (7.71d), gerbera (9.44c), rose (10.02b), carnation (16.26a), and chrysanthemum (16.44a). Differences were also observed between the treatments: control (4.67f), standard (5.35e), *Solanum nigrum* (11.62d), *Hamelia patens* (12.11c), *Equisetum arvense* (12.34c), *Azadirachta indica* (13.87b), and *Piper auritum* (14.59a), as well as between the concentrations: control (4.67e), standard (5.35d), 25 ppm (10.75c), 75 ppm (12.20b), and 50 ppm (15.77a).

Regarding the interactions, different statistical groups were identified (Tukey P≤0.05), with the best treatments being: carnation with *P. auritum* at 50 ppm (27.00a), chrysanthemum with *P. auritum* at 50 ppm (25.72a), and carnation with *A. indica* at 50 ppm (25.60a) (Figure 2a).

For the case of rose, the treatments showed significant differences in days to senescence (Tukey P≤0.05): control (2.80c), standard (3.40c), *H. patens* (9.85b), *S. nigrum* (10.16b), *E. arvense* (10.38b), *A. indica* (11.93a), and *P. auritum* (12.42a). The concentrations also presented differences: control (2.80d), standar (3.40d), 25 ppm (10.06c), 75 ppm (11.02b), and 50 ppm (11.76a), with the best results observed in the combinations of *P. auritum* at 75 ppm (12.92a), *P. auritum* at 50 ppm, and *A. indica* at 50 ppm (13.80a) (Figure 2b). These results are consistent with those reported by El-Naggar *et al.* (2019), who stated that the application of *A. indica* extracts prolongs the vase life of roses by inhibiting pathogenic microorganisms, reducing oxidative stress, and maintaining water balance.

Other studies have also highlighted the effectiveness of plant extracts, such as green tea, which extended the vase life of roses up to 15 days (Wu *et al.*, 2016), or the leaves and seeds of *Moringa oleifera*, which prolonged vase life to 13.7 and 11.9 days, respectively (Hassan and Fetouh, 2019). These findings emphasize the potential of plant extracts, particularly those from *P. auritum* and *A. indica*, as natural and effective alternatives to the synthetic preservatives commonly used.

In gerberas, significant differences (Tukey P≤0.05) were found between treatments: control (2.12d), standard (2.88d), *Solanum nigrum* (8.70c), *Equisetum arvense* (10.25b), *Hamelia patens* (10.56ab), *Azadirachta indica* (11.17a), and *Piper auritum* (11.18a), as well as between concentrations: control (2.12d), standard (2.88d), 25 ppm (8.75c), 75 ppm (10.38b), and 50 ppm (11.99a). The best combinations were *H. patens* (12.04abc), *A. indica* (12.80ab), and *P. auritum* (13.20a), all at 50 ppm, forming a statistically superior group (Figure 2c).

The treatments with *A. indica* and *P. auritum* are particularly noteworthy, as untreated gerberas typically have a vase life of about 5 to 7 days (Nahrabadi *et al.*, 2015; Combrink, 2018). In this experiment, the average duration was 11 days, which coincides with studies that used eucalyptus essences combined with sucrose, achieving a duration of 12.33 days. This is plausible, as sugars such as glucose have been investigated as a strategy to extend

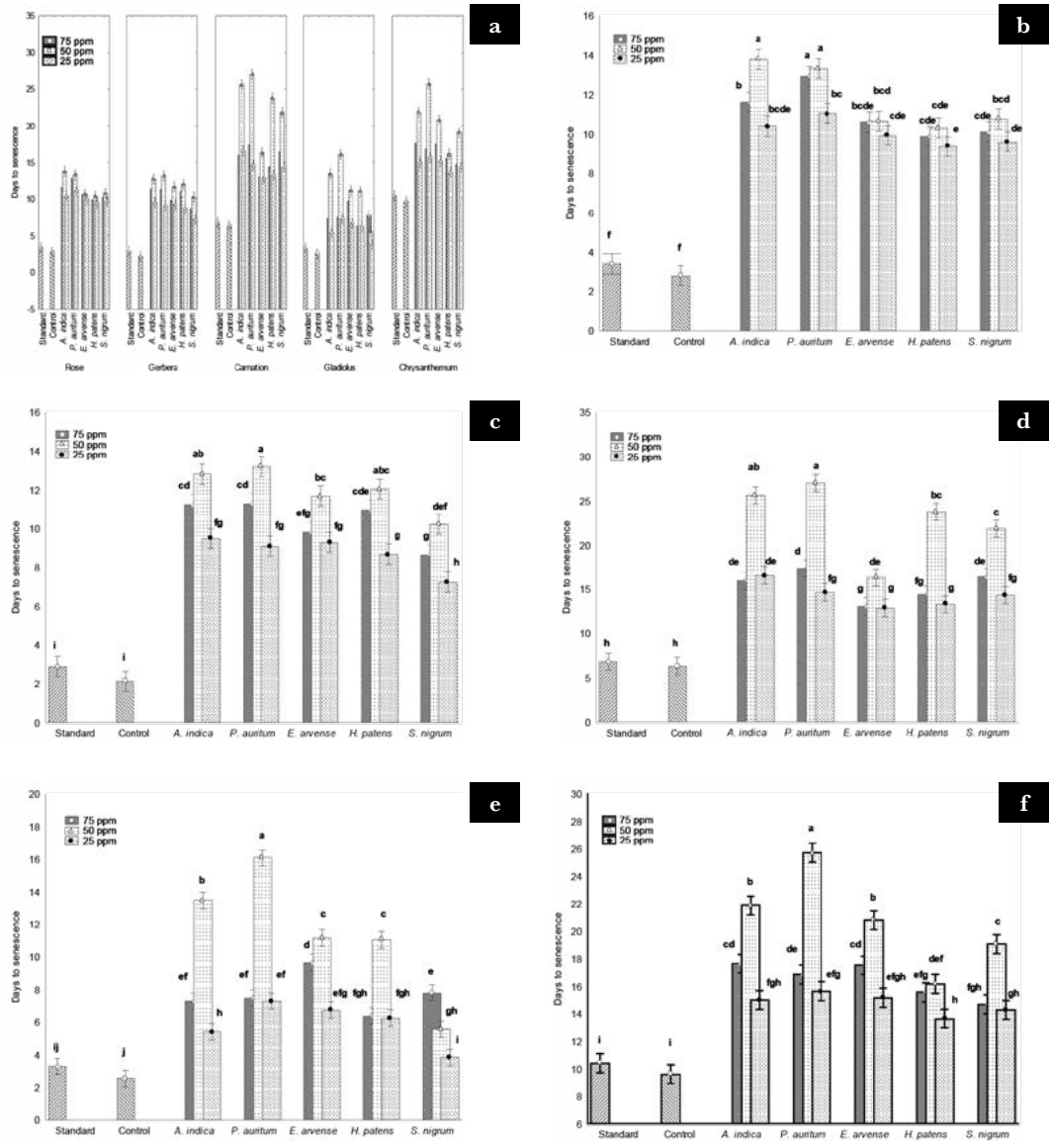

Figure 2. Days to senescence in different types of flowers treated with plant extracts. Different letters indicate statistically significant differences (Tukey P≤0.05). a) Interactions between flower types, treatments, and concentrations, b) interactions between treatments and concentrations in rose, c) interactions between treatments and concentrations in gerbera, d) interactions between treatments and concentrations in carnation, e) interactions between treatments and concentrations in gladiolus, and f) interactions between treatments and concentrations in chrysanthemum.

the vase life of cut flowers (Koyuncu *et al.*, 2017). Additionally, essential oils from thyme (*Thymus vulgaris*) and lavender (*Lavandula angustifolia*) have also been shown to extend the vase life of gerberas, reaching an average of 11 days (Nahrabadi *et al.*, 2015). Other studies have shown that vase life can be extended to 10-12 days with treatments not based on plant extracts, such as calcium chloride ($CaCl_2$), which improves flower longevity and quality by reducing scape curvature and increasing cell wall rigidity (Tonooka *et al.*, 2023). Similarly, silver nitrate and nano-silver have been shown to extend vase life

in gerberas and other flowers by reducing microbial attacks and inhibiting the ethylene hormone (Liu *et al.*, 2021).

Regarding carnations, significant differences (Tukey $P \leq 0.05$) were observed between the treatments: control (6.32d), standard (6.80d), *E. arvense* (14.08c), *H. patens* (17.14b), *S. nigrum* (17.52b), *A. indica* (19.37a), and *P. auritum* (19.66a), as well as between the concentrations: control (6.32d), standard (6.80d), 25 ppm (14.33c), 75 ppm (15.43b), and 50 ppm (22.90a). The most prominent interactions were *Azadirachta indica* (25.60ab) and *Piper auritum* (27.00a), both at 50 ppm (Figure 2d). These results align with those reported by El-Naggar *et al.* (2019), where *A. indica* extracts prolonged the vase life of carnations up to 22.73 days, compared to 11.33 days for untreated flowers. This extract, combined with glucose, extended the vase life to 15 days, improving flower quality in terms of turgidity and flower opening (Islam *et al.*, 2021). Similarly, other extracts, such as spearmint essential oils (*Mentha spicata*), prolonged vase life to 18.3 days (Dehestani-Ardakani *et al.*, 2022).

Despite the differences in senescence days between the various extracts used, it is clear that these extracts help prolong the vase life of carnations compared to their controls. This is particularly relevant in this study, as carnations showed the best results. However, it is also important to consider that, according to García-Sánchez *et al.* (2018), carnations have a longer vase life due to their lower respiratory rate and thicker petals, which contribute to their greater resistance to dehydration (Chidyllo *et al.*, 2015).

Regarding gladiolus, significant differences were observed between treatments: control (2.52e), standard (3.28e), *Solanum nigrum* (5.73d), *H. patens* (7.88c), *A. indica* (8.72b), *E. arvense* (9.17b), and *P. auritum* (10.28a), and concentrations: control (2.52d), standard (3.28d), 25 ppm (5.89c), 75 ppm (7.71b), and 50 ppm (11.46a), with the best combination being *P. auritum* at 50 ppm (16.08a) (Figure 2e). Although no specific studies on gladiolus were found, the active principles of *A. indica* and *P. auritum* could have positive effects similar to those observed with other plant extracts. For example, the extract of *Calotropis procera* has been shown to extend vase life up to 14.5 days (Hassan and Fetouh, 2019).

Finally, in chrysanthemums, significant differences were observed between treatments (Tukey $P \leq 0.05$): control (9.60e), standard (10.40e), *H. patens* (15.12d), *S. nigrum* (16.01c), *E. arvense* (17.82b), *A. indica* (18.17b), and *P. auritum* (19.40a), and concentrations: control (9.60d), standard (10.40d), 25 ppm (14.74c), 75 ppm (16.44b), and 50 ppm (20.72a). The best result was observed with the *P. auritum* extract at 50 ppm (25.72a) (Figure 2f). There are few studies specifically addressing the use of *A. indica* and *P. auritum* extracts in chrysanthemums. However, research with other plant extracts suggests that these may extend the vase life of chrysanthemums and other flowers. For example, myrtle essential oil extended the vase life of chrysanthemums up to 15.73 days (Bidarigh, 2015), thyme (*Thymus vulgaris*) essential oil up to 14.71 days (Bazaz *et al.*, 2015), and geranium essential oil up to 18.41 days (Dashtbay *et al.*, 2015). These essential oils primarily work by inhibiting microbial growth and reducing ethylene production, which helps prolong the freshness and vase life of cut flowers.

In summary, extracts of *Azadirachta indica* and *Piper auritum* possess valuable properties for postharvest conservation, thanks to their bioactive compounds such as azadirachtin, nimbolide, nimbin, and nimbidin in *A. indica*, and piperine in *P. auritum*, all of which have antimicrobial and antioxidant properties (Singh *et al.*, 2017; Cárdenas-Coronel *et al.*, 2019).

Additionally, it was observed that the concentration of 50 ppm was particularly effective for the preservation of all flowers, maintaining an optimal osmotic balance without causing damage to the tissues or generating phytotoxicity. This allows the flowers to maintain their structural integrity and aesthetic appearance for a longer period. However, the senescence process in plant products is influenced by factors such as temperature, humidity, type of product, variety, maturity stage at the time of harvest, and storage and transportation methods (Cai-Zhong, 2012). Therefore, it is important to consider that the effectiveness of plant extracts may vary depending on these factors, as well as the dosage and method of application.

CONCLUSIONS

Piper auritum and *Azadirachta indica* stood out in nearly all the evaluated flowers, consistently showing the best results in extending vase life and forming part of the statistically superior groups. In particular, the concentration of 50 ppm proved to be the most effective in all cases, suggesting that it is optimal for postharvest handling of the different evaluated species. The combinations of *P. auritum* and *A. indica* at 50 ppm excelled in all flowers, confirming their high efficacy and significantly outperforming both commercial treatments and the control. The natural character of these extracts did not cause significant phytotoxicity at the concentrations used, making them a low-cost, effective, and safe option for postharvest preservation. The use of plant extracts represents a potentially effective and natural strategy to improve the preservation of economically important cut flowers in Mexico.

REFERENCES

AOAC (Association of Official Analytical Chemists). (1990). Official Methods of Analysis (15th ed., Method 936.15). AOAC International.

Bakkali, F., Averbeck, S., Averbeck, D., & Idaomar, M. (2008). Biological effects of essential oils-a review. *Food and Chemical Toxicology, 46*(2): 446-475. https://doi.org/10.1016/j.fct.2007.09.106

Bazaz, A. M., Tehranifar, A., & Karizaki, A. R. (2015). Use of ethanol, methanol and essential oils to improve vaselife of chrysanthemum cut flowers. *Int. Res. J. Applied and Basic Sci, 9*(8): 1431-1436.

Bidarigh, S. (2015). Improvement vase life of chrysanthemum (*Dendranthema grandiflorum* L.) cut flowers using essential oils of geranium, eucalyptus and myrtus. *Journal of Ornamental Plants, 5*(4): 213-221.

Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods —a review. *International Journal of Food Microbiology, 94*(3): 223-253. doi: 10.1016/j.ijfoodmicro.2004.03.022

Cai-Zhong, J. (2012). Postharvest biology and technology of cut flowers and potted plants. *Horticultural Reviews*, 40: 3-56. doi: 10.1002/9781118351871.ch1

Cárdenas-Coronel, W. G., Robles-Zepeda, R. E., Gutiérrez-Lomelí, M., & Meza-Velázquez, J. A. (2019). Antimicrobial and antioxidant activity of pepper (*Piper nigrum* L.) extract in postharvest conservation of Ataulfo mangoes. *Food Control*, 102: 177-185.

Cerna-Chávez, E., Alejandro-Rojas, G., Ochoa-Fuentes, Y. M., Aguirre-Uribe, L., Landeros-Flores, J., & Hernández-Bautista, O. (2019). Evaluación *in vitro* de principios activos de origen botánico para el control de hongos fitopatógenos. *Scientia Fungorum*, 49: e1245. https://doi.org/10.33885/sf.2019.49.1245

Chidyllo, S., Bi, J., & Flowers, T. H. (2015). The vase life of cut flowers: Considering water relations. *International Journal of Environmental Horticulture, 3*(1): 1-7.

Combrink, N. J. J. (2018). Calcium improves gerbera (*Gerbera hybrida*) vase life. *J. Plant Soil*, 35: 235-236. https://doi.org/10.1080/02571862.2017.1354089

Dashtbay, S., Hasemi, M., and Hashemabadi, D. (2015). Study on interaction effects of mechanical and geranium essential oil treatments on vase life of cut chrysanthemum (*Dendranthema grandiflorum* L.). *J. Ornam. Plants, 5*(2): 97-103.

Debnath, T., Rani, M., and Das, P. (2019). Postharvest management of cut flowers. *Advances in Plants & Agriculture Research, 9*(1): 114-117.

Dehestani-Ardakani, M., Gholamnezhad, J., Alizadeh, S., Meftahizadeh, H., and Ghorbanpour, M. (2022). Salicylic acid and herbal extracts prolong vase life and improve quality of carnation (*Dianthus caryophyllus* L.) flowers. *South African Journal of Botany*, 150: 1192-1204. https://doi.org/10.1016/j.sajb.2022.09.028

Dutta, S. (2015). Essential oils and their antifungal activity: a mini review. *Journal of Applied Pharmaceutical Science, 5*(6): 32-37. https://doi.org/10.3390/ph10040086

El-Naggar, T., El-Hadidy, M., Abou-Aly, H., y Hassan, N. (2019). Enhancing vase life and postharvest quality of cut carnation and rose flowers using neem extract. *Scientia Horticulturae*, 250: 355-361.

García-Sánchez, F., López-Matas, M. A., y Sánchez-González, M. J. (2018). Exploring postharvest life of carnation and rose flowers: A comprehensive view of quality traits. *Scientia Horticulturae*, 237: 115-124.

Hassan, F. A. S., y Fetouh, M. I. (2019). Does moringa leaf extract have preservative effect improving the longevity and postharvest quality of gladiolus cut spikes? *Scientia Horticulturae*, 250: 287-293. https://doi.org/10.1016/j.scienta.2019.02.059

Islam, M. S., Kang, S. M., Hamiduzzaman, M. M., Park, K. J., y Choi, H. J. (2021). Synergistic effects of neem leaf extract and glucose on post-harvest quality and disease control of cut carnation flowers. *Scientia Horticulturae*, 281: 109934.

Juárez Hernández, P. J., Colinas León, M. T., Valdez Aguilar, L. A., Espinosa Flores, A., Castro Brindis, R., y Cano García, G. V. (2008). Soluciones y refrigeración para alargar la vida postcosecha de rosa cv. 'Black Magic'. *Revista Fitotecnia Mexicana, 31*(3): 73-77.

Koyuncu, M. A., Özdemir, F., y Şahin, M. (2017). Effect of glucose on vase life of cut carnation (*Dianthus caryophyllus*) and rose (*Rosa hybrida*) flowers. *Turkish Journal of Agriculture and Forestry, 41*(4): 236-244.

Liu, J., Lai, L., Liu, H., Li, H., Yu, G., Sun, Y., y He, S. (2021). Nano-silver treatment reduces bacterial proliferation and stem bending in cut gerbera flowers: An *in vitro* and *in vivo* evaluation. *Postharvest Biology and Technology*, 180: 111595. https://doi.org/10.1016/j.postharvbio.2021.111595

Meza-García, E. G., Quiroz-Rodríguez, G. S., y Rosales-Serna, R. (2017). Análisis de la competitividad del sector florícola mexicano: el caso de la Asociación Mexicana de Horticultura Ornamental. *Revista de Ciencias Sociales, 23*(1): 96-110.

Nahrabadi, L. K., Rood, N. D., Danyaei, A., Babarabie, M., y Shadbash, M. (2015). Effect of *eucalyptus* and *Rosa damascena* essences with sucrose on vase life and bent neck of cut *Gerbera* cv. Alain Ducasse. *Journal of Ornamental Plants, 5*(4): 205-212.

Nascimento Simões, A., Bandeira Diniz, N., Ribeiro da Silva Vieira, M., Ferreira-Silva, S. L., Bartira da Silva, M., Minatel, I. O., y Pereira Lima, G. P. (2018). Impact of GA3 and spermine on postharvest quality of anthurium cut flowers (*Anthurium andraeanum* cv. Arizona). *Scientia Horticulturae*, 241: 178-186. https://doi.org/10.1016/j.scienta.2018.06.095

Nguyen, T. K., y Lim, J. H. (2021). Do eco-friendly floral preservative solutions prolong vase life better than chemical solutions? *Horticulturae, 7*(10): 415. https://doi.org/10.3390/horticulturae7100415

Puri, S., y Chawla, P. (2012). Extraction and estimation of secondary metabolites: A review. *International Journal of Pharmaceutical Sciences and Research, 3*(5): 3061-3068.

Singh, S., Singh, R. P., y Singh, D. (2017). Post-harvest management of fruits and vegetables using emerging technologies: A review. *Food Chemistry*, 220: 1-14.

Soleimani Aghdam, M., Jannatizadeh, A., Sheikh-Assadi, M., y Malek-zadeh, P. (2016). Alleviation of postharvest chilling injury in anthurium cut flowers by salicylic acid treatment. *Scientia Horticulturae*, 202: 70-76. https://doi.org/10.1016/j.scienta.2016.02.025

Tejeda-Sartorius, O., y Arévalo-Galarza, M. L. (2012). La floricultura, una opción económica rentable para el minifundio mexicano. *Agroproductividad, 5*(3): 11-19.

Thakur, N. (2020). A review on the effect of storage methods and packaging material on the post-harvest longevity of cut flowers. *International Journal of Chemical Studies*, 8: 2375-2379. doi: 10.22271/chemi.2020.v8.i3ah.9568

Tonooka, M., Homma, Y., Nukui, H., & Ichimura, K. (2023). The extension of vase life in cut gerbera flowers through pretreatment with gibberellin A3 in combination with calcium chloride. *Horticulturae*, 9: 1106. https://doi.org/10.3390/horticulturae9101106

Valencia-Sandoval, C., & Guerrero-Morales, C. (2018). Cadena productiva de la floricultura en México: Retos y oportunidades en la exportación de flores. *EconoQuantum, 15*(1): 71-88.

Wu, L. Y., Xiao, H., Zhao, W. J., Sun, P. y Lin, J. K. 2016. Effect of green tea extract powder on the vase-life of fresh-cut rose (*Rosa hybrida* L.) 'Carola' stems. *J. Hortic. Sci. Biotechnol.* 91:279-284. doi: 10.1080/14620316.2016.1155316