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Scientific Article

Study postharvest characteristics, chemical composition and antimicrobial activity of *Dianthus caryophyllus* L., cut flowers using some essential oils

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Abstract

Carnation (*Dianthus caryophyllus* 'Servantes') is a popular and economically cut flower widely used in the florist industry. However, post-harvest senescence occurs in a few days and limits the cut carnation flowers' commercialization. Therefore, this research was performed to investigate the impact of essential oils such as tea tree oil (TTO), pumpkin seed oil (PSO), *Moringa* seed essential oils (MEO), and Eucalyptus oils (EEO), as eco-friendly preservative solutions to enhance the quality and longevity of carnation flowers. Carnation cut flowers were submitted to different concentrations (250 and 500 mg L^{-1}) of each essential oil used in the vase solution and the experiments were carried out as a completely randomized design in three replicates. The findings revealed that the longest vase life and the maximum total water solution uptake in cut carnation were achieved when treated with either TTO or PSO oil at 500 mg L^{-1} in solution preservative as compared to the control (distilled water). While the highest relative fresh weight was observed at 500 mg L^{-1} PSO, the highest chlorophyll a, b, total carotenoids, total sugar, total phenolic content in leaves, anthocyanin content, and enzyme activity in petals at 500 mg L^{-1} TTO and PSO. Additionally, all treatments of selected oils have positively declined the bacteria activity compared to control. Also, the lowest bacteria growth on third day with 500 mg L^{-1} TTO and PSO. However, observing a prim state of xylem vessels with TTO 500 mg $L^{-1}$and PSO 500 mg L^{-1}, comparable with distilled water, the application of essential oil in this study as a natural preservative in preservative solution as an alternative to chemicals could be of environmental value and great economic.

Keywords: bacterial activity, carnation, essential oils, preservative, vase life.

Resumo

Melhorando as características pós-colheita, composição química e atividade antimicrobiana de flores de corte de *Dianthus caryophyllus* usando novos óleos essenciais

O cravo (*Dianthus caryophyllus* 'Servantes') é uma flor e corte popular e economicamente viável, amplamente utilizada na indústria florística. Apesar disso, a senescência pós-colheita ocorre em poucos dias, sendo um problema limitante na comercialização de flores de cravos cortadas. Assim, realizou-se a pesquisa para investigar o impacto de óleos essenciais como o óleo de árvore de chá (TTO), óleo de semente de abóbora (PSO), óleos essenciais de semente de Moringa (MEO), e óleos de Eucalipto (EEO), como soluções conservantes ecologicamente corretas para melhorar a qualidade e a longevidade das flores de cravo. As flores de cravo cortadas foram submetidas a diferentes concentrações (250 e 500 mg L^{-1}) de todos os óleos essenciais utilizados na solução de vaso. Os resultados revelaram que a maior vida útil de vaso e a máxima absorção total da solução pelo cravo cortado ocorreu nos tratamentos com óleo TTO ou PSO a 500 mg L^{-1} na solução conservante em comparação com o controle (água destilada). Enquanto o maior peso relativo fresco indicado com 500 mg L^{-1} PSO, a maiores valores de clorofila a e b, carotenóides totais, açúcares totais, conteúdo fenólico total nas folhas, conteúdo de antocianina e atividade enzimática em pétalas tratadas com 500 mg L^{-1} de (TTO) e (PSO). Além disso, todos os tratamentos de óleos atuaram diminuindo a atividade bacteriana em comparação com o controle. Também, o menor crescimento bacteriano ocorreu no terceiro dia com o uso 500 mg de L^{-1} TTO e PSO. Entretanto, observando um estado primário de vasos de xilema de hastes tratadas com 500 mg L^{-1} de TTO e 500 mg L^{-1} de PSO, comparando com água destilada, a aplicação do óleo essencial neste estudo como conservante natural em solução conservante como alternativa aos produtos químicos pode ser de grande valor ambiental e econômico.

Palavras-chave: atividade bacteriana, conservante, cravo, óleos essenciais, vida de vaso.

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Introduction

In the global floriculture marketplace, cut flowers have become an exporting income. They are used for home decoration and ceremonies (such as funerals and weddings). The other attributes influencing post-harvest cut flowers and vase life are critical in the floral industry (El-Sayed et al., 2020; Soliman et al., 2022a) Carnation (*Dianthus caryophyllus* 'Servantes' Caryophyllaceae) is one of the most important cut flowers in the world. In the floricultural sector; the carnation has the greatest value for adornment and decoration. Furthermore, the shelf life of cut flowers of carnation varies among various cultivars and species. It is a criterion for determining quality consumer preferences and commercial value (Vehniwal et al., 2021).

Recently, researchers have looked for natural preservatives, such as essential oil extracts of medicinal or aromatic herbs that are environmentally friendly and have a long history of safety (Maurya et al., 2021). Using natural essential oils of medicinal or aromatic plants can help limit microbes' activities (Maurya et al., 2021). Also, they contain numerous phytochemicals such as tannins, flavonoids, alkaloids, and terpenoids, which inhibit microbe development. Furthermore, eco-friendly, easy-to-use, low-cost preservatives are always critical for commercial application, so researchers are interested in developing natural preservatives for cut flowers (El-Sayed and El-Ziat, 2021). Essential oils (EOs), organic raw materials with antibacterial activity against some diseases, are safe and eco-friendly. (Othman and Esmail, 2020; El-Sayed and El-Ziat, 2021).

Tea tree oil (TTO) is extracted from *Melaleuca alternifolia*, a tall shrub in the myrtle family Myrtaceae or tree species (Yasin et al., 2021a). Tea tree oil has been used as an alternative medicinal treatment in Australia for more than a century, and it is now becoming more popular worldwide because of its antibacterial activity (Yasin et al., 2021b). Furthermore, pumpkin seed oil (PSO), dark greenish-red oil, was obtained from *Cucurbita pepo* L. oval seeds. It belongs to the family Cucurbitaceae. Its oil contains many fatty acids such as linoleic, oleic, and phytosterols. PSO has beneficial properties such as antibacterial, anti-inflammatory, anti-ulcer, and antioxidant (Saleem et al., 2021). In addition, Moringa essential oil (MEO) obtained from (*Moringa oleifera* Lam., seeds) is one of the most plant biostimulants. In addition, Moringa oil has some bioactive compounds and has shown antimicrobial properties on numerous pathogenic strains (Christaki et al., 2021). MOE appears to be an efficient, friendly floral preservative due to its contents, as further detailed below. However, the essential oils of the Eucalyptus plant (EEO) are one of the most attractive essential oil for treating wound infections and has market potential as shelf life longevity via increasing the postharvest parameters of these cut flowers (Yonsawad and Teerarak, 2019).

To the best of our knowledge, no research use pumpkin seed oil (PSO), Moringa essential oil (MOE) as a preservative solution as well as, and there is little information about the application of tea tree oil (TTO), as a natural floral preservative on enhancing postharvest characteristics the quality of carnation cut flowers or any cut flowers. In addition, there is limited information on the influence of essential oils on the vase-life of carnation-cut flowers. Therefore, the research aims to highlight the potential of utilizing TTO, PSO and MOE oils as a new preservative solution and Eucalyptus oil (EEO) to enhance postharvest and longevity of vase life and maintain the quality of cut flowers of carnation, as well as determination of chemical composition and antibacterial activity of vase solution of cut carnation flowers.

Materials and methods

The current research was conducted in agriculture seasons 2021 and 2022 to test the effect of applying some essential oils as preserving vase solutions on the vase-life of carnation cut flowers and enhancing their longevity and quality. The cut flowers in this research were carnation *Dianthus caryophyllus* "Servantes" obtained from the commercial growing farm "Floramix Farm" Kafr Hakim, Giza, Egypt. The flowers were transported to the laboratory on the same day, and pre-cooled in the water for thirteen minutes after the stems had been cut again down in the water to the length of 55 cm; in all cut flowers, after removing the leaves from the lower third of the stem, placed each cut flower individually in the vase (400 ml) containing solution 350 ml under 21± 1 ºC with a relative humidity of 65± 5%. Essential oils were obtained from the unit by squeezing and extracting natural oils, National Research Centre (NRC). The control (distilled water) plus 2% sucrose as carbon source was applied as controls and pulsed with distilled water for the same period. The oils dissolved in "Tween -20 0.1 %" before adding to the preservative solution (Table 1).

Table 1. Treatments used in the experiment of carnation cut flowers.

Control (distilled water)	MEO (250 mg L^{-1})
TTO (250 mg L^{-1})	MEO (500 mg L^{-1})
TTO (500 mg L^{-1})	EEO (250 mg L^{-1})
PSO (250 mg L^{-1})	EEO (500 mg L^{-1})
PSO (500 mg L^{-1})	

The experiment's data was examined using a three replicate (randomized block design). One spike carried one head flower

The Data recorded mean two seasons were:

Vase life and quality assessments

Vase life (days): vase life was calculated as the number of days from when placed the cut carnation into the vase (day 0) until 50% of the petals had wilted, browned, or rolled inward (Pun et al., 2014). Diameter of flowers (cm): as the outer diameter of opened cut flowers of carnation using a calliper. Water solution uptake (g/flower/day), as the weight of absorbed preservative solution (g) of the treatments assessed (3, 6, and 9 d). Water loss (g/flower/day): as the weight of the vases containing cut flowers and vase solution assessed every two days. Total days of the vase solution loss rate were calculated at the end of the vase evaluation period of each treatment as follows: Water loss (g/flower/day) = (C_{t-1} - Ct); which, Ct is the weighting of cut carnation flowers plus the preservative solution (g) at 3, 6, 9 d, Ct^{-1} is the weighting of cut carnation flowers plus preservative solution (g) on 0,3,6, and 9 d, respectively, by (Bazaz et al., 2015). Relative fresh weight (RFW %): at the beginning of the experiment, we weighed the cut carnation flowers and weighed them again on days 3, 6, and 9 d during the vase life period. Relative fresh weight (RFW%) of cut flowers calculated as indicated by He et al. (2006).

RFW % = (Wt /W t^{-0}) × 100; where Wt is the weight of carnation flowers (g) at t = days 0, 3, 6, etc., and W t^{-0} is the weight of the same carnation flowers (g) at t = day 0.

Chemical analysis: Chlorophyll content (mg gm^{-1} F.W.), was obtained on 3, 6, and 9 d., throughout the vase-life evaluation. Chlorophyll *a*, *b*, and carotenoids were measured according to Saric (1967). Anthocyanin content (mg/100 mg), the extraction of anthocyanin pigment was prepared with an ethanolic hydrochloric acid solution (85 ml ethanol 95 % + 15 ml 1.5 N HCl) Fuleki and Francis (1968). Determination of total sugars in fresh leaves was estimated using the method described by (Dubois et al., 1956). Total phenols in fresh leaves were measured by colorimetric method, using a Folin-Ciocalteau reagent, determined by a spectrophotometer at 650 nm and using Gallic acid as the standard, according to previously described by Swain and Hillis (1959). Extraction and determination of antioxidant enzyme activities: Fresh petals extract of the enzyme as described by Mukherjee and Choudhuri (1983). Catalase (CAT) EC 1.11.1.6 and peroxidase (POX) EC 1.11.1.7 activity were dissolved to the method by (Kar and Mishra 1976). Superoxide dismutase activity (SOD) EC 1.15.1.1 was determined following a modification of the method (Marklund and Marklund 1974).

Mean bacterial counts (C.F.U m l^{-1}): Bacterial activity was estimated in the holding solutions, after 3, 6, and 9 d, with 1 ml of each sample taken and diluted with sterilized distilled water from the first to the sixth dilution. After that, inoculated 1 ml of each fourth, fifth, and sixth dilution in Petri dishes on media containing agar, peptone, and beef extract, and then incubated for 48h. At 30◦C, the colonies have been counted (Marousky, 1970).

Scanning electron microscopy (SEM): Used microscopic investigation to scan xylem occlusion by bacteria at the base of the cut carnation flower stem. At the end of the control vase-life, take sections (0.5 cm) from the control flowers as well as treated flowers with 500 mg L^{-1} of (TTO), 500 mg L^{-1} of)PSO(, 250 mg L^{-1} (EEO), and 500 mg L^{-1}) MOE(. Samples were processed and examined by transmission electron microscope JEOL (JEM-1400 TEM) (Bozzola and Russell, 1999).

Statistical Analysis: The experiment's data was examined using a three replicate randomized block design (RBD). One spike carried one head flower. The treatment's means were comparable significantly to new multiple-range tests at the 0.05% level of probability (Duncan, 1955) using COSTATV-63.

Results and Discussion

Vase life and quality assessments

Pulses with tea tree oil (TTO), pumpkin seed oil (PSO), Moringa essential oil (MOE), and essential oil of Eucalyptus plant (EEO) at different concentrations significantly prolonged the shelf life of cut carnations compared to untreated cut flowers. The longest vase life was obtained upon treatment with tea tree oil (TTO) 500 mg L^{-1} (22.65 days) for mean seasons, pumpkin seed oil (PSO) 500 mg L^{-1} (21.16 days), Eucalyptus essential oil (EEO) 250 mg L^{-1} (20.00 days), and Moringa essential oil (MEO) 500 mg L^{-1} (19.00 days), respectively. These treatments enhanced shelf life by approximately 8-11 days compared to the control (11.66 days) for mean seasons. Furthermore, the vase life was considerably reduced when the preservative solution contained 250 mg L^{-1} PSO, 250 mg L^{-1} MEO, and 500 mg L^{-1} EEO was applied. The lowest vase-life was observed in the control (distilled water) (Figures 1 and 2).

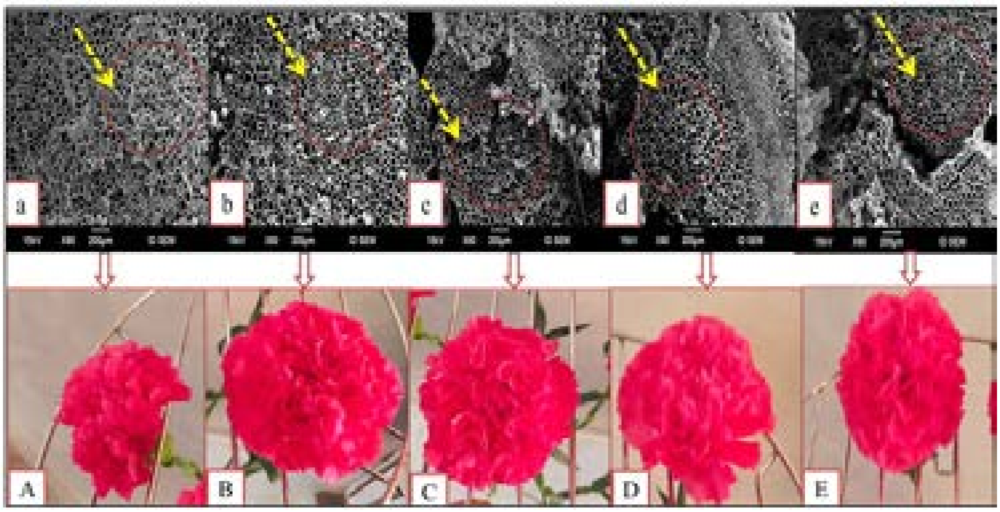

Figure 1. Effect of different concentrations of essential oils that delayed petal senescence in cut flowers of carnation cut flowers. The photograph was taken on day 9 day and the scanning was taken on day 11 after the test treatments. (A, a)**:** Control (distilled water). (B, b): TTO (500mg L^{-1}). (C, c): POS (500 mg L^{-1}) (D, d): MOE (500 mg L^{-1}) (E, e): EEO (250 mg L^{-1}).

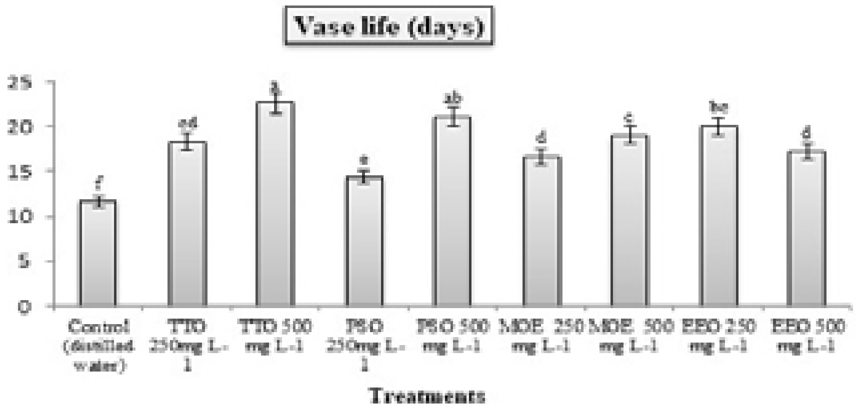

Figure 2. Effect of different concentrations of essential oils on vase life (days) on carnation cut flower of mean two seasons. Columns data with different letter/s differ significantly ($p < 0.05$), letters (a–f) are a comparison of individual treatment means.

Our findings demonstrated that the longest vase-life cut flowers could be obtained from these essential oils, particularly tea tree oil. These results agree with Amin and El Sayed (2021), which showed that using tea tree oil at 3 ml L^{-1} increases the vase life and enhances the water balance of cut *Aspidistra elatior* leaves. Moreover, El-Sayed and El-Ziat (2021) observed that applied thyme and clove oils extended the vase life of cut chrysanthemum. In another study, treatments with tea oil have positive longevity in the vase life on cut flowers (Yasin et al., 2021a). Essential oils are a viable for extending cut flowers› vase life because they are low-cost and environmentally friendly (El-Sayed and

El-Ziat, 2021). Besides, the effect of tea tree oil (TTO) on increasing the vase life may be due to its high antioxidative and antimicrobial activities of compounds such as terpinen-4-ol, methyl eugenol, and cineole- 1, 8 (Yasin et al., 2021b). Additionally, moringa oil has some bioactive compounds and antimicrobial properties on numerous pathogenic strains and intense coagulative (Christaki et al., 2021).

Diameter of head flower (cm),the influence of different concentrations of tea tree oil (TTO), pumpkin seed oil (PEO), Moringa essential oil (MEO), and eucalyptus essential oil (EEO) as solution preservatives on the diameter of the head flowers of cut carnation, the data are indicated that the diameter of the head flower was significantly increased with the preservation solution content 500 mg L^{-1} (TTO), 500 mg L^{-1} PSO, 250 mg L^{-1} EEO, and 500 mg L^{-1} MEO essential oils in all days selected compared with the control (distilled water) and other different concentrations of essential oils in (Figure 3).

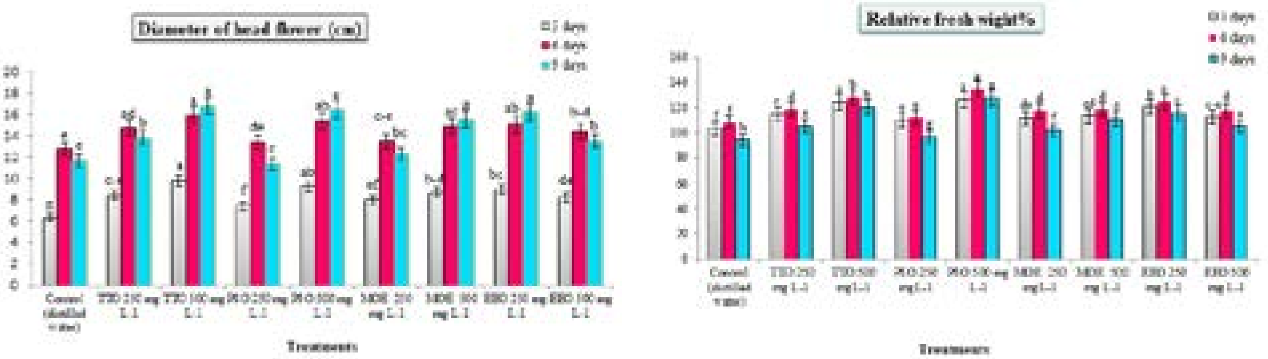

Figure 3. Mean comparisons of various effects of different concentration of essential oils on the diameter of head flower and relative fresh weight % of carnation cut flowers during evaluated days. Columns data with different letter/s differ significantly ($p < 0.05$), letters (a–g) are a comparison of individual treatment means by Duncan's letters.

These results, in agreement with Salehi Salmi et al. (2018), showed an increased diameter of rose cut flowers when treated with the *Bunium persicum* Bioss, *Menthae spicata* L., *Thymus vulgaris* L., and *Satureja hortensis* L. essential oils than the control. Similarly, El-Sayed and El-Ziat, (2021) showed the greatest diameter of head flower with 500 mg L^{-1} thyme oil of cut chrysanthemum during two seasons.

The influence of different essential oil concentrations on relative fresh weight (RFW%) was a positive effect via vase-life during all days evaluated. Average comparisons of various essential oils concentrations of cut carnation flowers are shown in (Figure 3). It can be observed that PSO 500 mg L^{-1}, TTO 500 mg L^{-1}, and EEO 250 mg L^{-1} (in 3, 6, and 9 days) had the greatest RFW% of other treatments. Besides, the least RFW% was shown in control (distilled water) on all days. These findings are similar to the vase-life trait mentioned above. The trend of RFW% in TTO, PSO, and EEO was higher than in distilled water (control) during the vase life period. It was releasing relative fresh weight (RFW%) for all treatments until day 6. Subsequently, it is reduced to 9 days (Figure 3). These findings showed that RFW% downfall by control (distilled water) compared to other treatments. This result is confirmed by Adam (2021), which suggested that treating cut Solidago with essential oils (nigella, rosemary essential oil at 200 mg L^{-1}) had a positive effect on maintaining longevity vase life and relative fresh weight. However, Amin and El Sayed (2021) mentioned that applying tea tree oil 3ml L^{-1} improves the fresh weight and water balance of cut *Aspidistra elatior* leaves. Also, Almeida et al. (2020) showed that adding 0.25%, 0.50, 1.0, and 1.25 sprayed Carola roses with eucalyptus oils increased total vase life and RFW%. The effect of essential oils on enhancing fresh weight results in the presence of phenolic compounds (important antioxidant compounds), maintaining fresh weight and protection from membrane leakage. (El-Sayed and El-Ziat, 2021). One of the stages of flower senescence is a reduction in the fresh weight of cut flowers; the more the flowers advise into senescence, their ability to absorb water decreases. Finally, a significant loss in the cellar occurs. Thus, assessing water uptake after flower harvest is one of the most positive factors of flower durability of RFW may cause insufficient solution absorption the increased water loss (Yang et al., 2021).

The influence of employed treatments on water solution uptake (g/flower/day) was significant via shelf-life period. Figure 4 indicated that using TTO at 500 mg L^{-1} concentration resulted in the highest water solution uptake in 3, 6, and 9 days. Additionally, the smallest water solution uptake was obtained from the control (distilled water) on all days studied. Water solution uptake was released until day 6 and then reduced for all treatments tested.

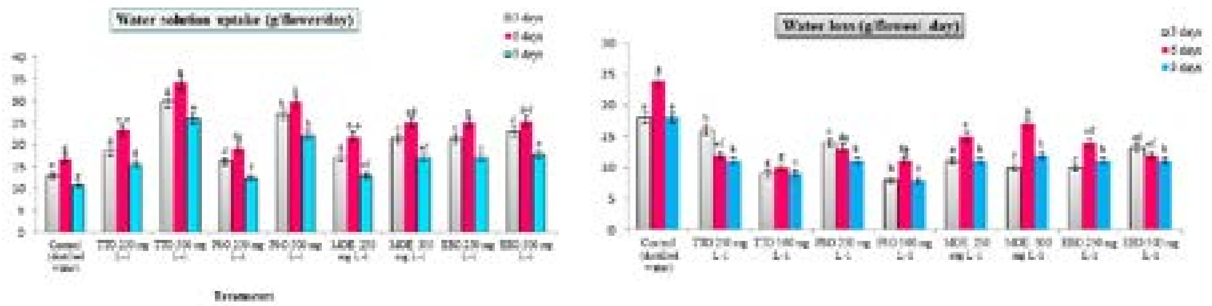

Figure 4. Mean comparisons of different concentrations of essential oils on water solution uptake and water loss of carnation cut flowers during evaluated days on carnation cut flowers. Columns data with different letter/s differ significantly ($p \leq 0.05$), and letters (a–f) are a comparison of individual treatment means by Duncan's letters.

The findings of this study are consistent with the findings of Gani et al. (2018) suggested that different combinations of essential oils damage the cell wall and cell membrane of microbes, causing the damaged cells to die, which probably in increasing water uptake and improves water balance. The cut flowers' ability to absorb vase water is significantly related to their vase life. As a result, increased vase water uptake raises tissue water content, which may be helpful in the hydrolysis of sugar in petal cells by providing energy and respiration. (El-Sayed and El-Ziat, 2021). Furthermore, the water balance attained by cut flowers' absorption and transpiration is an important aspect that impacts cut flowers' quality and vase life. Consequently, when transpiration exceeds water uptake, the cut flower is subjected to a water deficit, which causes the flower to wilt (Fanourakis et al., 2021). One of the causes of wilting is the inability of cut flowers to absorb water, which can be caused by bacterial growth in the cambial tissues of the stem (Fanourakis et al., 2021).

The water loss level(g/flower/day) of carnation cut flowers is presented in (Figure 4) for the 3, 6 and 9 days, showed a reduction with all concentrations used of essential oils, especially TTO and PSO (500 mg L^{-1}) compared to the control which indicated the highest value (18, 24, 18 g/flower/day). These results may be by the effect of the component content of used essential oil on the sugar's high-water uptake content, which may help maintain water balance and delay turgidity loss as the flower senescence. In addition, it decreases ethylene responsiveness in the flower's petals, besides the antioxidant effect of essential oil to inhibit ethylene production (Lopez- Gomez et al., 2020).

Chemical analysis

The data in Figure 5 shows that all solutions containing different oils used in this study had positive effects on the leaf content of pigments (Chlorophyll *a*, *b* and total carotenoids). Treating cut flowers with tea tree oil and pumpkin oil at 500 mg L^{-1} gave the highest means of the previous pigments in all days evaluated compared to the control (distilled water) and other concentrations. Results agree with Amin, and El Sayed (2021), when treated nigella essential oil Solidago cut flowers, increased chl *a*, and *b.* Many reports have explained the elicitation or maintenance of chlorophyll when essential oils are dissolved in a preservative solution due to the antioxidant activities of these oils (Adam, 2021).

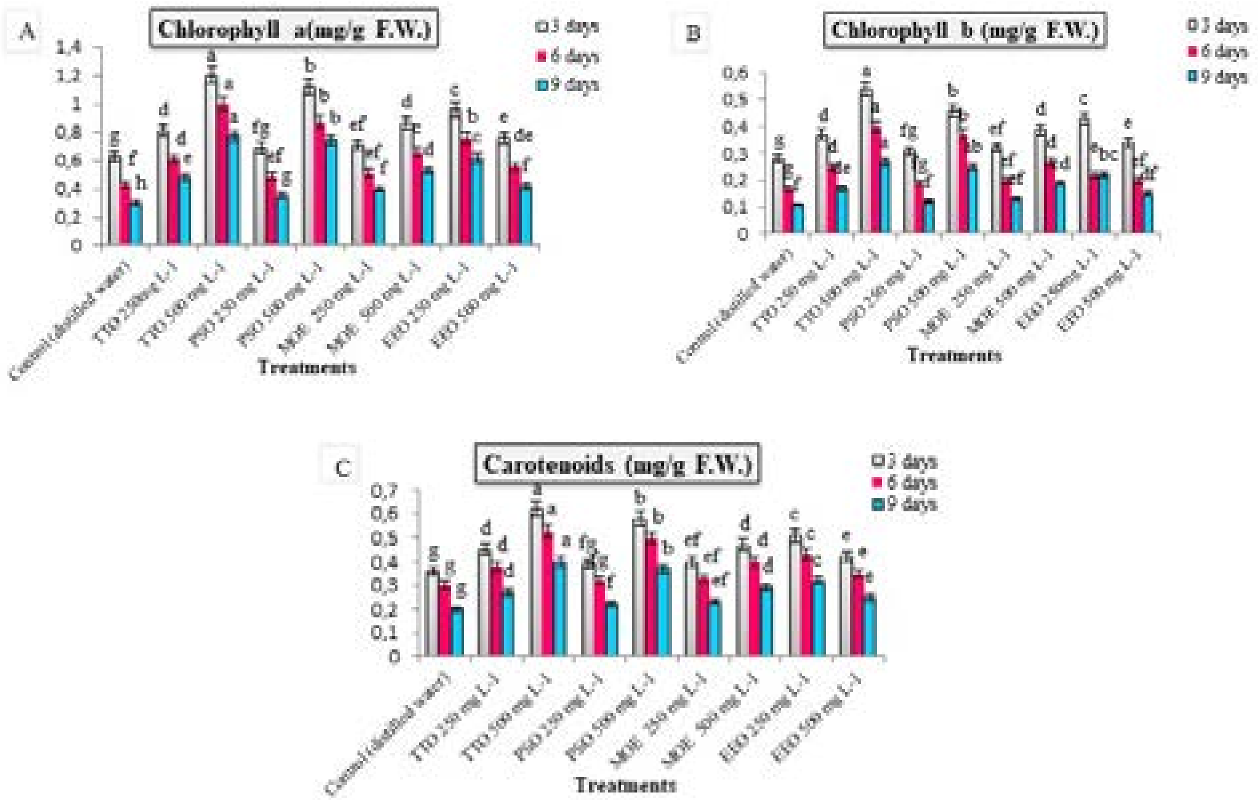

Figure 5. Effect of different concentrations of essential oils on chlorophyll a, b and carotenoids of carnation cut flowers during evaluated days (A, B and C).

The important key of essential oils in improving chlorophylls might be due to the antioxidant accumulation of essential oils in conserving chlorophylls. The increase in photosynthetic pigments is due to the increasing activity of sugars and cells, which decline chlorophyll loss by regulating the respiratory rate and osmotic pressure (Pouya et al., 2019).

Data presented in (Figure 6 A) indicated that essential oil treatments had positive effects on the leaf content of total sugar. Treating carnation cut flowers with tea tree oil (TTO) at 500 mg L^{-1}gave the highest means of total sugar, followed by treating with pumpkin oil at (500 mg L^{-1}) compared to the control. These results harmony with Amin and El Sayed (2021) on cut *Aspidistra elatior* leaves, when treated with tea tree oil at 3 ml L^{-1} as foliar treatment, enhanced pigments, total sugar, phenols and indols. The water status of the cut flower improves, and the percentage of plant dry matter increases, resulting in the presence of sugar in the water. Therefore, enough sugar replaces the sugar consumed during respiration (Hashemabadi et al., 2021).

The data in (Figure 6 B) demonstrated that the highest content of total phenol of cut flowers was maintained with tea tree oil and pumpkin oil treatment at the same concentration (500 mg L^{-1}) as compared with distilled water in (3, 6, and 9 days). In the same line, Adam (2021) indicated that phenolics had acquired much importance because of their disease prevention and health-promoting properties. Also, the rip seeds of *Moringa oleifera* have considerable antioxidant activity and concentration of vitamins, minerals, and β-carotene.

The current study showed a significant difference in the POD, CAT, and SOD activity in carnation cut flower petals (Figures 7 A, B, and C). Specifically, the tea tree oil (TTO) treatment at 500 mg L^{-1} followed by pumpkin oil (PSO) at the same concentration showed the highest POD, CAT and SOD activity (29.70, 4.48, 10.44 and 27.40, 3.72, 9.25 unit g^{-1} F.W. min^{-1}) respectively.

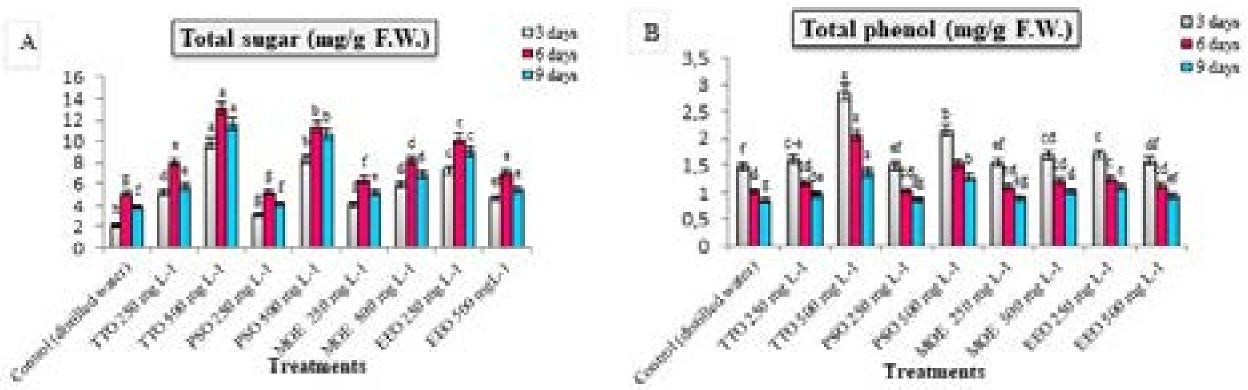

Figure 6. Effect of different concentrations of essential oils on total sugar (mg/g F.W.) and total phenol (mg/g F.W.) of carnation cut flowers during evaluated days (A, B).

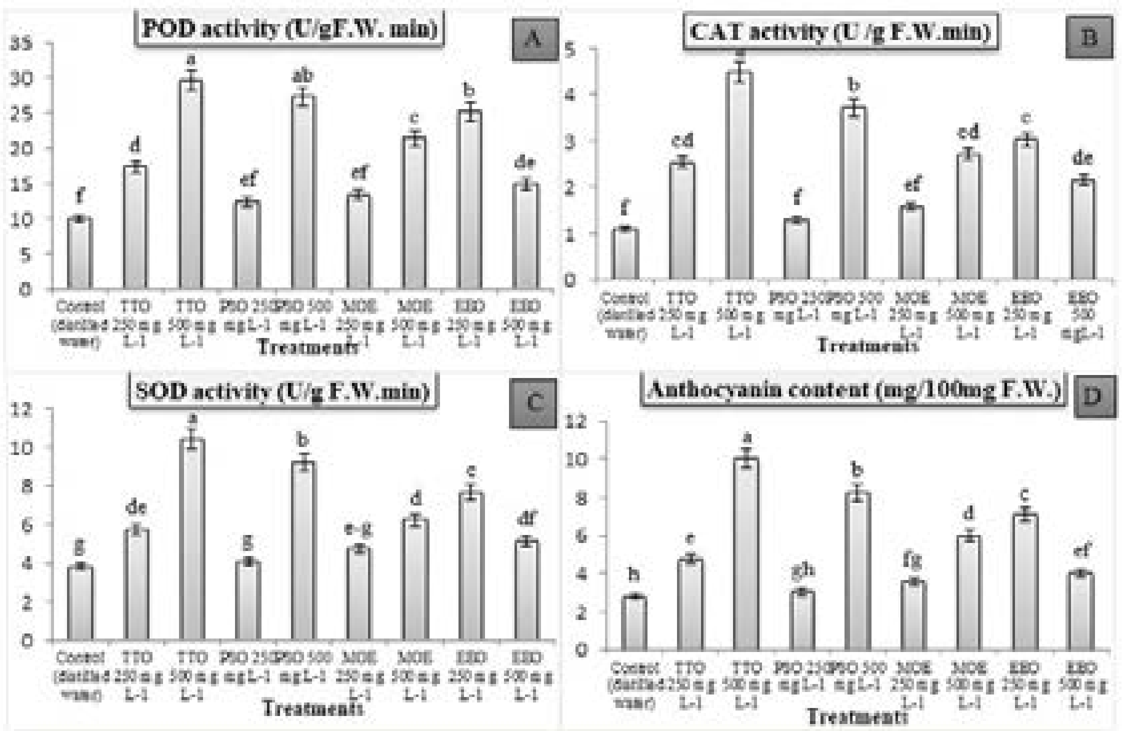

Figure 7 Effect of different concentration of essential oils on antioxidant enzyme activity U/g F.W. (A, B, and C) anthocyanin content mg/100mg F.W. (D) of carnation cut flowers “Servantes” in sixth day.

These results are in harmony with Yonsawad and Teerarak (2019) and Soliman et al., (2022b), who suggested that the essential oil may trigger higher antioxidant enzyme activity such as (POD, CAT or SOD), limiting the prospect for further free radical production of H_2O_2. Additionally, the activity of enzymes is controlled due to the antioxidant properties of plant essential oils, which are correlated with the senility of cut flowers. These conditions stimulate cut flowers’ freshness and longevity (Hashemabadi et al., 2021).

In (Figure.7 D), the results showed that the 500 mg L^{-1} of tea tree oil (TTO) and pumpkin oil (PSO), respectively, indicated the highest petal anthocyanin content compared with control and other treatments tested. Similarly, essential oil from dill at 200 mg L^{-1} as a plus solution contributed to the postharvest quality of *Helianthus annuus* cut flowers extending shelf life and improving anthocyanin petals (Othman and Esmail, 2020). On Carola roses that were sprayed with eucalyptus oils, 0.25% improved total anthocyanin content in the petals (Almeida et al., 2020).

Mean bacterial counts (C.F.U./ml)

During the evaluation period, the bacterial population in the vase solution of cut flowers increased dramatically. In contrast, essential oils selected considerably inhibited this rise (Figure 8).

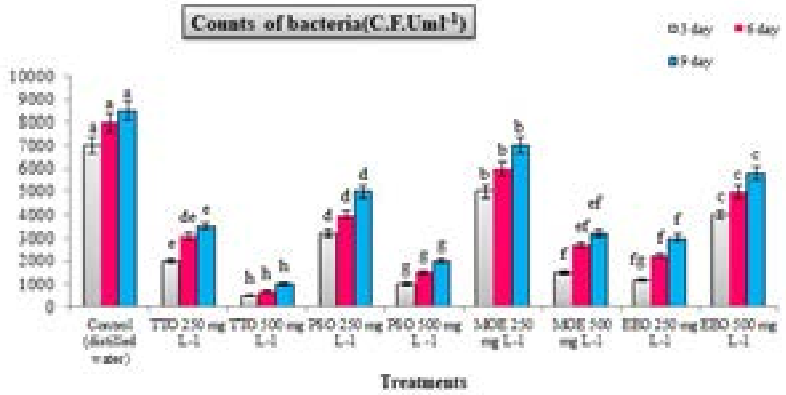

Figure 8 Effect of different concentration of essential oils on Bacterial counts (C.F.U/ml) of carnation cut flowers. "Servantes" during evaluated days.

The decrease in bacterial activity was significantly higher in the solution of 500 mg L^{-1} TTO, 500 mg L^{-1} POS, 250 mg L^{-1} EEO, and 500 mg L^{-1} MEO treated cut flowers compared with distilled water (control) ones. Essential oils are more effective against pathogenic germs that cause structural and functional damage to the bacterial cell membrane due to a significant number of phenols, alkaloids, terpenes, and other antimicrobial components (Othman and Esmail, 2020).

Scanning electron microscopy (SEM):

Using scanning electron microscopy (SEM) (Figure 9) indicated that the various concentrations studied of essential oils had a positive influence in prolonging the vase life of carnation cut flowers compared to untreated (distilled water). Water stress resulted from xylem blockage, a limiting factor in the prolongation and expression of the cut flowers as early wilting of flowers and leaves. The cross-section in the xylem cells in cut flowers of distilled water (control) neighbourhood was filled with bacteria, as shown in (Figures 9 A and B). The cut flowers would lose their turgidity due to the blockage, reducing the vase life of the carnation-cut flowers.

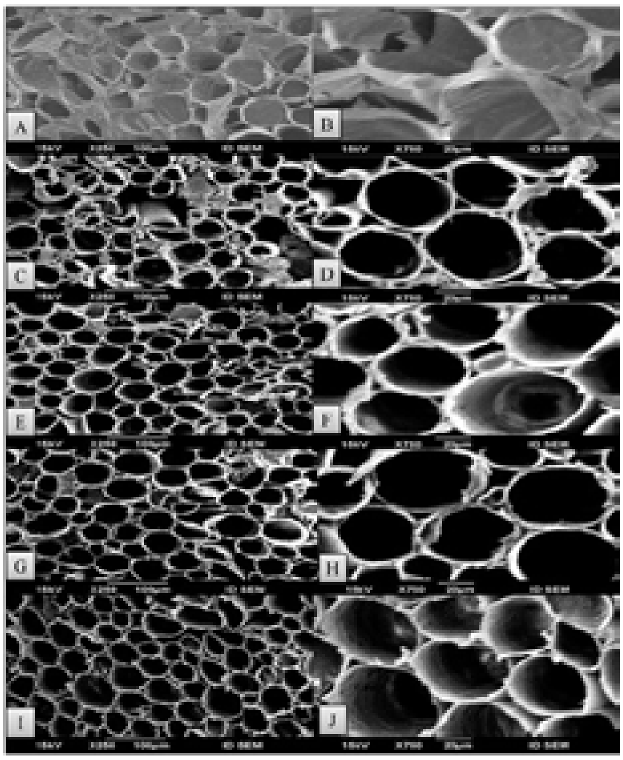

Figure 9. Scanning electron microscope micrograph of carnation xylem vessels at the base of stem of cut flower axis showing the impact of some treatments on bacterial proliferation and blockages in xylem vessels, A and B: control (distilled water). C and D: 500 mg L^{-1} TTO treatment. E and F: 500 mgL^{-1} PSO treatment. G and H: 500 mgL^{-1} MEO treatments and I and J 250 mg L^{-1} EEO.

On the other hand, the treatments with 500 mg L^{-1} TTO, 500 mg L^{-1} PEO, 250 mg L^{-1} EEO, and 500 mg L^{-1} MEO reveal a prime state of the xylem vessels. The essential oils and their constituents are a key antibacterial feature because it allows them to partition with the lipids of the bacterial cell wall, mitochondria, and cell membrane, increasing the permeability of these membranes. Moreover, the bacteria activity in the preservative solution of chrysanthemum flowers treated with clove and thyme oils was less than in control cut flowers, and other treatments were used (El-Sayed and El-Ziat, 2021). Hence, the antibacterial activities of essential oils of herbs could correlate with the increased carnation cut flower shelf-life. These effects have been indicated by (Amin and El Sayed 2021)

Conclusions

Briefly, essential oils selected, participle tea tree oil (TTO) and pumpkin seed oil (PSO), showed antimicrobial agents for prolonging the vase life and enhancing the water relations and relative fresh weight (RFW%) of carnation cut flowers and improving total phenolics and sugars as well as antioxidant enzyme activity. These findings suggest that 500 mg L^{-1} TTO and PSO efficiently prevented bacterial blockage and improved the water uptake of carnation. Therefore, Essential oils are eco-friendly to the environment and low cost, especially since the eco-friendly holding preservative solution is safe for people and animals in the future. Thus, future works will apply different concentrations of TTO, PSO, MEO, and EEO in other cut flowers.

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References

ADAM, A.I. Effect of essential oils on vase life of cut flowers of *Solidago condenses* L. (Golden rod). **Scientific Journal of Agricultural Sciences**, v.3, n.1, p.46-55, 2021.

ALMEIDA, A.E.F.A.; SANTOS, L.O.; CASTRICINI, A.; REIS, J.B.R.D.S. *Eucalyptus globulus* essential oil on the postharvest quality of 'Carola' roses. **Ornamental Horticulture**, v.26, n.2, p.159-165, 2020.

AMIN, O.A.; EL SAYED, N. Influence of the essential oils on improvement vase-life of cut *Aspidistra elatior*. **Plant Cell Biotechnology and molecular Biology**, v.22, p.60-79, 2021.

BAZAZ, A.M., TEHRANIFAR, A., KARIZAKI, A.R. Use of ethanol, methanol and essential oils to improve vase-life of chrysanthemum cut flowers. **International Research Journal of Applied and Basic Sciences**, v.9, n.8, p.1431-1436, 2015.

BOZZOLA, J.J.; RUSSELL, L.D.; **Electron Microscopy: Principles and Techniques for Biologists**. Boston: Jones and Bartlett, 1999. 670p.

CHRISTAKI, S.; MOSCHAKIS, T.; KYRIAKOUDI, A.; BILIADERIS, C. G.; MOURTZINOSS, I. Recent advances in plant essential oils and extracts: Delivery systems and potential uses as preservatives and antioxidants in cheese. **Trends in Food Science & Technology,** v.116, p.264-278, 2021. https://doi.org/10.1016/j.tifs.2021.07.029

DUBOIS, M.; GILLES, K.A.; HAMILTON, J.K.; REBERS, P.A.; SMITH, F. Colorimetric method for determination of sugars and related substances. **Analytical Chemistry**, v.28, n.3, p.350-356, 1956.

DUNCAN, D.B. Multiple range and multiple F-tests. **Biometrices,** v.11, n.1, p.1-42, 1955.

El-SAYED, I.M.; El-ZIAT, R.A. Utilization of environmentally friendly essential oils on enhancing the postharvest characteristics of *Chrysanthemum morifolium* Ramat cut flowers. **Heliyon**, v.7, n.1, e05909, 2021.

El-SAYED, I.M.; SALIM, R.G.; El-HAGGAR, E.F.; El-ZIAT, R.A.; SOLIMAN, D.M. Molecular characterization and positive impact of brassinosteroids and chitosan on *Solidago canadensis* cv. Tara Characteristics. **Horticulturae**, v.6, n.4, p.1-18, 2020.

FANOURAKIS, D.; PAPADOPOULOU, E.; VALLA, A.; TZANAKAKIS, V.A.; NEKARIOS, P.A. Partitioning of transpiration to cut flower organs and its mediating role on vase life response to dry handling: A case study in chrysanthemum. **Postharvest Biology Technology,** v.181, p.111636, 2021.

FULEKI, T.; FRANCIS, F.J. Quantitative method for anthocyanins. **Journal of Food Science**, p.33-72, 1968.

GANI, I.; DAR, Q.A.H.; MUDASIR, R.; WAHEED, A.; BHAT, Z.A. Effect of essential oils and silver based biocides on the vase life of cut carnation (*Dianthus caryophyllus* cv. Dark-Dona). **The Pharma Innovation Journal**, v.7, n.7, p.763-766, 2018.

HASHEMABADI, D.; HASSAN, A.A.; DONYA, H.R.; BEHZAD, K. Herbal extract and alcohol increase vase life of *Dianthus caryophyllus* L. cv. "yellow candy". **Revista Chapingo Serie Horticultura**, v.27, n.3, p.135-155, 2021.

HE, S.; JOYCE, D.C.; IRVING, D.E.; FARAGHER, J.D. Stem end blockage in cut *Grevillea* 'Crimson Yul-lo' inflorescences. **Postharvest Biology and Technology**, v.41, p.78-84, 2006.

KAR, M.; MISHRA, D. Catalase, peroxidas and polyphenol oxidase activities during rice leaf senescence. **Plant Physiology**, v.57, n.2, p.315-319, 1976.

LOPEZ-GOMEZ, A.; NAVARRO-MARTINEZ, A.; MARTINEZ- HERRANDEZ, G.B. Active paper sheets including nanoencapsulated essential oils: A green packaging technique to control ethylene production and maintain quality in fresh horticultural products- A case study on flat peaches. **Foods**, v.12, n.12, p.1-23, 2020. https://doi.org/10.3390/foods9121904

MARKLUND, S.; MARKLUND, G. Involvement of the superoxide anion radical in the autoxidation of pyragallol and aconvenient assay for superoxide dismutase. **European Journal Biochemistry**, v.47, p. 467-474, 1974.

MAROUSKY, F.J. Conditioning gladiolus spikes to maintenance of fresh weight with pre-treatments of 8-hydroxy-quinoline citrate plus sucrose. **Proceedings of the Florida State Horticultural Society**, v.82, p.411-414, 1970.

MAURYA, A.; PRASAD, J.; DAS, S.; DWIVEDY, A.K. Essential oils and their application in food safety. **Frontiers in Sustainable Food Systems**, v.5, p.133, 2021.

MUKHERJEE, S.P.; CHOUDHURI, M.A. Implications of water stress-induced changes in the levels of endogenous ascorbic acid and hydrogen peroxide in *Vigna* seedlings. **Physiologia Plantarum**, v.58, n.2, p.166-170, 1983.

OTHMAN, E.Z.; ESMAIL, S.E.A. Enhancing vase life of *Helianthus annuus* L. cut flowers using salicylic acid and dill essential oil. **Middle East Journal of Agriculture Research**, v.9, n.04, p.1045- 1056, 2020. https://doi.org/10.36632/mejar/2020.9.4.81

POUYA, Z.; HASSANI, R.N.; ZAREHAGHI, D. Effect of savory and clove essential oils on vase life, flower and leaf water balance in cut rose flower cv. Velvet. **Iranian Journal of Horticultural science**, v.50, n.1, p.163-172, 2019.

PUN, U.K.; YAMADA, T.; TANASE, K.; SHIMIZU-YUMOTO, H.; SATOH, S.; ICHIMUR, K. Effect of ethanol on ethylene biosynthesis and sensitivity in cut carnation flowers. **Postharvest Biology and Technology**, v.98, p.30-33, 2014. https://doi.org/10.1016/j.postharvbio.2014

SALEEM, U.; SHEHZAD, A.; SHAH, S.; RAZA, Z.; SHAH, M.A.; BIBI, S.; CHAUHDARY, Z.; AHMAD, B. Antiparkinsonian activity of *Cucurbita pepo* seeds along with possible underlying mechanism. **Metabolic Brain Disease**, v.36, n.6, p.1231-1251, 2021. https://doi.org/10.1007/s11011-021-00707-6

SALEHI SALMI, M.R.; FALEHI HOSEINI, M.; HEIDARI, M.; DANESHVAR, M.H. Extending vase life of cut rose (*Rosa hybrid* L.) cv. Bacara by essential oils. **Horticultural Science**, v.32, n.1, p.61-70, 2018.

SARIC, M.R.; KASTRORI-CUPINA, T.; GERGIS, I. Chlorophyll Determination. Univ. Unoven Sadu-Prakitikum is KiziologizeBilika-Beagrad, **HaucuaAnjiga**, p.215, 1967.
SOLIMAN, D.M.; AHMED, A.; EL-SAYED, I.M. Lead toxicity and spermine as affecting the chemical composition and growth of *Solidago Canadensis* L. cv. 'Tara' Plant. **Egyptian Journal of Chemistry**, v.65, n.2, p.471-485, 2022.

SOLIMAN, D.M.; MAZHAR, A.A.M.; EID, R.A.; ABD El AZIZ, N.G. Biostimulation effects of linseed and citrus oils on growth, antioxidant enzymes activity, metabolic changes and water relations of *Khaya senegalensis* seedlings under drought stress, **Journal of Pharmaceutical Negative Results**, v.13, p.2790-2801, 2022.

SWAIN T.; HILLIS, W.E. The phenolics constituents of *Prunus domestica*. The quantitative analysis of phenolic constituents. **Journal of Science of Food and Agriculture**, v.10, n.2, p.63-68,1959.

VEHNIWAL, S.S.; OFOE, R.; ASIEDU, S.K.; HOYLE, J.; ABBEY, L. Extension of cut carnation vase life using compost tea, putrescine and plant extracts. **Sustainable Agriculture ya**, v.10, n.1, p.32-45, 2021. https://doi.org/10.22004/ag.econ.309797

YANG, Y.; TAKENAGA, S.; OHNO, S.; DOI, M. Ethylene- sensitive abscission layer formation and petal senescence in cut *Dahlia* inflorescences. **The Horticulture Journal**, v.90, n.4, p.460-468, 2021.

YASIN, M.; YOUNIS, A.; JAVED, T.; AKRAM, A.; ASHAN, M.; SHABBIR, R.; ALI, M.M.; TAHIR, A.; EL-BALLAT, E.M.; SHETEIWY, M.S.; SAMMOUR, R.H.; HANO, C.; AIHUMAYDHI, F.A.; EL-ESAWI, M. River tea tree oil, composition, antimicrobial and antioxidant activities and potential applications in agriculture. **Plants**, v.10, n.2105, p.1-14, 2021a.

YASIN, M.; YOUNIS, A.; RAMZAN, F.; JAVED, T.; SHABBIR, R.; NOUSHAHI, H.A.; SKALICKY, M.; ONDRISIK, P.; BRESTIC, M.; HASSAN, S.; EL-SABAGH, A. Extraction of essential oil from river tea tree (*Melaleuca bracteata* F. Muell.): Antioxidant and antimicrobial properties. **Sustainability**, v.2021, n.13, p.4827, 2021b.

YONSAWAD, N.; TEERARAK, M. Eucalyptus and citronella essential oils used in preservative solutions affect the vase life of cut Philodendron leaves. **Horticultural Science and Technology**, v.37, n.1, p.78-91, 2019. https://doi.org/10.12972/kjhst.20190008.