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Research Article

Effect of peppermint and rose extracts on vase life of cut *Alstroemeria* ' Bali' flowers

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Abstract

In this study, the effects of peppermint and rose extracts on delaying the aging of *Alstroemeria* spp. cut flowers were investigated. Peppermint and rose extracts were used in concentrations of 10, 20 and 30%. Quantitative and qualitative traits such as vase life, flower opening index, water uptake, fresh weight, dry weight, population of bacteria in vase solution and stem end, ion leakage, decreasing Brix degree, content of carotenoid and chlorophyll were evaluated. In this study, treatment of 30% rose extract was better than other treatments and the highest vase life, Brix degree, and fresh and dry weights were obtained in this treatment. Treatment of 10% mint extract was also effective in reducing the bacterial population, increasing water absorption and vase life. Treatment of 10% rose extract had the highest efficiency in the process of flower opening and it acted like treatment of 30% rose extract in fresh weight and Brix degree. The highest amount of chlorophyll was related to 20% rose treatment and the highest amount of carotenoid was related to 30% mint extract treatment.

Keywords: Alstroemeria, Essential oils, Ornamentals, Postharvest longevity

Introduction

Alstroemeria spp. (belongs to the Alstroemeriaceae family) is a popular cut flower, mainly because of having a wide range of colors. The main problem of most cut flowers is short vase life. Vascular blockage, water stress, ethylene production and microorganisms' activity in vase solution are the major reasons for vase life reduction of a cut *Alstroemeria* flower (Anvari *et al*., 2022). Studies have been doing to find out safe, low-cost, easily accessible and environmentally-friend products to extend the vase life of cut flowers (Basiri *et al*., 2022; Singh *et al*., 2022).

Extracts and essential oils are natural antimicrobial compounds used during recent years for extending postharvest life of cut flowers. The active ingredients of some medicinal plants have antimicrobial properties due to their high concentration of phenolic compounds. The antimicrobial activity of essential oils is related to the phenolic compounds, alcohols, aldehydes, ketones, ethers and etc. (Singh *et al*., 2022). There is a direct relationship between the components of essential oils and their activity.

Peppermint (*Mentha pieperata*) and rose (*Rosa damascena*) are two important medicinal plants with antimicrobial, antioxidant, antibacterial and anti-inflammatory properties, suitable for using in vase solutions (Hussain *et al*., 2021; Venkatesha *et al*., 2022). Peppermint essential oil contains menthol (30-40%), menthone (15-25%), methyl acetate (about 10%) and menthofurane (less than 5%) (Safaei Khoram *et al*., 2011). Rose extract, which contains several active ingredients, is extracted from the sepals and petals of the plant and contains 300 different compounds, of which 50 compounds are known. The main and effective ingredients of rose are 30-40% geraniol, 40-60% citronlol, 20-30% linalool and 20-25% stiraptene (Zarghami *et al*., 2001).

Application of essential oils for extending the postharvest life of cut flowers has been in use for many years. The use of essential oils of medicinal plants and their active ingredients in the preservative solution of cut *Gerbera* flowers increased its vase life (Solgi *et al*., 2009). Thyme essential oil extended the vase life of cut narcissus flowers (Salehi Sardoei, 2013). Also, the use of 50 and 75 mg of thyme and safflower essential oils prolonged vase life of cut lilium flowers by the effect on water absorption and fresh weight. Treatment of 20 mg/l of thyme essential oil together with sucrose 4% increased the vase life of lilies from 8 days to 13 days (Tahmasbi Notorki *et al*., 2012). Application of

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cinnamon and carnation essential oils together with silver nanoparticles in vase solution of cut *Alstroemeria* cv. 'Jamaica' flowers reduced the number of petal shedding days by up to 50% delay compared to the control (Fazlalizadeh *et al*., 2013). Carvacrol extended the vase life of cut *Alstroemeria* cv. 'Bridal' flowers and improved its quality (Isapareh *et al*., 2016).

Peppermint essential oil and sucrose have a significant effect on increasing water absorption, stability of cell membranes and photosynthetic pigments and reducing fungal and bacterial contamination, resulted in extending the vase life (Jahanifar *et al*., 2015). The use of essential oils of savory and coriander plants reduced the microbial population in the vase solution and stem end of cut rose flowers, resulted in extending the vase life (Jalili Marandi *et al*., 2011). Application of thyme essential oils as disinfectant in the preservative solution of cut *Thymus capitatus* L. flowers increased antioxidant activity and vase life (Ouraiachi *et al*., 2011). Treatment of 50 mg/l thyme essential oil on cut Alstroemeria flowers increased the vase life (Mousavi Bazaz and Tehranifar, 2011). Rosemary and mint essential oils significantly increased the vase life of cut Alstroemeria flowers through reduction of microorganisms' population (Babarabie *et al*., 2016). Beneficial effect of some other essential oils on extending the vase life of cut Alstroemeria flowers have been shown (Ershad Langroudi *et al*., 2017).

The aim of the present study was to investigate the effect of peppermint and rose extracts on some physiological traits, microorganisms' population in vase solution and stem end and vase life of cut *Alstroemeria* 'Bali' flowers.

Materials and methods

Plant materials: Cut *Alstroemeria* 'Bali' flowers (Fig. 1) were prepared from a commercial greenhouse located in Tehran, Iran. Uniform cut flowers were transferred to the postharvest laboratory of Islamic Azad University, Rasht, Iran, immediately. Shoots were re-cut from a height of 52 cm under water and placed in vase solution.

Essential oils preparation: The Abdolmaleki *et al*. (2013) method was used to extract the peppermint and rose. Peppermint leaves and rose petals were dried out and powdered at ambient temperature and in the dark room for 72 h. The content of 100 g powder of each plant was poured into boiling water and extracted on a heater with 500 ml of boiling water. The plant residues in the extract were separated by Watman filter paper. The smooth extract was transferred to the hot water bath at 50°C and was dehydrated. After evaporation of the water from the extract, the extracts were transferred to dark glass containers and kept at 20°C until the experiments were performed.

Experimental design and treatments: Four cut flowers were placed in plastic pots and pulse treated with peppermint and rose extracts. The experiment was done based on a completely randomized block design with three replications, 21 plots and 4 flowers per plot. Treatments included 10, 20 and 30% of both of peppermint and rose extracts. Data were analyzed by MSTATC statistical software package and means were compared with the Least Significant Difference (LSD) test.

Measurement of traits, vase life: Evaluation of the retention or flowering vase life of cut flowers from the beginning of the treatment to the aging of the flower and yellowish and abscission of leaves was performed (Mensuali Sodi and Ferrante, 2005).

Water uptake: According to the initial volume of vase solution (500 mg.L^{-1}) and the evaporation rate in the room and reducing the volume of the vase solution, water absorption was calculated from the following formula (Mohammadi and Hashemabadi, 2016):

$$\text{Absorption of the solution (mL.g-1 F.W.)} = \frac{500 - (\text{Residual solution at the end of flower life} + \text{Average room evaporation})}{\text{Average fresh weight of 5 cut flowers}}$$

Increase of fresh weight: With respect to the final weight of flower on the last day, recuts weight, loss of weight and weight of first day, increase in fresh weight was calculated by the following equation (Mohammadi and Hashemabadi, 2016):

$$\text{Fresh weight (g) increase} = (\text{weight loss} + \text{weight of recuts} + \text{final weight at last day of control life flowers} - \text{initial weight}$$

Percentage of dry matter: At the end of vase life, fresh weight of flowers was measured and then dried out at 70°C for 48 h. To ensure complete drying, cut flowers were weighed and their dry matter percentage was calculated by calculating dry matter percentages according to following formula (Mohammadi and Hashemabadi, 2016):

$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight at the end of vase life}} \times 100$$

Decrease of Brix degree: To do this, small cuts at the ends of the stem were used. One or two drops of water in the mentioned pieces were poured on a glass plate of refractometer, N-1a model, ATAGO, Japan and its Brix degree was read and by subtracting the last day Brix degree from the first day Brix degree, the Brix degree decrease was calculated.

Bacterial counting at the stem end: The 24 hours after the application of treatments, the stem ends (about 2 cm) were cut. They were rinsed with distilled water followed by extracting with 0.9% normal saline serum. Then, 0.1 mL of the solution was cultured on agar and was put in an incubator at 37°C for 24 h. Then, bacteria colonies were counted by a microscope (Liu *et al*., 2009).

Bacterial counting at the preservative solution: The 24 h after applying the desired treatments, the water solution inside the pot was sampled and diluted with 0.9% normal saline solution to deliver 30 to 300 bacterial colonies per Petri dish. 0.1 ml of the above solution was expanded on agar and bacterial colonies were counted 24 h after incubation at 37°C (Oraee *et al*., 2011).

Petal carotenoid: To measure carotenoids, the petals were separated on the fifth day of the experiment and wrapped in foil, and then the carotenoid

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Fig. 1. An *Alstroemeria* 'Bali' flower used as cut flower.

measurement was performed using the Mazumdar and Majumdar (2003) method.

Chlorophyll a, b and total chlorophyll: To measure chlorophylls, the petals were separated on the fifth day of the experiment and wrapped in foil, and then the chlorophyll a, b and total chlorophyll measurement were performed using the Mazumdar and Majumdar (2003) method.

Ionic leakage: The 5 g of leaves from each plot with 50 ml of double distilled water were placed in closed containers at laboratory temperature for 24 h and then its EC_1 was calculated by EC-meter. In the next step, to measure EC_2, 0.5 g of leaves was frozen for 24 h and then the leaves were again at room temperature for 24 h and then the numbers were read with EC-meter. The following formula was used to determine ion leakage(Ben Hamed *et al*., 2007):

Ionic leakage = $EC_1 / EC_2 \times 100$

Flower opening index: The following equation (Mohammadi and Hashemabadi, 2016) was used to measure this index.

$$\text{Flower opening index} = (\text{closed flower number of last day} + \text{opened flower number of last day}) + (\text{closed flower number of first day} + \text{opened flower number of first day})$$

Data analysis: Data analysis and means comparison were carried out using MSTATC software and LSD test, respectively.

Results and discussion

Based on the analysis of variance the effect of peppermint and rose extracts was statistically significant at the level of 1% on all the measured parameters of Alstroemeria flower (data not shown).

Vase life: Regarding vase life, comparison of the mean data showed that all treatments increased vase life compared to the control, so that the treatments of 10% peppermint extract (24.67 days) and 30% rose extract (24.67) had the longest vase life that there was no significant difference with each other and with 10% rose and 30% mint treatments, but there was a significant difference with other treatments (Table 1). In a study, the effect of some plant essential oils (clove, cinnamon, ginger, marjoram and fennel) on the vase life of gladiolus, it was found that the essential oils reduced the microbial load, prevented the decomposition of the spike base and florets, and increased the vase life (Hegazi and Gan, 2009). Similar results on the positive effect of disinfectant compounds on vase life have been reported by Hashemi *et al*. (2011), Bayat *et al*. (2011), Ghaleh Shakhani *et al*. (2011), which is consistent with the results of the present study. Mousavi Bazaz *et al*. (2011) also reported that the use of peppermint essential oil with a concentration of 50 mg/l increased the vase life of Alstroemeria by 2.03 days, which is consistent with the findings of the present study.

Fresh and dry weights: Regarding the fresh weight of the plant, mean comparison of the data showed that all treatments increased the fresh weight compared to the control and the highest fresh weight (103.4 g) was related to the treatment of 10% rose which had no significant difference with 30% rose treatment, and 20 and 30% mint (Table 1). Mousavi Bazar and Tehranifar (2011) reported improvement in fresh weight of cut Alstroemeria flowers using plant essential oils in vase solution. The use of plant essential oils in the preservative solution of cut rose cv. Grand flowers increased fresh weight by improving water relations (Shanan, 2012). Application of 500 mg/l essential oil of *Corum copticum* increased the fresh weight of cut rose flowers compared to the control (Jalili Marandi *et al*., 2011). The results of the above findings were consistent with the present study.

Regarding the dry weight of the plant, mean comparison of the treatments showed that the highest increase in dry weight of the plant (13.97 g) belonged to 30% rose treatment, which was not significantly different from 10% peppermint and 10% rose extract treatments, but showed a significant difference with other treatments (Table 1). Preventing increased respiration and thus reducing the consumption of sugars ramped up dry matter. In addition to the above, antimicrobial compounds ramped up the maintenance and improvement of water relations by controlling soluble microorganisms in the vase solution and stem, and ramped up fresh and dry weight, which in turn will affect the dry matter (Hashemabadi, 2011; Blankenship and Dole, 2003). The use of plant essential oils in the preservative solution of cut gladiolus flower increased the amount of carbohydrates in this cut flower (Hegazi

Table 1. Mean comparison of the effect of peppermint and rose extracts on measured traits

Treatments	Vase life (day)	Fresh weight (g)	Dry weight (g)	Water uptake (mg/g F.W.)	Solution bacterium (Log_{10} CFU ml^{-1})	Stem end bacterium (Log_{10} CFU ml^{-1})	Ionic leakage (%)
Control	20.67^{c}	60.97^{b}	12.44^{c}	1.54^{d}	30.00^{a}	56.67^{a}	8.67^{a}
Peppermint extract 10%	24.67^{a}	69.27^{b}	13.22^{abc}	1.80^{a}	4.00^{c}	5.00^{d}	4.29^{f}
Peppermint extract 20%	21.67^{bc}	89.31^{a}	12.85^{bc}	1.77^{b}	11.67^{ab}	43.33^{b}	6.93^{b}
Peppermint extract 30%	23.33^{ab}	97.48^{a}	11.44^{d}	1.77^{b}	9.00^{ab}	15.00^{c}	5.98^{d}
Rose extract 10%	23.00^{ab}	103.4^{a}	13.55^{ab}	1.77^{b}	9.33^{ab}	37.00^{b}	6.14^{c}
Rose extract 20%	21.00^{c}	71.11^{b}	12.46^{c}	1.70^{c}	15.00^{ab}	45.00^{b}	8.51^{a}
Rose extract 30%	24.67^{a}	92.19^{a}	13.97^{a}	1.71^{c}	4.30^{c}	5.33^{d}	4.55^{e}

In each column, means with the similar letters are not significantly different at 5% probably level based on LSD test

and Gan, 2009). Examining the effects of antimicrobial and anti-ethylene compounds on cut monkey flowers showed that these compounds ramped up the amount of carbohydrates compared to the control (Abdul-Wasea, 2012). Basiri *et al*. (2011) reported the positive effect of antimicrobial compounds on increasing the dry matter content of cut clove flowers. These findings are consistent with the results of the current study.

Water uptake: Regarding water uptake, the results of comparing the mean of the data showed that all treatments had more water uptake than the control and 10% mint extract treatment had the highest amount of water uptake, which was significantly different from all other treatments (Table 1). Jalili Marandi *et al*. (2011) reported that the use of safflower and coriander essential oils increased water uptake in cut rose flowers compared to the control. Anjum *et al*. (2001) believed that adding disinfectants to vase solutions can inhibit the growth of microbes and increase water absorption. Meman and Dabhi (2006) reported the maximum solution uptake during the vase life of gerbera cut flowers in disinfected treatments with 4% sucrose. The use of 100 mg/l of peppermint essential oil in cut Alstroemeria flower solution improved the water relations and as a result increased water absorption and increased vase life as well. Shanan (2012) reported that plant essential oils improved water absorption in cut rose flowers by preventing vascular occlusion. All these findings confirm the results of the present study.

Bacterial population: Regarding the bacterial population, the results of mean comparison showed that the above treatments reduced the bacterial population in vase solution compared to the control that 10% mint and 30% rose treatments showed the greatest effect in reducing the bacterial population (Table 1). Accordingly, all the treatments studied reduced the bacterial population at the bottom of the stem compared to the control that 10% mint and 30% rose treatments showed the greatest effect in reducing the bacterial population and had a significant difference with other treatments. Antimicrobial activity of plant essential oils with its antimicrobial effect on pathogens and dysfunction of the respiratory chain of pathogens prevented the activity of microbes and eventually causes their death (Solgi *et al*., 2009). Hatami *et al*. (2012) believed that disinfectant treatments in vase solution with their antimicrobial effects reduced the activity of microorganisms and thus maintain water relations and ultimately increased the vase life of cut flowers, which were consistent with the results of the present study.

Ion leakage: The results of mean comparison showed that all the treatments studied reduced ion leakage compared to the control. The highest effect on reducing ion leakage was obtained from 10% mint treatment, which had a significant difference with all other treatments, and the lowest effect belonged to 20% rose extract treatment, which did not show a significant difference with the control (Table 1). In a study it was found that the use of extracts such as cumin, garlic, cinnamon and orange reduced ion leakage in *Narcissus* flower (Khisheh, 2016). It was also shown that the use of clove and cinnamon essential oils reduced ion leakage in pomegranates treated with these essential oils (Ghafouri *et al*., 2016). These findings confirmed the results of the present study.

Brix degree: Mean comparison showed that all the studied treatments improved the Brix compared to the control. Least amount was related to 10% peppermint extract and most amounts related to the treatments 20% peppermint extract, 10 and 30% rose extract (Table 2). Improvement of Brix could be due to the storage and accumulation of carbohydrates, which reduced respiration in cut flowers (Bartoli *et al*., 1997). The researchers also believed that the use of antimicrobial compounds increased the Brix. The use of compounds that prolong the vase life increases the Brix compared to the control in cut gerbera flowers (Di, 2008). Maintaining or increasing the Brix in the stem of cut flowers can be attributed to the continuous re-cuts of the flower under water and its relationship with other traits such as water uptake that affect the amount of carbohydrates in the stem (Hashemabadi, 2011). These findings were consistent with the present study.

Flower opening: Regarding the flower opening process, the mean comparison of the data showed that the highest value was related to 10% rose extract treatment which was significantly different from other treatments and the lowest value was related to 20% peppermint extract which had significant difference with control and 30% rose extract treatment (Table 2).

Treatment of cut *Dianthus* flowers using ethanol and methanol showed that the relative fresh weight and relative development of flowers had a positive and significant correlation with vase life (Sani *et al*., 2010).

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Table 2. Mean comparison of the effect of peppermint and rose extracts on measured traits

Treatments	Decrease of °Brix (%)	Flower opening process	Carotenoid (µg/g F.W.)	Chlorophyll a	Chlorophyll b	Total chlorophyll
				(mg/g F.W.)		
Control	0.30cd	0.45bc	0.016bcd	3.96d	1.92c	5.88d
Peppermint extract 10%	0.39d	0.49b	0.033ab	3.68e	1.61e	5.30e
Peppermint extract 20%	1.16a	0.43c	0.005d	4.57b	1.79d	6.36b
Peppermint extract 30%	0.74b	0.49b	0.042a	3.44g	1.28g	4.72g
Rose extract 10%	1.35a	0.56a	0.009cd	4.26c	1.98b	6.23c
Rose extract 20%	0.47c	0.49b	0.024abc	5.77a	2.59a	8.35a
Rose extract 30%	1.35a	0.46bc	0.018bcd	3.48f	1.43f	4.91f

In each column, means with the similar letters are not significantly different at 5% probably level based on LSD test

The use of rosemary and thyme essential oils had a positive and significant effect on the opening of cut roses (Hosseini Darvishan *et al*., 2012). Evaluation of the effect of coriander and savory essential oils showed that the use of these disinfectants improved the opening index of cut rose flowers compared to the control (Jalili Marandi *et al*., 2011). These results are consistent with the results of the present study on the effect of plant essential oils in improving the opening index of cut flowers.

Pigments contents: The highest amount of carotenoids was related to the treatment of 30% mint extract, which was not significantly different from the treatments of 10% mint and 20% rose and the lowest amount was related to the treatment of 20% mint extract (Table 2). One of the main and determining indicators in the quality after harvest of cut flowers and their marketing is the presence of pigment in the petals of the plant. Carotenoids and anthocyanins are among the most important pigments that are important in the survival of cut flowers (Hassanpour Asil and Karimi, 2010; Amarjit, 2000). Kazemi and Ameri (2012) showed that the disinfectant compounds were effective in preserving cut *Dianthus* flower pigments. The use of disinfectants in low concentrations increased the amount of pigment in cut gladiolus flowers (Mohammadi *et al*., 2011). Treatment of 10 mg/l silver Nanoparticles together with 50 mg/l thyme essential oil with 4% sucrose had the highest amount of carotenoids in cut lilium flowers (Tahmasbi Notorki *et al*., 2012). Zamani *et al*. (2011) reported the use of flower-extending agents on maintaining and increasing the amount of pigments in cut chrysanthemums. These findings were consistent with the results of the present study.

Mean comparison of the data showed that the highest amount of chlorophyll a, b and total chlorophyll was related to 20% rose treatment, which was significantly different from all treatments. The lowest amount of chlorophyll a, b and total chlorophyll belonged to 30% mint extract treatment which showed a significant difference with other treatments (Table 2). The reason for the superiority of disinfectant compounds over the preservation of pigments in cut flowers can be attributed to their positive effect on preventing the activity of microorganisms and increasing water absorption, which directly influence on the petals and indirectly on the amount of pigment (Hashemabadi, 2011). The use of disinfectants in low concentrations increased the amount of pigment in cut gladiolus flowers (Mohammadi *et al*., 2011). Kazemi *et al*. (2012) reported that the use of disinfectant compounds in solutions containing cut flowers increased the amount of chlorophyll. These researchers showed that thyme essential oil increased the amount of total chlorophyll in cut Lisianthus flowers compared to the control. Therefore, the significant effect of plant essential oils on increasing the amount of chlorophyll in the above research was in line with the present study.

Conclusion

In this study, 30% rose extract treatment was better than other treatments and had the highest vase life, Brix, and fresh and dry weights. Furthermore, treatment of 10% peppermint was useful in reducing the bacterial population, increasing water absorption and vase life. The 10% rose extract treatment was the most effective in the process of opening the flowers and in the fresh weight and Brix it was the same as the 30% rose extract treatment. The highest amount of chlorophyll was related to 20% rose extract treatment and the highest amount of carotenoids was related to 30% peppermint treatment.

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References

Abdolmaleki, A., Rajabi, A. and Sanginabadi, F. (2013) Evaluation of the analgesic and anti-inflammatory effects of aqueous extract of peppermint (*Mentha piperita*). SJKU 18: 67-74.

Abdul-Wasea, A. (2012) Effects of some preservative solution on vase life and keeping quality of snapdrag. Journal of Research (Science) on (*Antirrhinum majus*) cut flowers. Journal of the Saudi Society of Agricultural Science 11: 29-35.

Amarjit, B. (2000) Plant growth regulation agriculture and horticulture. Food Product Press 5: 147-165.

[DOR: 20.1001.1.23222727.1401.11.52.8.7]

Anjum, M. A., Naveed, F., Sahakeel, F. and Amin, S. (2001) Effect of some chemicals on keeping quality and vase life of tuberose (*Polianthus tuberosa* L.) cut flower. Journal of Research (Science) 12: 1-7.

Anvari, M., Hashemabadi, D., Kaviani, B. and Asadpour, L. (2022) Effect of blue light irradiation and silver nanoparticles at different rates on the vase life and traits involved in postharvest quality preservation of cut *Alstroemeria* cv. 'Napoli'. Journal of Ornamental Plants 12: 31-45.

Babarabie, M., Zarei, H. and Varasteh, F. (2016) Potential of increasing the vase life and improvement of some physiological characteristics of Alstroemeria cut flowers by using non-harmful compounds environmentally. Journal Chemical Health Risks 6: 1-8.

Bartoli, C. G., Juan, G. and Edgrdo, M. (1997) Ethylene production and responses to exogenous ethylene in senescing petals of *Chrysanthemum morifolium* cv. 'Ram'. Plant Science 124: 15-21.

Basiri, Y., Etemadi, N., Alizadeh, M., Nikbakht, A. and Saeidi, G. (2022) Vase life consequences of natural and chemical treatments in foxtail lily (*Eremurus spectabilis*), as a specialty cut flowers. Ornamental Horticulture 28: 120-129.

Basiri, Y., Zarei, H. and Mashayekhi, K. (2011) Effects of nanosilver treatments on vase life of cut flowers of carnation (*Dianthus caryophyllus* cv. White Liberty). Journal of Advanced Laboratory Research in Biology 2: 49-55.

Bayat, H., Azizi, M., Shoor, M. and Mardani, H. (2011) Effects of ethanol and essential oils on extending vase life of carnation cut flower (*Dianthus caryophyllus* cv. 'Yellow Candy). Notulae Scientia Biologicae 3: 100-104.

Ben Hamed, K., Castagna, A., Salem, E., Ranieri, A. and Abdelly, C. (2007) Sea fennel (*Crithmum maritimum* L.) under salinity conditions: A comparison of leaf and root antioxidant responses. Plant Growth Regulators 53: 185-194.

Blankenship, S. and Dole, J. M. (2003) 1- methylcyclo- propene: A review. Postharvest Biology and Technology 28: 1-25.

Di, W. (2008) Effects of antibiotics on the senescence of *Gerbera jamesonii* cut flower. Journal of Anhui Agriculture Science (Abstract).

Ershad Langroudi, M., Hashemabadi, D., Kalatejari, S. and Asadpour, L. (2017) Effect of silver nanoparticles, spermin, salicylic acid and essential oils on vase life of Alstromeria. Revista de Agricultura Neotropical 6: 100-108.

Fazlalizadeh, B., Naghshiband Hasani, R., Zare Nahandi, F. and Alizadeh Salteh, S. (2013) The effect of plant essences of cinnamon, *Daphne odora* and nanosilver on vase life of *Alstroemeria* cut flowers. Horticulture Sciences and Technics of Iran 14: 63-69. (In Persian with English abstract).

Ghafouri, M., Soleimani, A. and Rabiei, V. (2016) Effect of application of clove and cinnamon essential oils on maintain quality post-harvest of pomegranate. Journal of Crops Improvement 18: 389-401. (In Persian with English abstract).

Shakhani, Gh., Chamani, A., Esmailpoor, B. and Mohebi, M. (2011) The effect of nanosilver on the flowering life of purple-edged Lisianthus flowers. In: Proceedings of the 7th Iranian Congress of Horticultural Sciences, September 5-17, 2011, Iran, Isfahan University of Technology. (In Persian with English abstract).

Hashemabadi, D. (2011) Comparison of silver nanoparticles and silver thiosulfate on the quality and flowering life of cut cloves of Tempo cultivar. Final report of the research project, Rasht Branch, Islamic Azad University. (In Persian).

Hashemi, M., Mirdehghan, S. H., Farahmand, H. and Dasti, H. (2011) Effect of salicylic, methyl jasmonate and plant essential oils on the quality and flowering life of gerbera cut flowers. In: Proceedings of the 7th Iranian Congress of Horticultural Sciences, September 5-17, 2011, Iran, Isfahan University of Technology. (In Persian with English abstract).

Hassanpour Asil, M. and Karimi, M. (2010) Efficiency of benzyladenine reduced ethylene production and extended vase life of cut *Eustoma* flowers. Plant Omics Journal 3: 199-203.

Hatami, M., Hatamzadeh, A. and Ghasemnejad, M. (2012) Antimicrobial effect of silver nanoparticles and silver nitrate and their relationship with postharvest life of cut flowers of Red Ribbon cultivar. In: Proceedings of the 7th Iranian Congress of Horticultural Sciences, September 5-17, 2011, Iran, Isfahan University of Technology. (In Persian with English abstract).

Hegazi, M. A. and Gan, E. K. (2009) Influences of some essential oils vase life of *Gladiolus hybrida* L. 'Spikes'. International Journal for Agro Veterinary and Medical Sciences 3: 19-24.

Hosseini Darvishan, S., Chamani, A. and Poorbirami Hir, Y. (2012) Investigation of the effects of extracts of some medicinal plants on the life after harvesting cut roses. In: Proceedings of the 7th Iranian Congress of Horticultural Sciences, September 5-17, 2011, Iran, Isfahan University of Technology. (In Persian with English abstract).

Hussain, S., Tanvir, M., Ahmad, M. and Munawar, K. S. (2021) Phytochemical composition of mint (*Mentha*), its nutritional and pharmacological potential. Lahore Garrison University Journal of Life Sciences 5: 241-258.

Isapareh, A., Hatamzadeh, A. and Ghasemnezhad, M. (2016) The comparison of some chemical treatments and carvacrol on improving vase life of cut *Alstroemeria* flower cv. Bridal. Journal of Crop Production and Processing 5: 105-113. (In Persian with English abstract).

Jahanifar, E., Nazari Deljoo, M. J. and Aramideh, S. (2015) Water relations of flowering stem, microbial activity of preservative solution and postharvest quality of *Alstroemeria* cut flower under peppermint's essential oil and sucrose treatments. Journal of Crop Production and Processing 5: 221-232. (In Persian with English abstract).

Jalili Marandi, R., Hassani, A., Abdollahi, A. and Hanafi, S. (2011) Application of *Carum copticum* and *Saturega hortensis* essential oils and salicylic acid and silver thiosulphate in increasing the vase life if cut rose flowers. Journal of Medicinal Plants Research 5: 5034-5038.

Kazemi, M. and Ameri, A. (2012) Response of vase life carnation cut flower to salicylic acid, silver nanoparticles, glutamine and essential oil. Asian Journal of Animal Science 6: 122-131.

Kazemi, M., Hajizadeh, H., Gholami, M., Asadi, M. and Aghdasi, S. (2012) Efficiency of essential oils, citric acid, malic acid and nickel reduced ethylene production and extended vase life of cut *Lisianthus* flowers. Research Journal of Botany 7: 14-18.

Khisheh, Z. (2016) Investigation of the role of natural plant extracts in the life after harvest of cut daffodils. Master Thesis, Gorgan University of Agricultural Sciences and Natural Resources. (In Persian with English abstract).

Liu, J. P., He, S. G., Zhang, Z. Q., Cao, J. P., Lv, P. T., He, S. D., Cheng, G. P. and Joyce, D. C. (2009) Nano-silver pulse treatments inhibit stem- end bacteria on cut gerbera cv. 'Ruikou' Flowers. Postharvest Biology and Technology 54: 59-62.

Mazumdar, B. C. and Majumdar, K. (2003) Methods on Physicochemical Analysis of Fruits. www.Sundeepbooks.com.

Meman, M. A. and Dabhi, K. M. (2006) Effect of different stalk length and certain chemical substance on vase life of gerbera (*Gerbera jamesonii* L.). Journal of Applied Horticulture 8: 147-150.

Mensuali Sodi, A. and Ferrante, A. (2005) Physiological changes during postharvest life of cut sunflowers. 4th International Symposium on Postharvest Physiology of Ornamental Plants, ISHS Acta Horticulturae 669.

Mohammadi, N., Zarei, H. and Ghasemnehad, A. (2011) Investigation of the effect of rosemary extract on the quality of some quality indicators and durability of cut flowers of gladiolus. In: Proceedings of the 7th Iranian Congress of Horticultural Sciences, September 5-17, 2011, Iran, Isfahan University of Technology. (In Persian with English abstract).

Mohammadi, R. and Hashemabadi, D. (2016) Improvement postharvest longevity of Alstroemeria (*Alstroemeria hybrida*) by sucrose, honey and citric acid. Plant Ecophysiology 204-218. (In Persian with English abstract).

Mousavi Bazaz, A. and Tehranifar, A. (2011) Effects of ethanol, methanol and essential oils as novel agents to improve vase life of *Alstroemeria* flowers. Journal of Biological and Environmental Sciences 5: 41-46.

Oraee, T., Asgharzadeh, A., Kiani, M. and Oraee, A. (2011) The role of preservative compounds on number of bacteria on the end of stems and vase solution of cut *Gerbera*. Journal of Ornamental and Horticultural Plants 1: 161-166.

Ouraiachi, E. M. E., Paolin, J., Bouyanzer, A., Tomi, P., Hammouti, B., Salghi, R., Majidi, L. and Costa, J. (2011) Chemical composition and antioxidant activity of essential oils and solvent extracts of *Thymus capitatus* L. Hoffmanns and Link from Morocco. Journal of Medicinal Plants Research 5: 5773-5778.

Safaei Khoram, M., Jafarnia, S. and Khosroshahi, S. (2011) The most important medicinal plants in the world. Iran Green Agriculture Training Complex. (In Persian).

Salehi Sardoei, A. (2013) The effect of thyme essential oil (thymol) on the longevity of cut daffodils. In: Proceedings of the 2th National Congress of Hydroponics and Greenhouse Products. Mahalat. (In Persian with English abstract).

Sani, R., Kazemi Dogolsar, H. and Nozari, S. (2010) The effect of ethanol on postharvest quality and longevity of cut *Anthurium* flowers. In: First National Conference on Agriculture and Sustainable Development, Opportunities and Challenges Ahead. Shiraz. (In Persian with English abstract).

Shanan, N. (2012) Applications of essential oils to prolong the vase life of rose (*Rosa hybrid* L. cv. 'Grand') cut flowers. Journal of Horticultural Science and Ornamental Plants 4: 66-74.

Singh, K., Sharma, R. and Sahare, H. (2022) Implications of synthetic chemicals and natural plant extracts in improving vase life of flowers. Scientia Horticulturae 302: 111133.

Solgi, M., Kafi, M., Taghavi, T. S. and Naderi, R. (2009) Essential oils and silver nanoparticles (SNP) as novel agents to extend vase-life of gerbera (*Gerbera jamesonii* cv. 'Dune') flowers. Postharvest Biology and Technology 53: 155-158.

Tahmasbi Notorki, E., Alizadeh, A., Aboutalebi, A. and Bagheri, M. (2012) Effects of plant essential oils and silver nanoparticles on the postharvest life of cut (Lilium, Robina). In: Proceedings of the National Conference on New Achievements in Agriculture. Tehran. (In Persian with English abstract).

Venkatesha, K. T., Gupta, A., Rai, A. N., Jambhulkar, S. J., Bisht, R. and Padalia, R. C. (2022) Recent developments, challenges, and opportunities in genetic improvement of essential oil-bearing rose (*Rosa damascena*): A review. Industrial Crops and Products 184: 114984.

Zamani, S., Hadavi, E., Kazemi, M. and Hekmati, J. (2011) Effect of some chemical treatments on keeping quality and vase life of *Chrysanthemum* cut flowers. World Applied Sciences Journal 12: 1962-1966.

Zarghami, M., Farzin, D. and Bagheri, K. (2001) Antidepressant effects of *Rosa damascena* on laboratory rats (A controlled experimental blind study). Journal of Mazandaran University of Medical Sciences 11: 27-33. (In Persian with English abstract).

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