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# Increasing the Vase Life of Cut Carnation (*Dianthus caryophyllus* L. 'Baltico') by Reducing Xylem Congestion with Some Solutions

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**Abstract**

Microorganisms that build up in the vase solution or in the vessels themselves can clog xylem vessels, which is one of the main reasons why cut flowers lose quality. The length of time cut flower carnations last in a vase is determined by the genotype and other chemicals. The current study was carried out at Bingol University. In order to reduce bacterial decay and extend the vase life of cut carnation (*Dianthus caryophyllus* L. 'Baltico') flowers, the purpose of this study was to compare the effects of salicylic acid (SA) at (150 mg $L^{-1}$ and 250 mg $L^{-1}$), thymol at (150 mg $L^{-1}$ and 200 mg $L^{-1}$), and 8-hydroxyquinoline citrate (8-HQC) at (150 mg $L^{-1}$ and 250 mg $L^{-1}$). Vase life (days), which was determined as the number of days before the flowers began to wilt, loss of flower fresh weight percentage (RFW), daily solution uptake (DSU), bacterial counts in vase solution, pigment color (L, a, b) and several chemical component tests were all evaluated at the end of the experiment. In the study, statistically significant differences were observed in all treatments applied on the vase life of cut carnation flowers compared to the control. 8-HQC at concentration of 250 mg $L^{-1}$ (12.92 days) and Salicylic acid at concentration of 250 mg $L^{-1}$ (12.85 days) were most effective on the vase life of cut carnation flowers compared to the control (10.83 days) (distilled water). Simultaneously, it emerged that 8-HQC at 250 mg $L^{-1}$ was beneficial for the post-harvest stress mechanisms of cut carnation flowers. 8-HQC at 250 mg $L^{-1}$ increased DSU, decreased RFW loss, and decreased bacterial counts to prolong vase life.

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## 1. Introduction

The carnation (*Dianthus caryophyllus* L.), is a member of the *Caryophyllaceae* family and is grown extensively for its fragrant, colorful, and beautiful flowers that are cut and used as garden ornaments or for other purposes. It has a significant economic value. The Mediterranean region is from where it originated (Yagi et al., 2020). Carnations can be categorized as spray or standard types. According to Boxriker et al. (2018), the spray type has several blooms per stem while the normal form only has one blossom. Due to its extreme ethylene sensitivity, carnation is produced in large quantities upon full flower opening (Darqui et al., 2017). Carnation flowers have a limited vase life of around seven days if they are not preserved with a floral preservative solution (Aalifar et al., 2020). Numerous factors impact the vase life and postharvest performance of cut flowers (Mayak et al., 1974; Ichimura et al., 2002; Aydın, 2023). It is impacted by a number of factors, including ethylene, the composition of the atmosphere, flower handling, growth circumstances, carbohydrates, xylem channel blockage, and chemical solutions of preservatives (Pizano, 2009). According to van Doorn (1997), filamentous fungi, bacteria, and yeasts are the most common types of microorganisms found in vase solutions, foliage, and stems of cut flowers. The way these microbes react to biocidal substances varies. For instance, Gram-positive and Gram-negative bacteria are the most susceptible to biocides, but mycobacteria are more resistant to them (Maillard, 2002). Furthermore, a microorganism's developmental stage may cause it to react differently to a biocidal chemical. Microorganisms can respond differently to biocides due to differences in their morphological structure (vegetative cell versus mature spore, for example) and chemical composition (various forms of peptidoglycans in bacterial spores, for example).

By using vase solutions containing germicide, surfactant, acidifier, or ethylene inhibitor, which will stop or lessen ethylene action and blockage of xylem channels, cut flowers can have a longer vase life. Numerous studies have used different preservative substances, such as citric acid, HQS, STS, and GA3, to extend vase life based on species and even cultivars (Hassan and Schmidt 2004, Kazami et al., 2011; Kuddin et al., 2016; Kazaz et al., 2019; Kazaz et al., 2020). A couple of them have also been put to the test in vases with cut carnations. While some researchers have discovered that using vase solutions extends vase life of the carnation, other researchers have not seen any positive or negative effects. (Dole et al., 2013; Amin, 2017). A couple of them have also been put to the test in vases with cut carnations. This discussion indicates that further research is necessary to maximize postharvest quality and prolong the vase life of cut carnations. The purpose of this study was to determine how different vase solutions containing 8-HQC, thymol, and salicylic acid affected the vase life of cut carnations.

## 2. Material and Methods

Carnation flowers (*Dianthus caryophyllus* cv. ‘Baltico’) were obtained from Isparta, a commercial farm in Turkey. The standard flowers were harvested at the paintbrush stage in the early morning on 25$^{th}$ April in 2023. To reduce the effects of the high field temperature, the cut flowers were pre-cooled at 4 °C for six hours. Afterward, they were wrapped in kraft paper in bunches and transported in dry conditions to the vase life room at Bingol University, Faculty of Agriculture. The vase life room of temperature was 21 ± 2 ºC, the relative humidity was 60±5 %, and the light intensity was 1000 lux. The flowering stems were trimmed to a 40 cm length. The cut flowers were placed in a glass (1000 ml) filled with 750 ml of vase solutions (Table 1). There were 5 replicates in each treatment and 3 flowers in each replicate. All solution was prepared freshly at the beginning of the experiment. Treatments were given in Table 1.

**Table 1**. Treatment of vase solutions and their concentration

| Treatment | Concentration |
|---|---|
| Distilled water | |
| 8-hydroxyquinoline citrate (HQC) | 150 mg $L^{-1}$ |
| | 250 mg $L^{-1}$ |
| Thymol | 150 mg $L^{-1}$ |
| | 200 mg $L^{-1}$ |
| Salicylic acid | 150 mg $L^{-1}$ |
| | 250 mg $L^{-1}$ |

## 2.1. Vase life

The number of days from cutting until the petals displayed obvious signs of senescence, such as wilting, loss, discoloration of petals, stem shrinkage, brown edges, and yellow/brown foliage, was used to calculate the vase life of each flower.

## 2.2. Daily solution uptake

The evaporative loss by weight was determined using control bottles (distilled water) holding the same volume of the test solution the bottle (1000 ml) in order to quantify the amount of solution absorption. The weight decrease in flower-containing bottles was the source, and the values were stated in g.stem$^{-1}$ day$^{-1}$. For every replicate, this process was carried out every two days until the vase life trial was over. (He et.al., 2006; Kazaz et al., 2020) (the related model is given in Equation 1")

$$\text{Daily solution uptake (g stem}^{-1}\, day^{-1}) = (S_{t-1} - S_t) \qquad (1)$$

St is theweight of vase solution (g) at t = days 1, 2, 3, etc., and $S_{t-1}$ is the weight of vase solution (g) on the previous day.

## 2.3. Relative fresh weight

By weighing every two days independently, the daily volume of vase solution consumed by carnations, vases, and flower stems was determined. Subtracted findings were given in milliliters (mL). Flower stem fresh weight was measured on every two days and individual basis, with results expressed as a percentage of the initial fresh weight. Throughout the experiment, the fresh weight of cut flowers was measured every two days until the vase life was reached. (the related model is given in Equation 2")

$$\text{Relative fresh weight (\% of initial)} = \frac{\mathrm{Wt}}{W_{t-0}} x100 \qquad (2)$$

Wt is the weight of stem (g) att = day 0,1,2, etc., and Wt-0 is the weight of the same stem (g) at t = day 0.

## 2.4. Bacterial counts in vase solution

The samples of the vase solutions used for standing carnation flowering stems were kept at 30 °C in an incubator for 48–72 hours. Using the dilution plate method for the counting of microorganisms on a standard plate count agar (PCA) medium, the total viable count of bacterial cells in the solution was determined (ISO 4833-1, 2013). Since the tenth day was the last day of the control vase's life, the number of bacterial cells was counted for all treatments on that day.

## 2.5. Measurements of pigment color

Using a colorimeter (Lovibond; Spectrophotometre a sphere, Serie SP60), CIELAB values were determined, and color changes were noted first day and last day. Colors provide for the color values a* (red, green), b* (yellow, blue), and L* (brightness). It demonstrates that as the L* value approaches 100, the brightness rises. The chroma value conveys both the bud's liveliness and dullness. Matte colors have low chroma values, whereas bright colors have higher chroma values. The angle formed by the X-axis and the line that crosses the intersection of the a* and b* values is known as the hue angle. It is associated with the following values: red at 0 degrees, yellow at 90 degrees, green at 180 degrees, and blue at 270 degrees (Düzgün and Çavuşoğlu 2024).

### 2.6. Statistical analysis

The six-treatment experiment with five replicates was carried out using a completely randomized design. Every treatment used fifteen flowers. Every measurement is constantly recorded. IBM SPSS Statistic 20.0 was used to perform a one-way analysis of variance (ANOVA) on the data. The Duncan's test was used to compare means at p=0.05.

## 3. Results and Discussion

### 3.1. Vase life, relative fresh weight, daily solution uptake

The findings indicate that the vase life of cut carnation was considerably impacted by the various vase solutions. The longest vase life was recorded in 8-HQC 250 mg $L^{-1}$ (12.92 days) which was improved the vase life by 2,09 days compared to control (10,83 days). Although control showed the lowest vase life (Figure 1). There was a significant difference between control and other vase solutions 8-HQC 150 mg $L^{-1}$, 8-HQC 250 mg $L^{-1}$, Thymol 150 mg $L^{-1}$, Thymol 200 mg $L^{-1}$ Salicylic acid 150 mg $L^{-1}$ Salicylic acid 250 mg $L^{-1}$ (Figure 1).

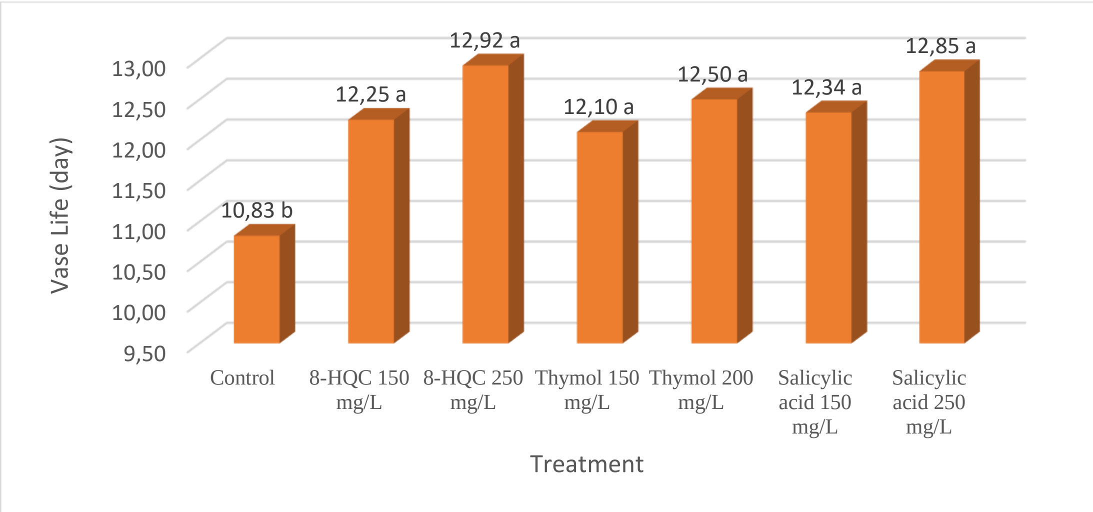


**Figure 1**. The effects of sanitation solitions on cut carnation vase life (Data in columns with different letters show a significant difference (p ≤0.05). The means of each individual treatment are compared in letters (a–b))

Vase solutions were found to have considerable effects on the RFW of cut carnations, in line with vase life data. It was found that 8-HQC 250 mg $L^{-1}$, and Salicylic acid 250 mg $L^{-1}$ were more effective at preserving RFW than other vase solutions. 8-HQC 250 mg $L^{-1}$ and Salicylic acid 250 mg $L^{-1}$ increased RFW till the 4th day while in other vase solutions including control were till 2nd day. Day 5 and day 6 showed a progressive decline in RFW. Compared to 8-HQC 250 mg $L^{-1}$ the decline in RFW of other vase solutions started earlier. According to the vase solutions, RFW has shown a notable difference after the fifth day. From that day to the end of the vase life, 8-HQC 250 mg $L^{-1}$ showed the least RFW loss, while Thymol 200 mg $L^{-1}$ showed the most RFW loss (Figure 2).

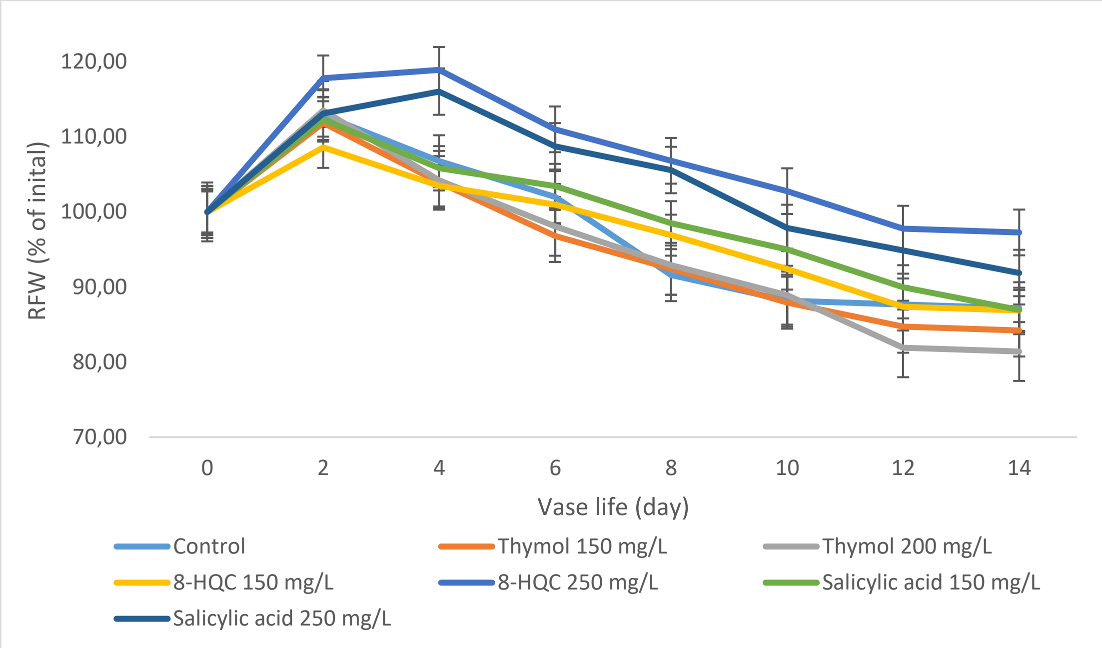


**Figure 2.** The effects of sanitation solutions on the relative fresh weight (RFW) of cut carnation

DSU of cut carnations reduced over time in all treatments during the vase life, except the fourth day. On the second day of every vase solution, the highest DSU was noted. Vase life solutions began to significantly affect DSU on the fourth day. The highest DSU was found in 8-HQC 250 mg $L^{-1}$ and the lowest in control (Figure 3).

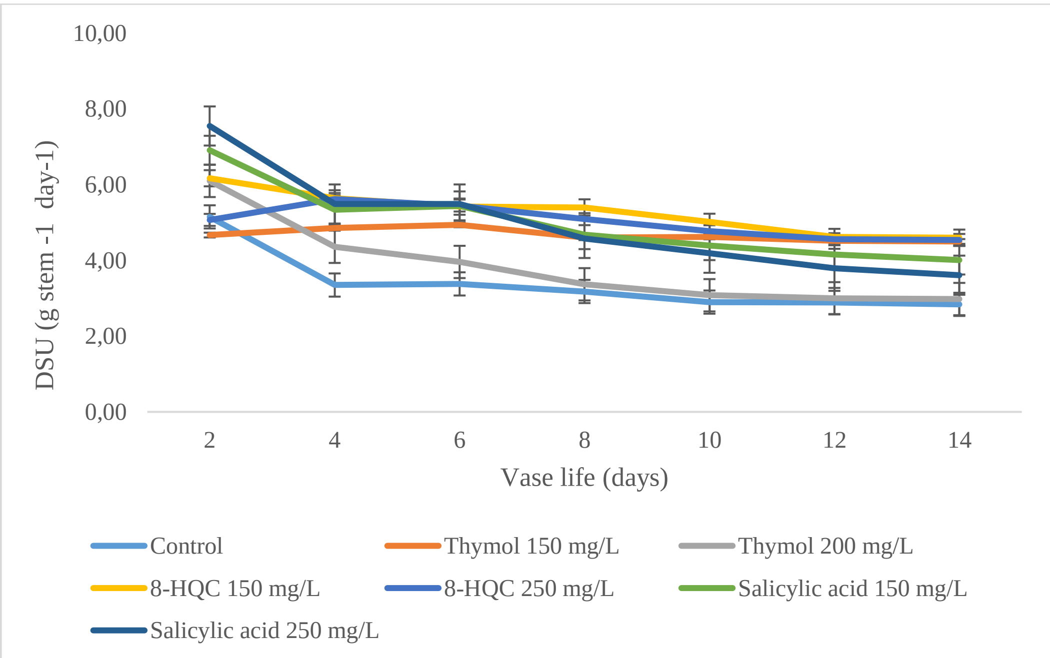


**Figure 3.** The effects of sanitation solutions on daily solution uptake (DSU) of cut carnation

8-HQC (150 mg $L^{-1}$, 250 mg $L^{-1}$) Salicylic acid (150 mg $L^{-1}$, 250 mg $L^{-1}$) and Thymol (150 mg $L^{-1}$, 200 mg $L^{-1}$) improved vase life, relative fresh weight, vase solution uptake. These findings closely align with those of Vilas et al. (2017), who revealed a significant positive impact of chemical treatments on solution absorption over control. 8-HQC 250 mg$L^{-1}$ improved vase life over all other treatments examined in this experiment by increasing water intake, maintaining a water balance, and increasing the fresh weight of flowers. In the control group (distilled water), the minimum vase life was noted. It is important that the carnations get enough water to stay fresh. 8-HQC helped flowers stay fresh by increasing water uptake. 8-HQC allowed water to be better absorbed by the flowers, which supports the transpiration process and could keep the flowers fresh. The hormone ethylene plays an important role in the aging process of cut flowers. 8-HQC could reduce ethylene production indirectly: Increased water uptake and inhibition of microbial growth can reduce the stress level in flowers. Less stress may result in reduced ethylene production. Known for its ability to reduce reactive oxygen species (ROS) by enhancing the enzyme antioxidant activity, Salicylic acid is an intrinsic growth regulator with phenolic character (Kereçin and Öztürk 2024) and also A is a phenol that can block the activity of ACC-oxidase, which is the direct precursor of ethylene (Ansari and Misra, 2007; Mba et al., 2007; Mahdavian et al, 2007; Canakci, 2008). The SA employed in our investigation may have increased the vase life for reasons related to these findings, and the outcomes are in line with those published by Mei-hua et al. (2008), and Kazemi and Shokri (2011). The results mentioned above closely align with those of Vilas et al., (2017) The cut carnation flowers in the holding solution containing Thymol (doses 150 mgL$^{-1}$ , 200 mg L$^{-1}$) lost noticeably less weight than the cut carnation flowers in solution, which reduced the maximum weight. Several phenolics of the presence of thymol with antibacterial properties, which inhibit or lessen bacterial development and lessen xylem tissue clogging, can help to explain these results (Di, 2008; Jalili Marandi et al., 2011). It also extended the vase life of cut flowers by enhancing water uptake, preventing water stress, and preventing flower wilting (Solgi et al., 2009; Solgi and Ghorbanpour, 2014; Aydın, 2015).The extended vase life of cut flowers may be attributed to several factors, including decreased water stress in conjunction with high water uptake because of xylem vessel blockage and suppressed microbial growth, decreased water loss through inhibition of ethylene evolution, and decreased transpiration rate, which regulates cellular turgor.

### 3.2. Bacterial counts in vase solution

While compared to the control treatment (distilled water), which recorded the highest total count of bacterial cells at 11.21 $\log_{10}$ CFU ml$^{-1}$, the data in Figures 4 showed that all treatments pulsing vase solution significantly reduced the bacterial counts ($\log_{10}$ CFU ml$^{-1}$) of carnation cut flowers. In addition, when compared to the other tested treatments and the control, the vase solution comprising 250 mg L$^{-1}$ HQC and 250 mg L$^{-1}$ salicylic acid had the lowest average bacterial count of less than 4 CFU ml$^{-1}$. This was followed by 200 mg L$^{-1}$ thymol, which had a bacterial count of 4.07 CFU ml$^{-1}$. Hydroxyquinoline (HQ) compounds such as hydroxyquinoline citrate (HQC) (Knee, 2000; Marousky, 1969; Van Doorn et al., 1990) and 8-hydroxyquinoline sulphate (HQS) (Hussein, 1994) have been reported to play an important role among the major antimicrobial compounds used to prolong the vase life of cut flowers. Numerous investigations have demonstrated the potent antibacterial qualities of the essential oils isolated from various plant components against a wide range of diseases. High concentrations of phenolic, aldehyde, terpene, alcohol, and flavonoid compounds, including methyl cinnamate, eugenol, e-cinnamaldehyde, alpha-pinene, citral-a, citral-b, beta-pinene, patchouli alcohol, azadirachtin, 1-8-cineole, pongamicin, and karanjin, have been reported to be present (Prabuseenivasan et al., 2006; Damjanović-Vratnica et al., 2011; Khan and Ahmad, 2011; Lavanya and Brahmaprakash, 2011; Assiri et al., 2016). Furthermore, vascular obstruction brought on by bacteria and other microorganisms has been shown in numerous studies on cut flowers to reduce water intake, which in turn can cause stem breakage and petal wilting (Van doorn and De Witte, 1994; Nair et al., 2003). 8-HQC inhibited the proliferation of bacteria and fungi in water. These microorganisms could cause flowers to wilt by reducing their water intake.

By inhibiting the growth of microorganisms, it prevented blockage of the water transport vessels of flowers. This allows flowers to take up water better and slows down the wilting process. Carnation flowers are ethylene sensitive plants. ethylene increases during vase life. 8-HQC, salicylic acid, and thymol limited the growth of microorganisms and increased the water uptake of the flowers for a longer period of time and kept them fresh longer. Although studies on the inhibition of ethylene production by 8-HQC, salicylic acid, and thymol are limited, it is thought that these treatments indirectly reduce stress-induced ethylene production in flowers by increasing water uptake and limiting bacterial growth.

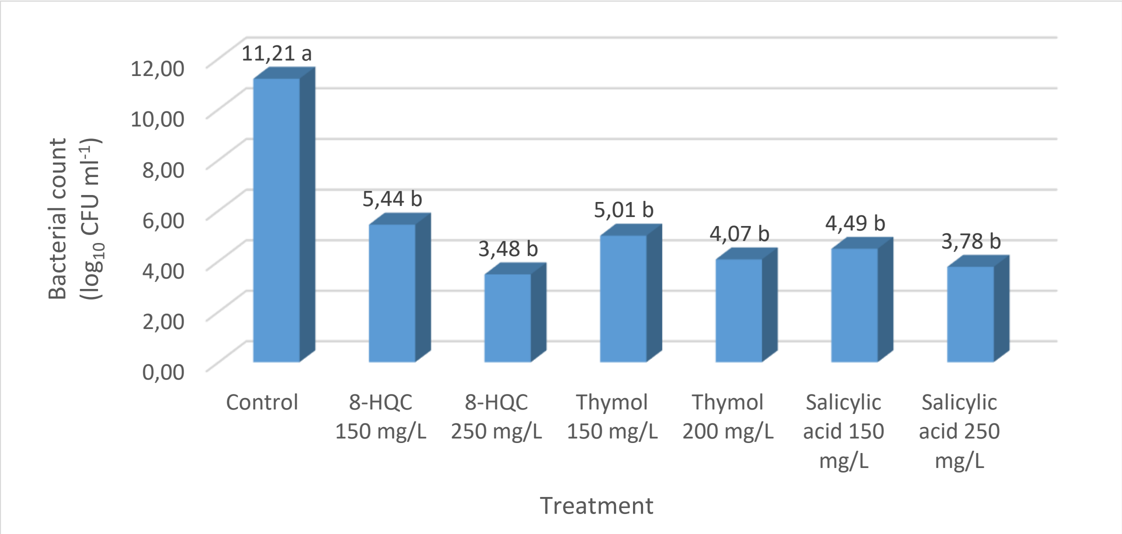


**Figure 4.** The effects of sanitation solutions on bacterial count of cut carnation (Data in columns with different letters show a significant difference ($p \leq 0.05$).The means of each individual treatment are compared in letters (a–b)).

### 3.3. Pigment content

In the study, various changes in L a b values occurred during the vase life of white carnations. White carnations usually have a high L value on the first day, because the white colour shows high luminosity (brightness). When the flower faded completely, the white color became dull and the L value decreased in all treatments, including the control (Figure 5). In general, the a-value of white carnations is usually close to zero or may have a very low positive or negative value. As the flower wilted, the value became more pronounced in the control treatment in the last days of vase life, as the white color deteriorated to brown or grey (Figure 6). On the first day, the b-value in carnations of 'Baltico' is also usually close to zero or has a very low positive (slightly yellow) value. With aging there may be a slight yellowing, which caused the b value to increase positively in all treatments, including the control (Figure 7).

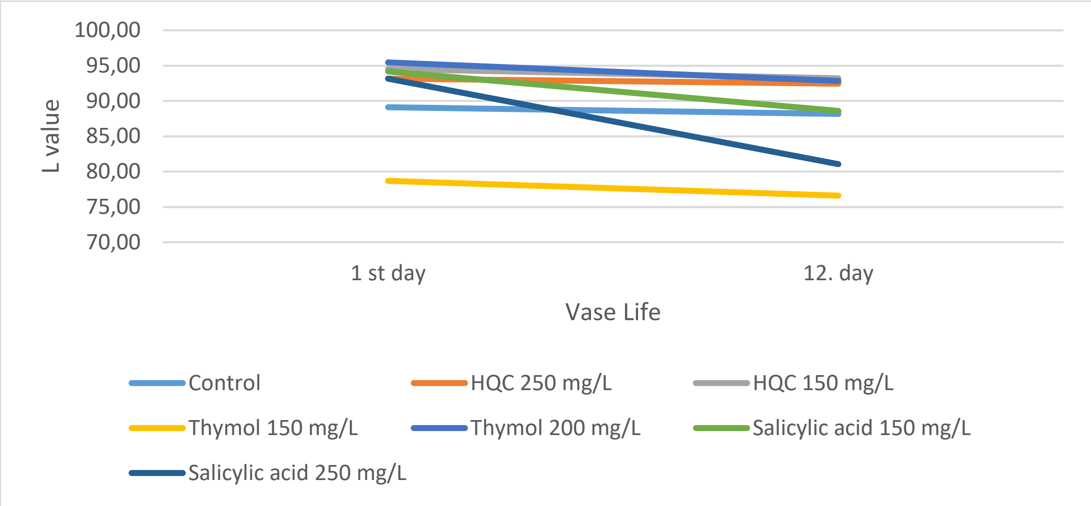


**Figure 5.** Variances in 'Baltico' flower color and L value (brightness) during the vase life

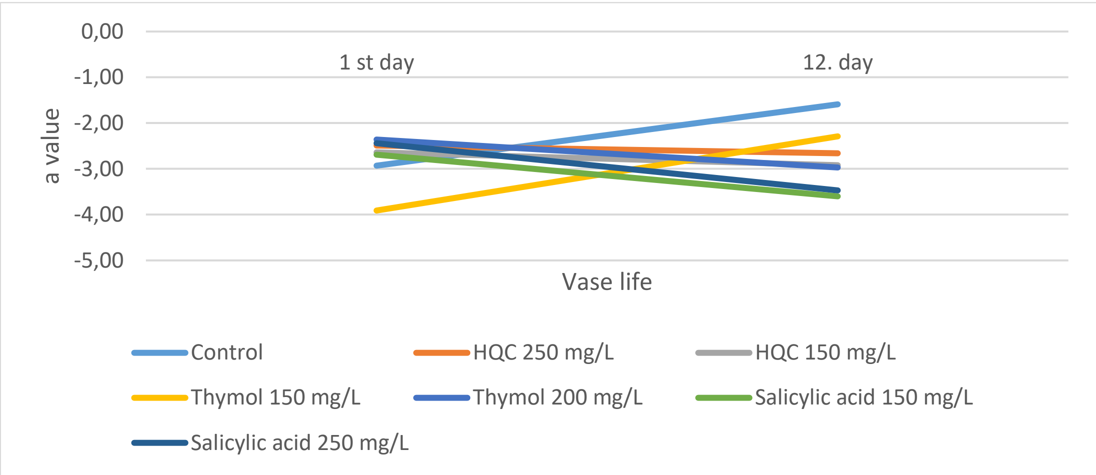


**Figure 6.** Variances in *a*-value color of 'Baltico' flowers during vase life

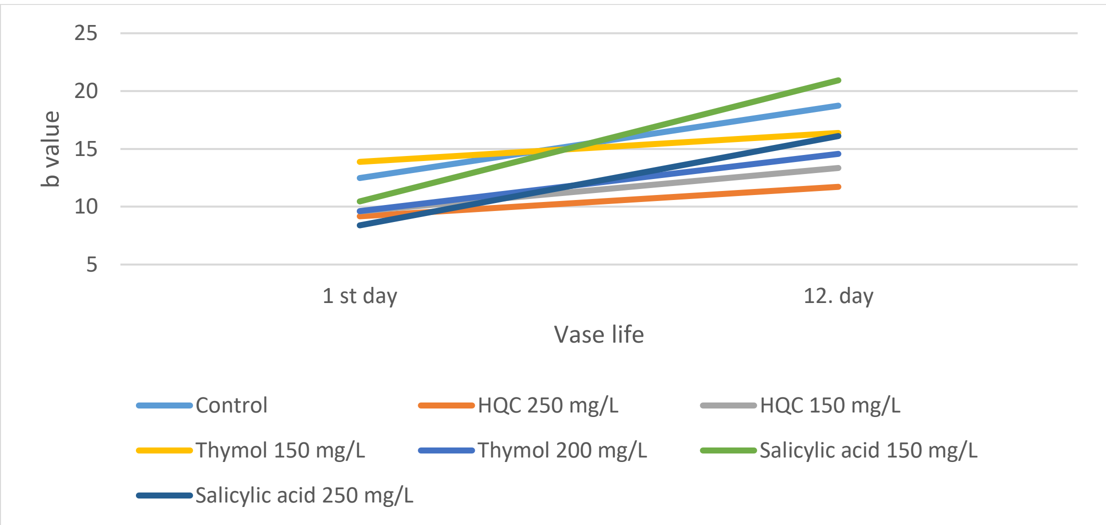


**Figure** 7. Variances in *b*-value color of 'Baltico' flowers during vase life

## 4. Conclusions

This study had a significant effect on the physiological changes that occur in carnation cut flowers during their vase life after harvest. The vase life of the 'Baltico' flowers was extended by up to 2.09 days and 2.02 days, respectively, by the 250 mg $L^{-1}$ 8-HQC and 250 mg $L^{-1}$ salicylic acid treatments, compared to the control. 8-HQC and salicylic acid prevented bacterial development, floral wilting, and color deterioration. These statistics are crucial because they highlight how difficult it can be to choose the right pulse solution treatment to prolong the vase life of a carnation-cut flower. Players in the cut carnation market can utilize this research as a resource to help them choose the best pulsing solution treatment for carnation cut flowers that will satisfy consumers while also interests of taking farmers into account.

## References

Aalifar, M., Aliniaeifard, S., Arab, M., Zare Mehrjerdi, M., Dianati Daylami, S., Serek, M., Woltering, E., Li, T., 2020. Blue light improves vase life of carnation-cut flowers through its effect on the antioxidant defense system. *Frontiers in Plant Science,* 11:511.

Amin, O.A., 2017. II-Effect of some chemical treatments on keeping quality and vase life of cut chrysanthemum flowers. M*iddle East Journal of Agriculture Research*, 6 (1): 221-243.

Ansari, M.S., Misra, N., 2007. Miraculous role of salicylic acid in plant and animal system. *American Journal of Plant Physiology*, 2:51-58.

Assiri, A.M.A., Elbanna, K., Abulreesh, H.H., Ramadan, M.F., 2016. Bioactive compounds of cold-pressed thyme (*Thymus vulgaris*) oil with antioxidant and antimicrobial properties. *Journal of Oleo Science,* 65(8):629–640.

Aydın, V., 2015. Magnum kesme gül çeşitinin vazo ömrü üzerine pulsing, nano gümüş ve sakkaroz uygulamalarının etkileri. Yüksek Lisans Tezi, Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Isparta.

Aydın, V., 2023. Research topics in Agriculture, (Ed: K. Kökten, S. Özdemir). Some chemicals used in cut flower vase solutions and their effects, Iksad Publishing House, Ankara, pp.147-162.

Boxriker, M., Möhring, J., Piepho, H.P., 2018. Genetic and phenotypic correlation for breeding relevant traits in *Dianthus caryophyllus* L. *Postharvest Biology and Technology*, 143:129-136.

Canakci, S., 2008. Effects of salicylic acid on fresh weight change, chlorophyll and protein amounts of radish (*Raphanus sativus* L.) seedling. *Journal of Biological Sciences*, 8:431-435.

Damjanović-Vratnica, B., Đakov, T., Šuković, D., Damjanović, J., 2011. Antimicrobial effect of essential oil isolated from *Eucalyptus globulus* Labill. from Montenegro. *Czech Journal of Food Sciences*, 29(3):277–284.

Darqui, F.S., Radonic, L.M., Hopp, H., Bılbao, M.L., 2017. Biotechnological improvement of ornamental plants. *Ornamental Horticulture*, 23(3):279-288.

Di W.U., 2008. Effects of antibiotics on the senescence of *Gerbera jamesonii* cut flowers. *Journal of Anhui Agricultural Sciences*, 25.

Dole, J.M., Carlson, A.S., Crawford, B.D., McCall, I.F., 2013. Vase life of new cut flowers. *Acta Horticulturae,* 1000:63-70.

Düzgün, S., Çavuşoğlu, Ş.,2024. Maintaining the quality and storage life of strawberries (*Fragaria×ananassa* Duch.) with melatonin and methyl jasmonate. *ISPEC Journal of Agricultural Sciences*, 8(2):273-282.

Hassan, F., Schmidt, G., 2004. Post-harvest characteristics of cut carnations as the result of chemical treatments, *Acta Agronomica Hungarica*, 52(2):125-132.

He, S., Joyce, D.C., Irving, D.E., Faragher, J.D., 2006. Stem end blockage in cut Grevillea 'Crimson Yul-lo' inflorescences. *Postharvest Biology and Technology,* 41:78–84.

Hussein, H.A.A., 1994. Varietal responses of cut flowers to different antimicrobial agents of bacterial contamination and keeping quality. *Acta Horticulturae*, 368: 106–116.

Ichimura, K., Kawabata, Y., Kishimoto, M., Goto, R.,Yamada, K., 2002. Variation with the cultivar in the vase life of cut rose flowers. *Bulletin of the National Institute of Floricultural Science*, 2: 9–20.

Jalili Marandi, R., Hassani, A., Abdollahi, A., Hanafi, S., 2011.Application of *Carum copticum* and *Saturega hortensis* essential oils and salicylic acid and silver thiosulphate in increasing the vase life of cut rose flowers. *Journal of Medicinal Plants Research,* 5(20):5034–5038.

Kazaz, S., Kilic, T., Doğan, E., Sekmen, Ş., 2020. Vase life extension of cut hydrangea (*Hydrangea macrophylla*) flowers, T*he Journal of Horticultural Science and Biotechnology,* 95(3): 325-330.

Kazaz, S., Doğan, E., Kilic, T., Sahin, E.G.E., Seyhan, S., 2019. Influence of holding solutions on vase life of cut hydrangea flowers (*Hydrangea macrophylla* Thunb.). *Fresenius Environmental Bulletin*, 28(4A): 3554-3559.

Kazemi, M., Shokri, K., 2011. Role of salicylic scid in decreases of membrane senescence in cut lisianthus flowers. *World Applied Sciences Journal,* 13(1):142-146.

Kereçin, G., Öztürk, F., 2024. The effect of salicylic acid and salt stress on seeder development of some soya (*Glycine max*. L.) cultivars. *ISPEC Journal of Agricultural Sciences*, 8(1): 25-35.

Khan, M.S.A., Ahmad, I., 2011. Antifungal activity of essential oils and their synergy with fluconazole against drug resistant strains of *Aspergillus fumigates* and *Trichophyton rubrum*. *Applied Microbiology and Biotechnology*, 90:1083–1094.

Knee, M., 2000. Selection of biocides for use in floral preservatives. *Postharvest Biology and Technolology*, 18: 227–234.

Kuddin, A.F.M.J., Shamsuzzoha, M., Nusrat, A., Taufıque, T., Mehraj, H., 2016. Vase life improvement of yellow gladiolus through different preservative solutions. *Journal of Bioscience and Agriculture Research*, 10(1):837-842.

Lavanya, G., Bramhaprakash, G.P., 2011. Phytochemical screening and antimicrobial activity of compounds from selected medicinal and aromatic plants. *International Journal of Science and Nature*, 2(2):287–291.

Mahdavian, K,. Kalantari, K.M., Ghorbanli, M., 2007. The effect of different concentrations of salicylic acid on protective en-zyme activites of pepper (*Capsicum annuum* L.) plants. *Pakistan Journal of Biological Sciences*, 10:3162-3165.

Maillard, J.Y., 2002. Bacterial target sites for biocide action. *Journal of Applied Microbiology,* 92: 16–27.

Marousky, F.J., 1969. Vascular blockage, water absorption, stomatal opening and respiration of cut 'Better Times' roses treated with 8-hydroxyquinoline citrate and sucrose. *Journal of the American Society for Horticultural Science,* 94: 223–226.

Mayak, S., Halevy, A.H., Sagie, S., Bar-Yoseph, A., Bravdo, B., 1974. The water balance of cut rose flowers. *Physiologia Plantarum,* 31: 15–22.

Mba, F.O., Zhi-Ting, X., Hai-Jie, Q., 2007. Salicylic acid alleviates the cadmium toxicity in chinese cabbage (*Brassica chinensis*). *Pakistan Journal of Biological Sciences,* 10:3065-3071.

Mei-hua, F., Jian-Xin, W., Shi, L., Shi, G., Fan, L., 2008. Salicylic acid and 6-BA effects in shelf-life improvement of *Gerbera jamesonii* cut flowers. *Anhui Agricultural Science Bulletin.*

Nair, S.A., Singh, V.T., Sharma, V.R.S., 2003. Effect of chemical preservatives on enhancing vase-life of gerbera flowers. *Journal of Tropical Agriculture,* 41:56–58.

Pizano, M., 2009. Research shows the way for postharvest treatment roses. *Flower Tech.* 12(6):1-13.

Prabuseenivasan, S., Jayakumar, M., Ignacimuthu, S., 2006. In vitro antibacterial activity of some plant essential oils. *BMC Complementary and Alternative Medicine*, 6(39):1–8.

Solgi, M., Ghorbanpour, M., 2014. Application of essential oils and their biological effects on extending the shelf-life and quality of horticultural crops. *Trakia Journal of Sciences*, 2:198–210.

Solgi, M., Kafi, M.T., Taghavi, S., 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.

Van Doorn, W.G., 1997. Water relations of cut flowers. Horticultural Reviews, 18: 1–85.

Van Doorn, W.G., Witte, Y.D., Perik, R.R.J., 1990. Effect of antimicrobial compounds on the number of bacteria in stems of cut rose flowers. *Journal of Applied Bacterıology*, l(68): 117–122.

Van Doorn, W.G., Witte, Y.D., 1994. Effect of bacteria on scape bending in cut *Gerbera jamesonii* flowers. *Journal of the American Society for Horticultural Science*, 119:568–571.

Vilas, R., Karhana, P.K., Meena, R.K., Singh, S., 2017. Effect of biocides {$AgNO_3$, $Al_2$ $(SO_4)_3$, 8-HQC and Sucrose} on the post harvest life of carnation (*Dianthus caryophyllus* L.), *International Journal of Pure & Applied Bioscience*, 5(5): 1599-1602.

Yagi, A., Ataka, S., Yu, B.P., 2021. Putative roles of aloe ingredients in aging and age-related diseases: management of microbiota seno inflammatory process. *Journal of Gastroenterology and Hepatology Research*, 10(2):3460-3465.

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