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Effects of Some Essential Oil Compounds on Vase Life of Cut Hydrangea Flowers

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Abstract: The usage of hydrangeas in ornamental plants and especially cut flower has been increasingly important in recent years. One of the most important problems is the short vase life due to early wilting in cut hydrangea flowers. Essential oils are safety and ecologically friendly materials and they are used as food, cosmetic and medical purpose. They are also thought to be alternative substances for increasing the vase life of cut flowers. This study was conducted to determine the effects of some essential oil compounds on the vase life of cut hydrangea flowers. *Hydrangea macrophylla* 'Ankong Rose' variety used as a plant material and 3 different concentrations of thymol and carvacrol (50 mg l^{-1}, 100 mg l^{-1} and 150 mg l^{-1}) with and without 10 g l^{-1} sucrose as a vase solution. Vase life, relative fresh weight, solution uptake were recorded. Thymol and carvacrol were significantly found effective on vase life of cut hydrangea flowers. The highest vase life (12.14 days) was recorded in thymol (150 mg l^{-1})+sucrose which was in the same statistically group with carvacrol (150 mg l^{-1})+sucrose. Thymol (150 mg l^{-1})+sucrose increased the vase life by 41.66% compared to control (distilled water). The study indicated that thymol can be used successfully in increasing cut hydrangea flowers' vase life.

Keywords: Carvacrol, cut flower, essential oils, hydrangea, thymol, vase life

Bazı Uçucu Yağ Bileşenlerinin Kesme Çiçek Ortancaların Vazo Ömrü Üzerine Etkileri

Özet: Dünyada ortancaların süs bitkileri ve özellikle kesme çiçek sektöründe kullanımı son yıllarda giderek artmaktadır. Kesme çiçek ortancalarda hasat sonrası karşılaşılan sorunların başında çiçeklerin erken solması nedeniyle vazo ömrünün kısa olması gelmektedir. Bitkisel uçucu yağlar insan sağlığı açısından güvenli ve çevre dostu maddeler olup gıda, kozmetik ve tıbbi kullanımların yanı sıra kesme çiçeklerde hasat sonrası ömrün artırılmasında alternatif olmaya aday maddelerdir. Bazı uçucu yağların kesme çiçek ortancaların vazo ömrüne etkilerini belirlemek amacıyla yürütülen çalışmada, bitkisel materyal olarak *Hydrangea macrophylla* Thunb. türüne ait olan pembe çiçekli 'Ankong Rose' çeşidi kullanılmıştır. Çalışmada, vazo solüsyonu olarak timol ve karvakrolün 3 farklı dozu (50 mg l^{-1}, 100 mg l^{-1} ve 150 mg l^{-1}) ile bunların 10 g l^{-1} sakkaroz içeren kombinasyonları kullanılmıştır. Çiçeklerde; vazo ömrü ve oransal taze ağırlığın yanı sıra günlük ve toplam vazo solüsyon alımları incelenmiş ve uçucu yağların çiçeklerin vazo ömrünü önemli derecede etkilediği belirlenmiştir. Uygulamalar arasında en uzun vazo ömrü (12.14 gün), kontrole (saf su) göre vazo ömrünü %41.66 oranında artıran timol (150 mg l^{-1})+sakkaroz uygulamasından elde edilirken, bunu 12.0 gün ile karvakrol (150 mg l^{-1})+sakkaroz uygulaması izlemiştir. Çalışma, özellikle timolün kesme çiçek ortancaların vazo ömrünü artırmada başarılı bir şekilde kullanılabileceğini ortaya koymuştur.

Anahtar Kelimeler: Karvakrol, kesme çiçek, ortanca, timol, uçucu yağ, vazo ömrü

Introduction

Hydrangea macrophylla Thunb. is one of the most popular species of the ornamental plants and used as a cut flower, potted and landscape plant due to a number of attractive characteristics such as large, showy inflorescences and brightly colored flowers. Usage of hydrangea as a cut flower has increased recently in worldwide and according to the Royal FloraHolland auction where most cut flowers are sold, it ranked 10th among the top selling cut flowers in 2017 (Anonymous, 2018). However, vase life which is one of the most important criteria in trade of many cut flowers is short in cut hydrangea flowers because of wilting and sepal browning (Kazaz et al., 2019). Insufficient water uptake and exposure to ethylene are the main reasons for these symptoms but it isn't clear that hydrangea is sensitive to ethylene or not (Jones, 2001; Lauridsen et al., 2015). Hydrangea is considered to be vulnerable to water deficiency and it wilts easily (Fulcher et al., 2016).

Improving the water uptake for better vase life is possible by prevention of xylem blockage which occurred as a result of proliferation of microorganisms, air emboli, formation of tyloses and deposition of materials in the lumen of xylem vessels (Jedrzejuk et al., 2012). Addition of preservative substances such as germicide, surfactant and acidifier in holding solutions is recommended to prevent blockage of xylem vessels in all cut flowers (Soad et al., 2011). Silver thiosulfate (STS), 8-hydroxyquinolin sulfate (8-HQS), aluminum sulfate [$Al_2(SO_4)_3$], silver nitrate ($AgNO_3$) etc. were used in lots of studies and they have been found effective in increasing both water uptake and vase life (Seyf et al., 2012; Bhanushree and Hariprasad Rao, 2015; Kazaz et al., 2019).

In many researches, essential oils such as rosemary, turmeric, thyme and lavender were also used as preservative substances (Thakur et al., 2014; Basiri et al., 2012; Bayat et al., 2013). They are organic, safety and ecologically friendly materials and have a strong antimicrobial effect against pathogens because of their monoterpenoid phenols (Crocoll, 2011) that exhibit strong antimicrobial and antioxidant activity (Zhou et al., 2007; Han et al., 2017). The most active monoterpenoid phenols of essential oils are known thymol and carvacrol (Dhifi et al., 2016) which were found effective to increase the vase life of some cut flowers (Thakur et al., 2014).

Essential oils or other preservative substances are more effective to increase the vase life of cut flowers when they used in combination with sucrose (Elgimabi and Ahmed, 2009). Sucrose acts as osmolytes and source of energy that plays an important role to preserve the quality of cut flowers (Ichimura, 1998; Abu Seman and Mohd Rafdi, 2019). Hence, the aim of this study was to determine the effects of different holding solutions including essential oil compounds like thymol and carvacrol and their combination with sucrose on cut hydrangea flowers' vase life.

Materials and Methods

The experiment was carried out in the vase life room at the Department of Horticulture, Ankara University in Ankara, Turkey in 2016. *Hydrangea macrophylla* 'Ankong Rose' variety was used as a plant material and flowers of this variety were obtained from a greenhouse of the same department (39°57'40.2"N 32°51'51.7"E).

The cut hydrangea flowers were harvested at commercial stage which approximately 25% of the petals on the inflorescence had opened and transported to the vase life room within 30 minutes. The stems were re-cut approximately 45 cm and 2 pair of upper leaf was retained on each stem. They were then placed in glass vases containing 750 ml of preservative solutions which were thymol (50, 100 and 150 mg l^{-1}) (Sigma-Aldrich, CAS:89-83-8), carvacrol (50, 100 and 150 mg l^{-1}) (Sigma-Aldrich, CAS:499-75-2), distilled water with and without 10 g/L sucrose (Merck, CAS:57-50-1). Distilled water used as a control and all of the solutions was freshly used. The vase life conditions were as follows: the temperature was 21±1°C, the relative humidity was 65±5%,

the photoperiod was 12 h and the lighting was 1000 lux (cool-white fluorescence lamps). Vase life, relative fresh weight, daily and total solution uptake of the flowers was recorded and all parameters measured daily. The vase life was terminated when approximately 80% of decorative florets in an inflorescence had showed wilting, sepal browning, or sepal desiccation (Kitamura et al., 2017). Relative fresh weight (RFW) total and daily solution uptake (DSU) were determined by measuring the weights of the flowers. Total solution uptake (TSU) was the total amount of solution uptake by the flower and given as (g stem^{-1}). RFW and DSU were calculated using the equation as:

RFW (%) = (W_t/W_{t-0}) x 100 (W_t is the stem weight (g) at t=day1,2,3 etc. and W_{t-0} is the same stem weight at t=day0) (He et al., 2006; Lü et al., 2010).

DSU (g stem^{-1} day^{-1}) = S_{t-1} - S_t (S_t is vase solution weight (g) at t = day1,2,3 etc. and S_{t-1} is the vase solution weight on the previous day) (He et al., 2006).

The experimental design was a Randomized Plot Design (RPD) with seven replications and each replicate had one flower. Recorded data were analyzed by one-way ANOVA using IBM SPSS Statistics 20.0. Duncan's multiple range tests was used to establish mean differences between treatments ($P \leq 0.05$).

Results

Vase life

The results showed that different holding solutions significantly affected vase life of cut hydrangea flowers. The highest vase life (12.14 days) was found in thymol 150 mg l^{-1} + sucrose treatment and there was no significant difference between this treatment and carvacrol 150 mg l^{-1} + sucrose (12.00 days), thymol 100 mg l^{-1} + sucrose (11.43 days), thymol 50 and 100 mg l^{-1} (10.14 days) treatments. The vase life of cut hydrangea flowers in thymol 150 mg l^{-1} + sucrose was found 3.57 days longer than distilled water (control). All treatments including carvacrol with and without sucrose except carvacrol 150 mg l^{-1} + sucrose were in the same statistical group with distilled water with (7.86 days) and without sucrose (8.57 days). Carvacrol 100 mg l^{-1} + sucrose (7.14 days) had lowest vase life (Figure 1).

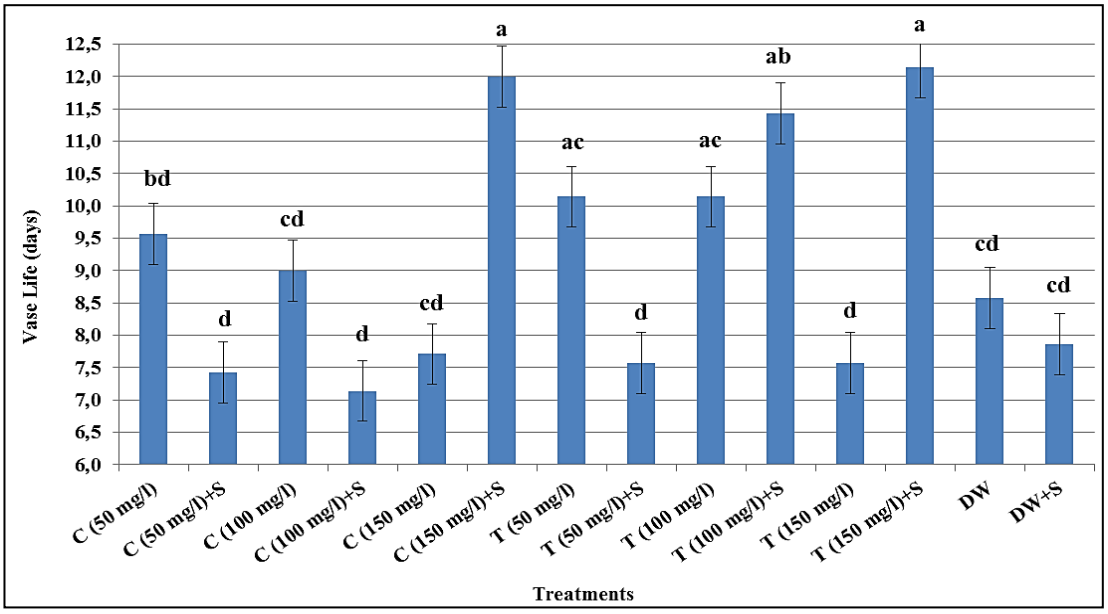

Figure 1. Effects of the holding solutions on the vase life
C: carvacrol, T: thymol, S: sucrose, DW: distilled water

Solution uptake

Solution uptakes of cut hydrangea flowers were statistically difference due to the holding solutions. The maximum TSU was obtained at thymol 150 mg l^{-1} + sucrose (162.60 g $stem^{-1}$) whereas the minimum TSU was recorded at carvacrol 150 mg l^{-1} (110.69 g $stem^{-1}$) (Figure 2).

Similar results were determined for DSU. The highest average DSU was found in thymol 150 mg l^{-1} + sucrose (10.84 g $stem^{-1}$ day^{-1}) and this treatment was in the same statistical group with carvacrol 50 mg l^{-1} with and without sucrose, carvacrol 100 mg l^{-1}, carvacrol 150 mg l^{-1} + sucrose, thymol 50 mg l^{-1}, thymol 100 mg l^{-1} with and without sucrose. The lowest average solution uptake was in carvacrol 150 mg l^{-1} (7.38 g $stem^{-1}$ day^{-1}) and it was the same statistical group with distilled water. DSU in all treatments was initially higher (21.38 g $stem^{-1}$ day^{-1} on first day) and over time it showed a declining trend (3.97 g $stem^{-1}$ day^{-1} at the end of the vase life) (Figure 3).

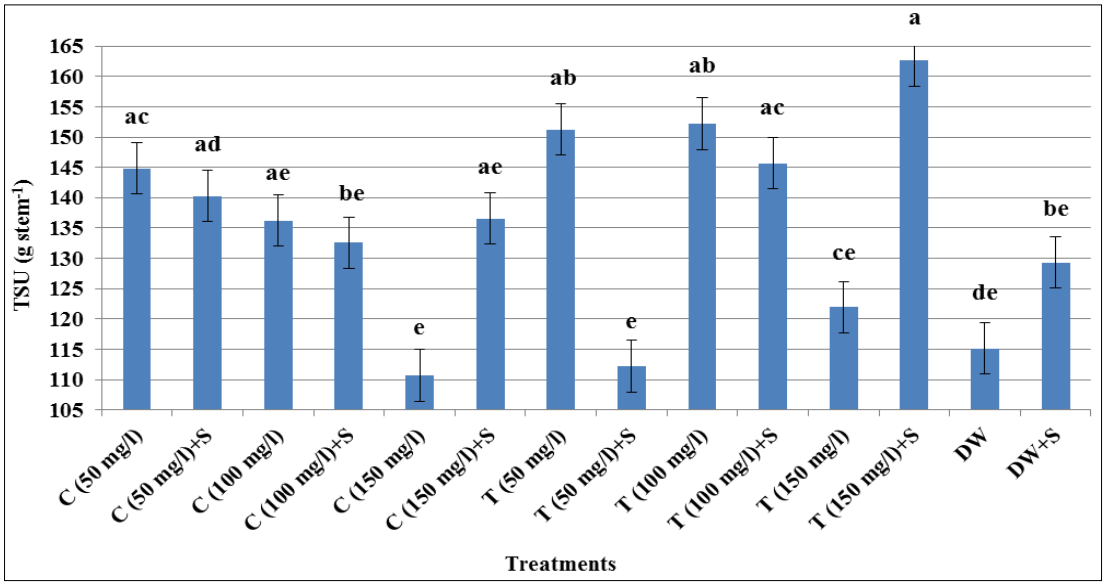

Figure 2. Effects of the holding solutions on total solution uptake

TSU: total solution uptake, C: carvacrol, T: thymol, S: sucrose, DW: distilled water

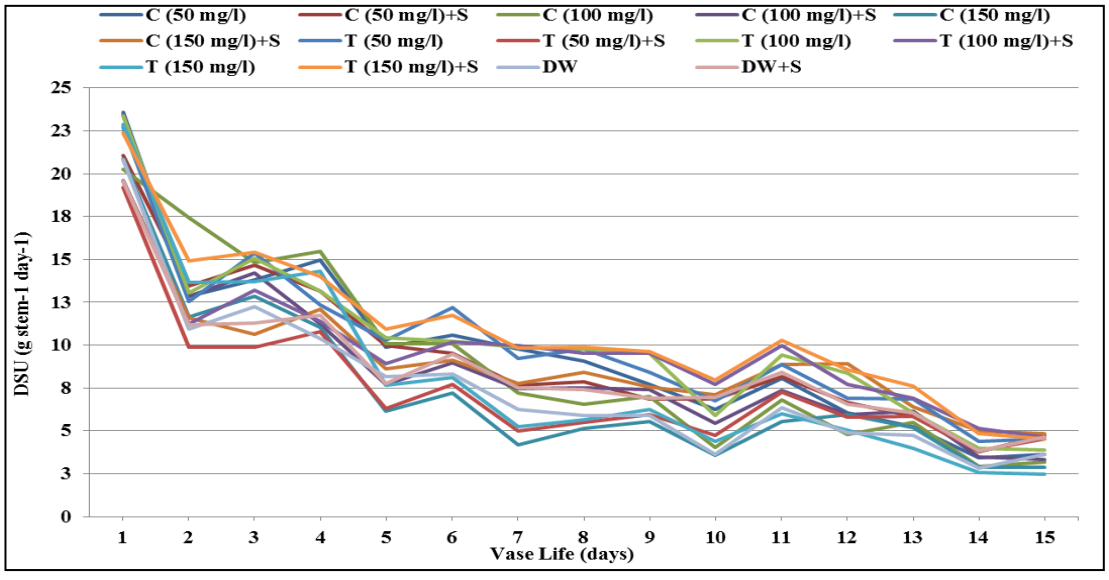

Figure 3. Effects of the holding solutions on daily solution uptake

DSU: daily solution uptake, C: carvacrol, T: thymol, S: sucrose, DW: distilled water

Relative fresh weight

Different holding solutions were found significantly effective on relative fresh weight of flowers. RFW of the flowers in all solutions except thymol 50 mg l^{-1}+ sucrose increased up to 2nd day then decreased. In thymol 50 mg l^{-1} + sucrose, relative fresh weight increased up to 3th day then decreased (Figure 4). Among the treatments, maximum average relative fresh weight was recorded thymol 100 mg l^{-1} + sucrose (90.32%) which was not statistically difference from thymol 150 mg l^{-1} + sucrose, thymol 50 and 100 mg l^{-1}, carvacrol 50 and 150 mg l^{-1} + sucrose, carvacrol 100 mg l^{-1} treatments. Minimum relative fresh weight was obtained distilled water with sucrose (70.27%). However, the lowest relative fresh weight loss was 38.87% in carvacrol 150 mg l^{-1} + sucrose from the first day to end of the vase life whereas the highest was 70.60% in carvacrol 50 mg l^{-1}.

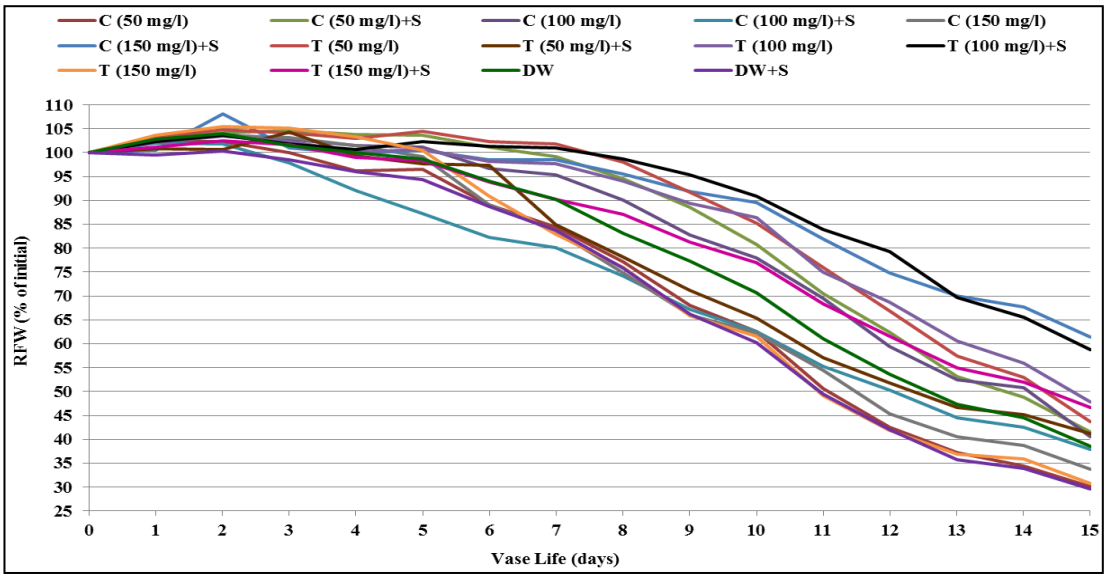

Figure 4. Effects of the holding solutions on relative fresh weight
RFW: relative fresh weight, C: carvacrol, T: thymol, S: sucrose, DW: distilled water

Discussion

Vase life is an important criterion for evaluation of cut flower quality in floral industry. For improving the vase life of cut flowers, several preservative substances are used as vase solution however their reliability in terms of human health and ecologically friendly is important as well as keeping quality. Essential oils have gained importance for researches about vase life due to being organic materials and results of many researches have shown that they are effective in extending the vase life of cut flowers. Artemisia (Hashemabadi et al., 2013), geranium, eucalyptus and myrtus (Bidarigh, 2015), thymus and nigella (Bazaz and Tehranifar 2011), lavandula and thymus (Kazemi and Ameri, 2012) essential oils and main compounds of essential oils such as thymol (Babarabie et al., 2015), carvacrol (Solgi et al., 2009) and eugenol (Hashemi et al., 2013) were found successful to increase the vase life, solution uptake and relative fresh weight of cut flowers such as chrysanthemum, alstroemeria, dianthus, gerbera and rosa.

Similar to previous researches, the use of thymol and carvacrol increased the vase life of cut hydrangea flowers in this research. In all thymol and carvacrol doses which increased the vase life were obtained better solution uptake and also gain the relative fresh weight. These results may be due to the role of thymol and carvacrol as antimicrobial agent (Memar et al., 2017) and they might have reduced xylem blockage and increased solution uptake which may improve the vase

life and relative fresh weight. A positive correlation is stated between vase life, solution uptake and relative fresh weight in many researches (Alaey et al. 2011; Amini et al., 2016).

Thymol was found to be more effective than carvacrol in terms of vase life. Even the lowest dose of thymol increased the vase life compared to the control whereas only the highest dose of carvacrol with sucrose had an effect on the cut hydrangea flowers' vase life. However, the lowest dose of thymol with sucrose and the highest dose of thymol without sucrose didn't have a positive affect neither vase life nor solution uptake and relative fresh weight. The lowest dose of thymol may be insufficient to decrease microbial growth when sucrose is thought to promote microbial growth (Asrar, 2012). The highest dose of thymol may have toxic for cut hydrangea flowers when it was thought that thymol had a phytotoxic effect due to herbicidal activity in various plant systems and caused electrolyte leakage resulting in cell death (Kordali et al., 2008). But it was also found that the highest dose of thymol in combination with sucrose was one of the best treatments for the vase life of cut hydrangea flowers. The highest dose of thymol with sucrose was effective on vase life because it might have tolerated toxic effect due to the presence of sucrose which may act as a 'priming' agent activating cell wall strength (Tauzin and Giardina, 2014). Tuna (2012) stated the similar results that the highest dose of thymol (150 mg l^{-1}) with sucrose increased the vase life, relative fresh weight and solution uptake in gerbera.

Interestingly our study results showed that solution uptake by 50 mg l^{-1} carvacrol with and without sucrose, 100 mg l^{-1} carvacrol increased whereas the vase life didn't improve. 50 mg l^{-1} carvacrol with sucrose and 100 mg l^{-1} carvacrol also improved relative fresh weight but this was not reflected in the vase life. Solgi et. al. (2009) found that carvacrol 50 mg l^{-1} and 100 mg l^{-1} increased all these parameters in gerbera. This suggests that the response to holding solutions may vary depending on species or varieties. Moreover, carvacrol with and without sucrose may have an effect on other mechanisms that are unknown for us. Salehi Salmi et. al. (2018) indicated that essential oils affected early flower opening and senescence in cut roses.

Conclusion

Based on the experimental results it is concluded that vase life of cut hydrangea flowers was affected by different holding solutions. Thymol (150 mg l^{-1}) with sucrose can be used successfully in increasing cut hydrangea flowers' vase life. However further studies which will compare the efficacy of thymol with other commercially preservative substances are needed. The role of carvacrol and even thymol in plant systems should be also investigated in detail.

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