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Effective Solutions for Extending Vase Life in Cut Gerbera Flowers

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ABSTRACT

One of the critical quality criteria in cut flower marketing is vase life. The neck bending issue observed in gerbera flowers can substantially reduce vase life. This study aimed to identify effective vase solutions to prolong the vase life in the 'Yeliz' and 'Rosalin' gerbera varieties. Seven different vase solutions were evaluated: sodium dichloroisocyanurate (DICA), sodium hypochlorite (klorak), sodium hypochlorite + sucrose, 8-hydroxyquinoline citrate (8-HQC), perlan + sodium hypochlorite, and perplex + sodium hypochlorite and potable water (Ks: control). Parameters such as vase life, total and daily solution uptake, relative fresh weight, and microbial density in vase solutions were assessed. Vase life ranged from 8.33 to 13.22 days for the 'Yeliz' variety and from 10.00 to 14.67 days for the 'Rosalin' variety. DICA provided the longest vase life for both varieties among the seven different vase solutions. All vase solutions except for flowers in control improved relative fresh weight within the first 3 days. DICA was also the most effective in reducing microbial density in the vase solutions. Furthermore, all treatments significantly reduced microbial density compared to the control. The findings suggest that substances such as DICA, perlan, and perplex could serve as viable alternatives in vase solutions for extending the vase life of gerbera flowers.

Keywords: *Gerbera jamesonii*, DICA, perlan, perplex, sodium hypochlorite

Kesme Gerbera Çiçeklerinde Vazo Ömrünü Uzatan Etkili Solüsyonlar

ÖZ

Kesme çiçeklerin pazarlanmasında en önemli kalite kriterlerinden biri vazo ömrüdür. Gerbera çiçeklerinde görülen boyun bükme problemi, vazo ömrünü önemli ölçüde kısaltabilmektedir. Bu çalışma, 'Yeliz' ve 'Rosalin' gerbera çeşitlerinde vazo ömrünü uzatmaya yönelik potansiyel vazo solüsyonlarını belirlemeyi amaçlamıştır. 7 farklı vazo solüsyonunun [sodyum dikloroizosiyanürat (DICA), sodyum hipoklorit (klorak), sodyum hipoklorit + sakaroz, 8-hidroksiquinolin sitrat (8-HQC), perlan + sodyum hipoklorit, perplex + sodyum hipoklorit, içme suyu (Ks, kontrol)] denendiği araştırmada; vazo ömrü, toplam ve günlük solüsyon alımı, oransal taze ağırlık ve vazo solüsyonlarında mikrobiyal yoğunluk parametreleri incelenmiştir. Vazo solüsyonları arasında 'Yeliz' çeşidinin vazo ömrü 8.33 gün ile 13.22 gün, 'Rosalin' çeşidinin ise 10.00 gün ile 14.67 gün arasında değişmiştir. Her iki çeşit içinde DICA uygulaması en uzun vazo ömrüne sahip uygulama olmuştur. İçme suyu içeren vazolarda bekletilen çiçekli dallar hariç tüm vazo solüsyonlarının, oransal taze ağırlıkta ilk 3 güne kadar artış sağladığı saptanmıştır. Vazo solüsyonlarındaki mikrobiyal yoğunluğu azaltma/önleme bakımından da DICA'nın en başarılı uygulama olduğu belirlenmiştir. Bunun yanında diğer tüm uygulamaların da kontrole göre mikrobiyal yoğunluğu önemli ölçüde azalttığı tespit edilmiştir. Elde edilen sonuçlar, gerbera çiçeklerinde vazo ömrünün uzatılmasında başta DICA olmak üzere, perlan ve perplex gibi maddelerin vazo solüsyonları içeresinde kullanılabilecek alternatif maddeler olarak rol oynayabileceğini göstermektedir.

Anahtar Kelimeler: *Gerbera jamesonii*, DICA, perlan, perplex, sodyum hipoklorit

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus ex Hooker f.), a member of the Asteraceae family, is a widely cultivated ornamental plant valued for its versatility as an outdoor plant, potted plant, and cut flower [1, 2, 3]. It is also one of the most traded cut flower species globally, renowned for its vibrant colors and showy blooms. Its popularity among producers and consumers is due to its adaptability to various ecological conditions and its suitability for diverse floral arrangements [4, 5, 6]. Vase life is a crucial commercial quality criterion for gerberas, as it is for other cut flowers. Vase life, which significantly affects consumer satisfaction, refers to the period from when flowers are placed in a vase until they lose their visual appeal. This period can vary based on the genetic characteristics of the flowers and is

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influenced by factors occurring before, during, and after harvest [7, 8].

In gerberas, known to be insensitive to ethylene, vase life is shortened due to neck bending and petal wilting [9, 10, 11]. The primary cause of these symptoms in gerberas is impaired water relations [12, 13]. Water balance is disrupted when the blocked vascular bundles cannot reabsorb the water lost by the plant through transpiration due to microbial activity in the vase water, enzymatic activities in the flower stem, physical injuries, etc. [14, 15]. This disruption leads to water stress, causing petals to lose turgidity and wither. Concurrently, the flower stem loses turgor pressure, loses its mechanical strength, and bends under gravity, unable to support the weight of the flower head. Consequently, the plant loses its visual appeal, and its vase life ends [13]. Many studies have been conducted to extend the vase life of gerberas by improving water balance [3, 16, 17]. These studies have used various substances, either as short-term pre-treatments by producers or as vase solutions when the flowers are in the vase. Typically, antimicrobial substances such as STS (silver thiosulfate), $Al_2(SO_4)_3$ (aluminum sulfate), 8-HQS, and 8-HQC (8-hydroxyquinoline sulfate and citrate) are used to inhibit microorganism growth [18, 19]. Organic acids such as citric, salicylic, and succinic acids are used to lower the pH of solutions to improve water uptake [20, 21] while carbohydrate sources such as sucrose adjust water balance and osmotic pressure [22, 23]. The effectiveness of these substances has been successfully demonstrated under certain conditions. However, given the physiological diversity of flowers and environmental variability, it remains uncertain whether these substances provide optimal efficacy in all situations. Advances in science and technology may lead to the discovery of new substances that could offer more effective and long-lasting protection. Therefore, identifying the most effective substances and their optimal concentrations is still crucial for the industry. This study aims to evaluate new vase solutions that may be effective in extending the vase life of cut gerbera flowers and to determine the impact of new substances on vase life.

MATERIAL AND METHODS

The experiment to determine the effects of different vase solutions on the vase life of gerbera flowers was conducted under laboratory conditions at the Department of Horticultural Plants, Faculty of Agriculture, Ege University, with a temperature of 21°C, 77% relative humidity, 1000 lux light, and a 12-hour photoperiod. The plant material used consisted of flowering stems of *Gerbera jamesonii* cv. 'Rosalin' and 'Yeliz'. Flowering stems of both varieties were sourced from a commercial gerbera production facility in the Menderes district of Izmir Province.

Gerbera flowers, harvested manually when they reach commercial harvest maturity (when 2-3 outer rows of flowers on the central disk are open and the male organs are mature) [24], were packaged in cardboard boxes without any pre-treatment and brought to the laboratory within a short period (4-6 hours). After being re-cut at a 40±2 cm length, the flowering stems were placed in glass vases containing 450 ml of solution, with three stems per vase. Seven different vase solutions were used. The formulations of the prepared solutions are provided in Table 1. The pH value of all solutions was adjusted to 5.0, and they were freshly prepared at the beginning of the experiment.

Table 1. Contents of the vase solution used in the experiment and properties of the ingredients

Vase Solution	Concentration	Substance Properties
DICA = Sodium Dichloro Isocyanurate	200 mg/L	It is an effective bactericide. CAS No: 2893-78-9, manufacturer: BLOOM TECH.
KL = Klorak	1 ml/L	It is a commercial product containing < 5% chlorine-based bleach (sodium hypochlorite) and has antimicrobial activity.
KL+S = Klorak + Sucrose	1 ml/L + 10 g/L	It contains sodium hypochlorite (KLORAK brand) as a carbohydrate source (sucrose) (Product Barcode: 869-746409-000-9).
Pn+KL = Perlan + Klorak	0.25 ml/L + 1 ml/L	Perlan, a plant growth regulator, is a commercial product containing 18.5 g/L gibberellin A4/A7 + 18.8 g/L 6-Benzyladenine.
Px+KL = Perplex + Klorak	15 ml/L + 1 ml/L	Perplex, a plant growth regulator, is a commercial product containing 20 g/L gibberellin.
8-HQC = 8-hydroxyquinoline citrate	200 mg/L	Organic compound used as a biocide. CAS No: 134-30-5. Company: Toronto Research Chemicals.
Ks = Control = Potable Water	-	The pH is 7.8 and contains 0.88 mg/L chloride and 6.34 mg/L sulfate. Conductivity is 142.2 µS/cm at 20°C, and oxidizability is 0.46 mg/L O_2.

To assess the effectiveness of the vase solutions, the relative fresh weight, daily vase solution uptake, and total vase solution uptake and vase life of flowering stems were analyzed. Microbial density in the vase solutions was also determined.

•*Relative Fresh Weight (OTA) (%):* The weights of the flowering stems were individually measured daily throughout the vase life using a precision scale sensitive to 0.01 g. OTA measurements were conducted daily for all flower stems until the end of their vase life. The determination of OTA is based on the following formula [25, 27].

$$OTA = \frac{A\ (t)}{A\ (t = {}_0)} \times 100$$

At: Weight of the stem at day t,

$A_{t=0}$: Initial weight of the stem

•*Daily Vase Solution Uptake (GVSA) (g/day fresh weight):* The amount of daily vase solution uptake by the flowering stems throughout their vase life was determined by weighing daily using a digital scale sensitive to 0.01 g. The daily vase solution uptake was calculated as follows [25, 28]. The GVSA value is the mean value (in grams) of the three flowering stems for each replicate.

$$GVSA = S(t-1) - S(t)$$

S_{t-1} = Vase solution weight from the previous day,

St = Vase solution weight on day t

•*Total Vase Solution Uptake (TVSA) (g/stem):* The total amount of solution absorbed by the flowering stems over their vase life was determined by subtracting the amount of water evaporated in vases without flowers. The TVSA value was calculated as the average (g) of the three stems in each replicate [26].

•*Vase Life (days):* The number of days from when the flowering stems were placed in the vase until the petals showed signs of wilting and the flower stem bent more than 90° [24].

•*Microbial Density (CFU/mL):* Samples were taken from the vase solutions on the 7th day after the flowers were placed in the vase to determine the microbial density in the vase solutions. For each treatment, 2 mL of the solution from each of the three replicates was aseptically transferred into sterile tubes. Then, serial dilutions were prepared using a 0.85% NaCl solution, and 100 µL of the 4-fold diluted solution was spread onto Nutrient agar plates using a pipette. The plastic Petri dishes with vase solution were incubated at 37°C for 48 hours, after which colonies were counted. The data obtained were expressed as CFU/mL [29].

The experiment was designed according to a Randomized Complete Block Design with 3 replications, each consisting of 3 flower stems. A total of 63 flower stems of a single variety were used, with 9 flowers per treatment. The obtained data were subjected to analysis of variance (ANOVA) using the SPSS version 22 statistical software. Differences between means were determined using the 'Duncan's Multiple Range Test' ($p<0.05$).

RESULTS

In this study, which investigated the effects of different vase solutions on the vase life of 'Yeliz' and 'Rosalin' varieties, the results of the analysis of variance showed that all three factors ('variety', 'treatment', and 'variety × treatment' interaction) were statistically significant concerning the relative fresh weight, daily and total solution uptake parameters. For the vase life parameter, only the 'treatment' factor was statistically significant, while for the microbial density parameter, both 'treatment' and 'variety × treatment' factors were statistically significant ($p \leq 0.05$).

Vase Life

The effects of solutions containing DICA, KL, KL+S, Pn+KL, Px+KL, 8-HQC, and Ks on the vase life of gerbera flowers are shown in Table 2. For the 'Rosalin' variety, the longest vase life of 14.67 days was achieved with the DICA treatment. This treatment was in the same statistical group as all other treatments except Px+KL and Ks (control). The second-best treatment was 8-HQC, with a vase life of 13.44 days. The shortest vase life of 10.00 days was observed with the Ks treatment. For the 'Yeliz' variety, the longest vase life of 13.22 days was observed with the KL+S treatment. This treatment, similar to the 'Rosalin' variety, was in the same statistical group as all treatments except for Px+KL and Ks. The shortest vase life of 8.33 days was observed with the Ks treatment.

When ranking the treatments without considering the variety factor, the best treatment was DICA, followed by KL+S, 8-HQC, and Pn+KL, which were in the same statistical group as DICA. This was followed by KL and Px+KL, which were also not statistically different. The lowest rank was for the Ks treatment, which used potable water (DICA > KL+S ≥ 8-HQC ≥ Pn+KL > KL ≥ Px+KL > Ks) (Table 2).

Table 2. Effects of different vase solutions on vase life of gerbera flowers (days)

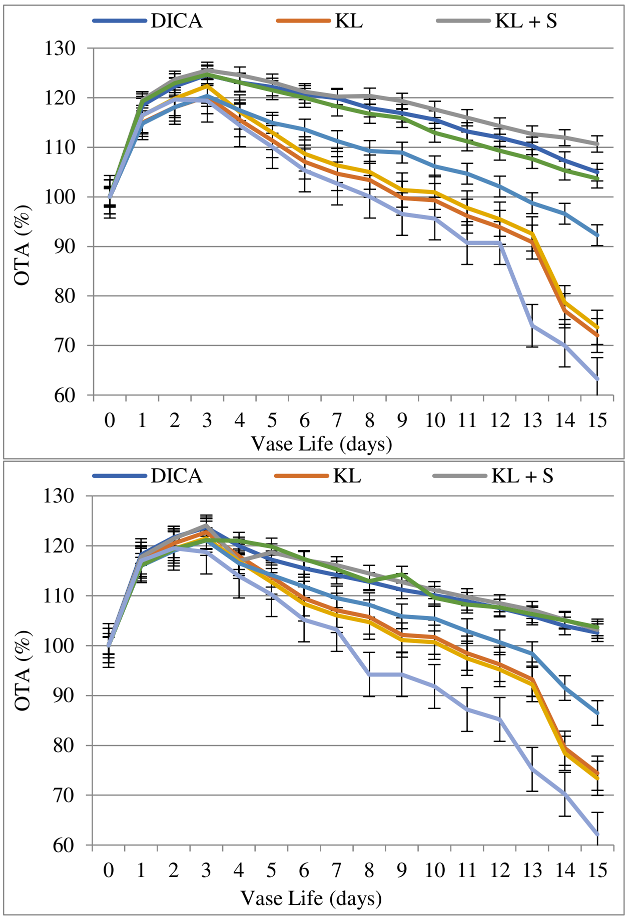
Variety	Treatments							
	DICA	KL	KL+S	Pn+KL	Px+KL	8-HQC	Ks	Avg.
Rosalin	14.67 a	12.00 ac	12.33 ac	11.67 ac	11.00 bc	13.44 ab	10.00 c	12.16 A
Yeliz	12.56 ab	11.67 ab	13.22 a	12.33 ab	11.17 b	11.68 ab	8.33 c	11.56 A
Avg.	13.62 A	11.84 B	12.78 AB	12.00 AB	11.09 B	12.56 AB	9.17 C	-

$p \leq 0.05$. Differences between variety means within the same column are indicated by uppercase letters, differences between treatments within the same row are indicated by uppercase letters, and differences between treatments within the same variety are indicated by lowercase letters. DICA: sodium dichloroisocyanurate, KL: chlorox, S: sucrose, Pn: perlan, Px: perplex, 8-HQC: 8-hydroxyquinoline citrate, Ks: control.

Relative Fresh Weight

The effects of different vase solutions on the relative fresh weight of gerbera flowers are presented in Figure 1. On days 1, 2, 3, 4, …, and 15 of vase life, the highest relative fresh weight in the 'Rosalin' variety was observed with the KL+S treatment. The lowest relative fresh weight was recorded on days 1, 5, 13, and 14 with the Ks treatment for the 'Rosalin' variety and on other days with the Ks treatment for the 'Yeliz' variety.

For the 'Rosalin' variety, the greatest relative fresh weight loss over the vase life from day 1 to day 15 was 45.60% with the Ks treatment. This was followed by KL and Pn+KL treatments. The least relative fresh weight loss, at 7.43%, was observed with the KL+S treatment. This was followed by DICA, 8-HQC, and Px+KL treatments. An increase in relative fresh weight was noted for all treatments except Ks for the 'Rosalin' variety up to day 3. The relative fresh weight decreased progressively after day 3 for all treatments except the Ks treatment, which decreased after day 2. Among the treatments, KL+S, DICA, and 8-HQC were identified as the best, showing the same statistical group for average relative fresh weight. No significant statistical difference was found between these treatments and the control (Figure 1).



p≤0.05, error bars represent standard error. DICA: Sodium dichloroisocyanurate, KL: Chloral, S: Sucrose, Pn: Perlan, Px: Perplex, 8-HQC: 8-hydroxyquinoline citrate, Ks: Control.

Figure 1. Changes in relative fresh weight (%) of 'Rosalin' (top) and 'Yeliz' (bottom) varieties due to different vase solutions

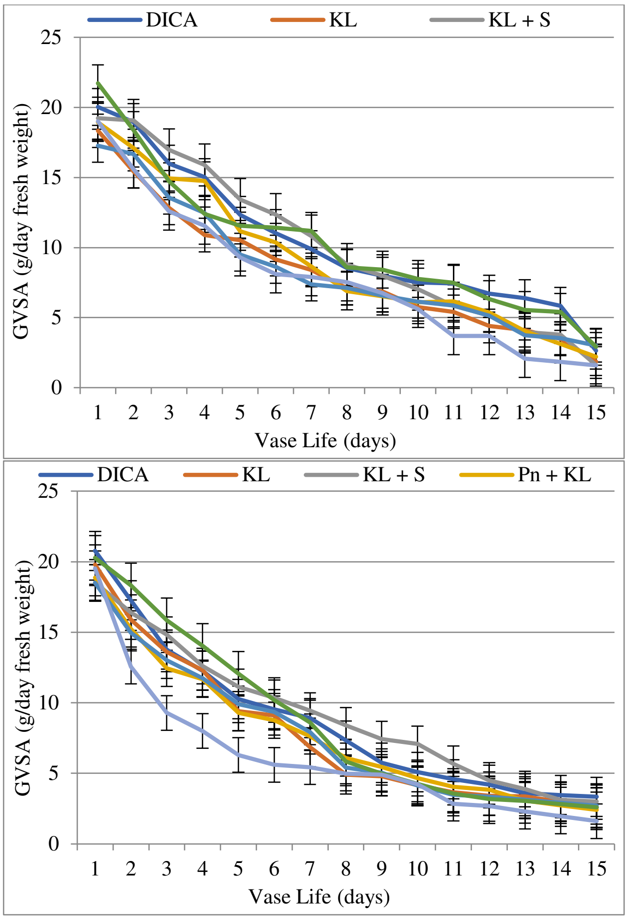
For the 'Yeliz' variety, the greatest relative fresh weight loss from day 1 to day 15 was 46.86% with the Ks treatment. This was followed by Pn+KL, KL, and Px+KL treatments. The least relative fresh weight loss, at 10.65%, was observed with the 8-HQC treatment. This was followed by KL+S and DICA treatments. All treatments improved the average relative fresh weight compared to the control for the 'Yeliz' variety, but similar to the 'Rosalin' variety, the best treatments were KL+S, DICA, and 8-HQC. All treatments, except Ks, showed an increase in relative fresh weight up to day 3, followed by a decrease. The Ks treatment showed an increase up to day 2 (Figure 1).

Daily Vase Solution Uptake

The effects of different vase solutions on the daily vase solution uptake of gerbera flowers are presented in Figure 2. The highest daily solution uptake was observed for the 'Rosalin' variety under the KL+S treatment on days 1, 2, 4, 5, 6, and 8. On days 3, 7, 9, 10, and 11, the highest uptake was recorded with the 8-HQC treatment for 'Rosalin', and on days 12, 13, and 14, it was with the DICA treatment for the same variety. On day 15, the highest uptake was noted with the DICA treatment for both 'Rosalin' and 'Yeliz' varieties, along with 8-HQC and Px+KL treatments in the same statistical group. The lowest daily vase solution uptake was observed with the control treatment for the 'Yeliz' variety on all days.

When analyzing the effects of the treatments on vase solution uptake regardless of days, the highest average daily solution uptake was 10.43 g/day fresh weight with the DICA treatment for 'Rosalin'. This was in the same statistical group as KL+S and 8-HQC treatments for 'Rosalin'. The lowest average solution uptake was 5.61 g/day fresh weight with the control treatment for 'Yeliz' (Figure 2).

Considering the days without accounting for treatments and varieties, daily solution uptake increased up to day 3 and then continuously decreased. When varieties were evaluated individually, 'Rosalin' showed an increase in daily solution uptake up to day 3 with all treatments except the control. In the control treatment, the uptake increased up to day 2, but it decreased after day 3 for other treatments. Among the treatments, KL+S, DICA, and 8-HQC were in the same statistical group and were identified as the best treatments for solution uptake. No statistical difference was found between the control and other treatments, except for Pn+KL. For the 'Yeliz' variety, all treatments had higher average daily solution uptake than the control, with KL+S, DICA, and 8-HQC as the best treatments, similar to 'Rosalin'. All treatments except the control showed high daily vase solution uptake up to day 3, gradually decreasing, whereas the control started to decrease from day 2 (Figure 2).



p≤0.05, error bars represent standard error. DICA: Sodium dichloroisocyanurate, KL: Chlorac, S: Sucrose, Pn: Perlan, Px: Perplex, 8-HQC: 8-hydroxyquinoline citrate, Ks: Control.

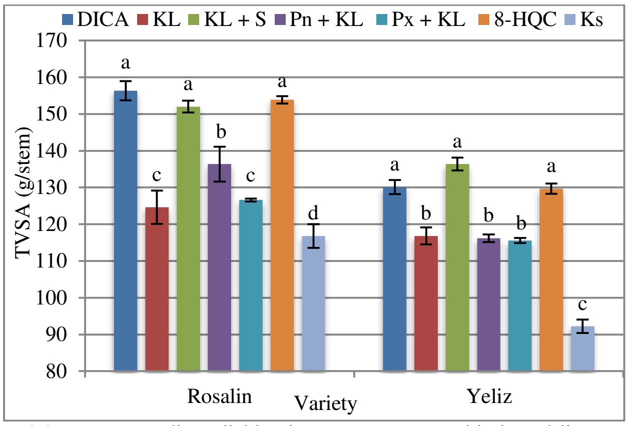
Figure 2. Changes in daily solution uptake of 'Rosalin' (top) and 'Yeliz' (bottom) varieties under different vase solutions

Total Vase Solution Uptake

The effects of different vase solutions on total solution uptake in 'Rosalin' and 'Yeliz' gerbera flowers are presented in Figure 3. The highest total vase solution uptake was recorded for the 'Rosalin' variety with DICA treatment (156.36 g/stem), and this treatment was in the same statistical group as the 8-HQC treatment (153.88 g/stem) for the same variety. The lowest total vase solution uptake was found in the control group of the 'Yeliz' variety (84.21 g/stem).

When evaluating the varieties without considering the treatments, it was found that the total vase solution uptake of 'Rosalin' (137.38 g/stem) was greater than that of 'Yeliz' (118.44 g/stem). When evaluating the treatments without considering the varieties, KL+S, DICA, and 8-HQC treatments, with total solution uptakes of 144.21 g/stem, 143.25 g/stem, and 141.78 g/stem respectively, were in the same statistical group. The lowest total solution uptake was found in the control group (98.05 g/stem) (Figure 3).

When evaluating within varieties, the highest total vase solution uptake for 'Rosalin' was achieved with DICA, KL+S, and 8-HQC treatments. In contrast, the lowest total solution uptake was recorded in the control group. The lowest total solution uptake was observed in KL and Px+KL treatments following the control group. For the 'Yeliz' variety, the highest total solution uptake was shown by DICA, KL+S, and 8-HQC, whereas the control was the treatment leading to the least solution uptake. Other treatments, including KL, Px+KL and Pn+KL, were in the same statistical group (Figure 3).

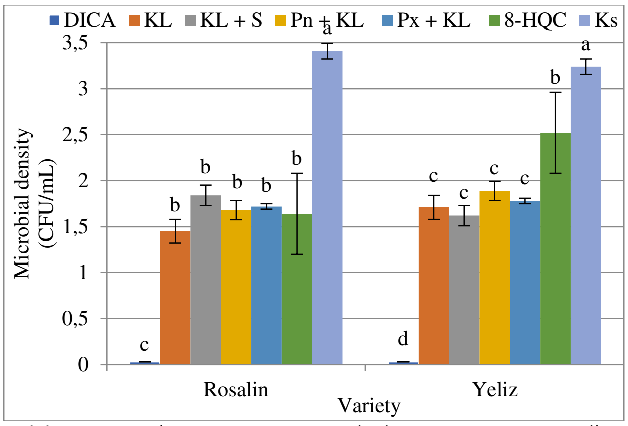


p≤0.05. DICA: Sodium dichloroisocyanurate, KL: Chlorinated lime, S: Sucrose, Pn: Perlan, Px: Perplex, 8-HQC: 8-hydroxyquinoline citrate, Ks: Control.

Figure 3. Effects of different vase solutions on total solution uptake in 'Rosalin' and 'Yeliz' varieties

Microbial Density

The effects of different treatments on microbial density in vase solutions containing flowering stems of 'Yeliz' and 'Rosalin' varieties are given in Figure 4. As shown in Figure 4, the highest microbial density in both varieties was observed in the control group, i.e., potable water (Yeliz: 3.24×10^6 CFU/mL; Rosalin: 3.41×10^6 CFU/mL). The lowest microbial density was found in the DICA treatment for both varieties (Yeliz: 1.0×10^1 CFU/mL; Rosalin: 1.2×10^1 CFU/mL). For the 'Rosalin' variety, there were no statistically significant differences among the other treatments (KL: 1.45×10^4 CFU/mL; KL+S: 1.84×10^4 CFU/mL; Pn+KL: 1.68×10^4 CFU/mL; Px+KL: 1.72×10^4 CFU/mL; 8-HQC: 1.64×10^4 CFU/mL). However, for the 'Yeliz' variety, the second highest microbial density was observed in the 8-HQC treatment (2.52×10^4 CFU/mL). Other treatments were in the same statistical group and were the next best treatments after DICA (KL: 1.71×10^4 CFU/mL; KL+S: 1.62×10^4 CFU/mL; Pn+KL: 1.89×10^4 CFU/mL; Px+KL: 1.78×10^4 CFU/mL).



p≤0.05. Error bars represent standard error. DICA: Sodium dichloroisocyanurate, KL: Bleach, S: Sucrose, Pn: Perlan, Px: Perplex, 8-HQC: 8-hydroxyquinoline citrate, Ks: Control.

Figure 4. Effects of different treatments on microbial activity in vase solutions for 'Rosalin' (top) and 'Yeliz' (bottom) varieties

DISCUSSION

This study investigated the effects of various treatments, including DICA, KL, and 8-HQC (known for their antimicrobial properties), as well as plant growth regulators Pn and Px in different doses, on the post-harvest longevity of some gerbera varieties; it was found that all vase solutions were effective in extending the vase life of gerbera flowers by improving water uptake and reducing relative fresh weight loss. Numerous studies have demonstrated that the vase life of cut flowers, including gerberas, can be enhanced by adding certain substances to vase solutions. Similar to the results of this study, previous research has also reported that extending vase life can be achieved by reducing relative fresh weight loss and increasing solution uptake [30, 31, 32]. Many researchers have indicated a significant relationship between increased vase solution uptake and reduced relative fresh weight loss and the maintenance of post-harvest quality [13, 33, 34].

The average vase life of the 'Yeliz' and 'Rosalin' varieties was determined to be 11.56 days and 12.16 days, respectively. Ferrante et al. [35] reported that the vase life of 20 different gerbera varieties ranged from 5.0 days to 23.43 days, while Javad et al. [36] reported that the vase life of 21 different gerbera varieties ranged from 9.0 days to 21.0 days. The variation in vase life observed in these studies is thought to be due not only to genotype but also to differences in the solutions used for the flower stems, experimental conditions, and changes in the cultivation conditions of the plants.

It has been determined that the solutions, particularly DICA, KL+S, and 8-HQC, successfully improved post-harvest longevity in gerbera flowers. Similarly, Ketsa and Dadaung [30] found that solutions containing DICA improved vase life and solution uptake and reduced relative fresh weight loss in cut roses. Hema et al. [37] reported that sodium hypochlorite (KL) improved the vase life of cut gerbera flowers up to 10.57 days, while Gendy and Mahmoud [38] found that 8-HQC positively affected vase life, solution uptake, and relative fresh weight in cut gerberas and delayed senescence. Using KL with sucrose resulted in longer vase life, better solution uptake, and better relative fresh weight preservation compared to its use with Pn and Px. This may be related to sucrose's greater positive effects on gerbera vase life compared to plant growth regulators. The addition of sucrose to the vase solution provides an energy source for the flowers and regulates water relations and osmotic pressure and delays senescence [22, 39, 40]. The study found that commercial products containing benzyl adenine with gibberellin (Pn) and gibberellin alone (Px) successfully increased the vase life of gerberas compared to the control. Previous research has also reported the success of growth regulators like gibberellin and benzyl adenine in extending vase life [41, 42, 43]. However, in this study, their effects on vase life were lower than other treatments. This may be related to the use of non-optimal dosages or formulations. Indeed, Aydın [44], reported that the Pn product caused toxic effects at high doses in solidago flowers. The presence of benzyl adenine in Pn, which may accelerate senescence at high doses, could also contribute to the relatively shorter vase life observed.

It was determined that there is a difference in vase solution uptake between the 'Yeliz' and 'Rosalin' varieties. Acharya et al. [45] also reported that vase solution uptake rates vary among gerbera varieties. However, for both varieties, the vase solution uptake of treated flower stems was higher than that of the control group flowers. Javad et al. [16] and Malakar et al. [3], have also reported that the addition of antimicrobial agents in appropriate doses to vase solutions can improve water uptake in cut flowers. Indeed, in this study, all treatments were found to reduce microbial density compared to the control. These findings on microbial density align with those of Kader [46], Jowkar [47] and Macnish et al. [48] who reported that DICA, KL, and 8-HQC treatments significantly reduced or prevented microbial growth in vase solutions for gerbera flowers.

The study found that the relative fresh weight loss of flower stems held in different vase solutions was less than the control for both varieties. The increase in solution uptake may play a role in reducing relative fresh weight loss in the flowers. Indeed, studies are showing a relationship between relative fresh weight and solution uptake [34, 49].

In gerbera flowers held in different vase solutions, it was observed that both solution uptake and relative fresh weight increased up to the third day. This finding is similar to the results reported by Danaee et al. [50] and Geshnizjany et al. [51] who noted that in cut gerbera flowers, solution uptake and relative fresh weight can increase for the first three days depending on the vase solution. The higher solution uptake in the first three days of vase life compared to other days may be attributed to factors such as the solution's microbial activity not yet reaching levels that block the vascular tissues, the flowers having sufficient energy for water uptake, and minimal transpiration.

Kılıç and Arslan [52] reported that the highest average daily solution uptake in gerbera flowers was 69.17 g/day per 5 flower stems, with the lowest relative fresh weight loss at 33.71%. Kılıç and Yaman [32]found that the highest daily average vase solution uptake was 11.85 g/stem/day, with a total solution uptake of 106.68 g/stem, and relative fresh weight loss ranged between 13.86% and 38.66%. In this study, relative fresh weight loss varied between 7.43% and 46.86%, with the highest daily and total solution uptake being 10.43 g/day and 137.38 g/stem, respectively. Differences in solution uptake rates and relative fresh weight loss among studies may be attributed to variations in the varieties used, solution compositions, and experimental conditions.

CONCLUSIONS

The results indicate that substances such as DICA, KL+S, 8-HQC, and Perlan and Perplex, can play a role in extending the vase life of gerbera flowers. In particular, DICA should be considered a primary choice due to its effectiveness in reducing microbial density. However, further research is needed to establish its efficacy on microbial density in other gerbera varieties and cut flower species. The improvement in vase life with vase solutions containing KL and sucrose, compared to other solutions containing klorak, may be related to the presence of sucrose. While perlan and perplex have been found effective in extending vase life, further concentration studies are needed to determine their efficacy fully. The results of this study could contribute to improving post-harvest longevity in cut flowers through ongoing and future research, treatment, and development of post-harvest solutions.

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