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VASE LIFE EXTENSION OF GERBERA USING DIFFERENT PRESERVATIVE VASE SOLUTIONS

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Abstract

An experiment was conducted at the Postharvest Laboratory, Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during January-February 2024 to evaluate different preservative solutions for vase life extension of gerbera. Two varieties of gerbera were collected from commercial growers in Jhikargacha, Jashore. The experiment was laid out in two-factorial completely randomized design included Factor A: flower variety (V_1- Sangria Red and V_2- Olivia White) and Factor B: preservative vase solutions (T_0: control-Tap water, T_1: 3% sucrose solution, T_2: 250 ppm citric acid solution, T_3: 250 ppm $AgNO_3$ solution, T_4: 2% lemon Juice, T_5: 150 ppm citric Acid + 150 ppm $AgNO_3$, T_6: 2% sucrose + 150 ppm citric acid, T_7: 2% sucrose + 150 ppm $AgNO_3$, T_8: 1% sucrose + 100 ppm $AgNO_3$ + 1% lemon juice and T_9: 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm citric acid). Data were recorded were flower diameter, freshness, petal discoloration, solution uptake, pathogen attack and vase life. Results showed significant varietal differences; V_2 exhibited longer vase life (12.7 days) than V_1 (11.6 days). The longest vase life (13.5 days) was recorded in V_2T_2, while the shortest (10.3 days) of the same was found in V_2T_5. Findings suggest suitable preservative solutions can reduce postharvest losses and improve marketability under ambient conditions.

Key Words: Gerbera flower, Sucrose, Citric acid, $AgNO_3$, Lemon juice.

Introduction

Gerbera (*Gerbera jamesonii* L.) is the world's fifth most popular cut flower, valued for its vibrant colors and adaptability. Though the genus comprises 40 species, *Gerbera jamesonii* cultivation is predominant (Prodhan *et al.*, 2017). Native to South America and Africa, now gerbera is grown widely across Asia, including Bangladesh, where Jashore leads expanding acreage. Bangladesh's floriculture spans 10,000ha, engaging 3,000,000 people; 500-600 farmers produce gerbera commercially, with women predominant in harvesting, sorting and packaging (Khan, 2024). Despite strong export potential, 30% of flowers are lost annually due to inadequate postharvest technologies. Postharvest longevity of gerbera is limited due to issues like neck bending, microbial contamination, vascular blockage and water stress (Mohammadiju *et al.*, 2014). The hollow stem and large capitulum further reduce its vase life. Bacterial blockage of xylem vessels is a major contributor to early senescence, often exacerbated by ethylene-producing bacteria (Marandi *et al.*, 2011). Proper postharvest handling and use of floral preservatives can significantly enhance vase life by maintaining stem turgidity and delaying senescence.

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Carbohydrates, particularly sucrose, are critical in sustaining respiration, improving water uptake and supporting bud opening. Sucrose also interacts with cytokinins and reduces ethylene sensitivity (Xia *et al.,* 2024). Antimicrobial agents like silver nitrate, 8-hydroxyquinoline sulfate and citric acid are effective in reducing microbial growth and maintaining water conductance (Heidarnezhadian *et al.,* 2017). Therefore, optimized combinations of sugars, antimicrobial agents and acidifiers in vase solutions can significantly extend the vase life of gerbera. This study aims to evaluate the effects of different preservative solutions on postharvest physiology, vase life and quality retention of cut gerbera.

Materials and Methods

Experimental Site and Duration

The experiment was carried out at the Postharvest Laboratory, Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during 25 January to 11 February 2024. Temperature and humidity were monitored with digital thermo-hygrometer, while light intensity with a digital lux meter.

Plant Materials

Two commercial gerbera varieties, Sangria red (V_1) and Olivia white (V_2), were collected at half-bloom stage from Jhikargacha, Jashore. Stems were wrapped in polythene and transported in the laboratory. Stems were trimmed with slant cuts, excess leaves removed and only healthy flowers were selected.

Experimental Design

The study was conducted using a two-factorial Completely Randomized Design (CRD) with three replications. Factor-A represented flower varieties (V_1- Sangria Red; V_2-Olivia White) and Factor-B represented preservative vase solutions, resulting in 20 treatment combinations.

Vase solutions, setup and experimental procedure

Ten preservative solutions were evaluated where T_0: Control (tap water), T_1: 3% sucrose, T_2: 250 ppm citric acid, T_3: 250 ppm $AgNO_3$, T_4: 2% lemon juice, T_5: 150 ppm citric acid + 150 ppm $AgNO_3$, T_6: 2% sucrose + 150 ppm citric acid, T_7: 2% sucrose + 150 ppm $AgNO_3$, T_8: 1% sucrose + 100 ppm $AgNO_3$ + 1% lemon juice and T_9: 1% sucrose + 100 ppm $AgNO_3$ + 100 ppm citric acid. Each 250 mL glass vase was filled with 150 mL of the respective solution, sealed with aluminum foil and placed for observation in ambient condition (Temperature: 19.2-22.2°C; Humidity: 65–70% and Light intensity: 27–31 lux). Each treatment had three replications with two stem per vase and initial water levels were marked to monitor solution uptake.

Observations and Data Collection

Observations were recorded at two days intervals from the day of treatment until flower senescence. Data were recorded on flower diameter, flower freshness, Petal Discoloration, solution uptake, pathogen attack and vase life.

Methods of Studying Parameters

1. **Flower Diameter**

   The flower diameter was recorded every alternative day after treatment up to 14 days after treatment (DAT) at cm scale (Khan *et al.*, 2015).

2. **Flower Freshness**

   Flower freshness was scored visually following the scale of Macnish *et al*. (2000): 1= Fresh flower; 2= Slight petal curling; 3= Noticeable curling; 4= Petal shriveling; 5= Severe shriveling.

3. **Petal Discoloration**

   Petal color fading was assessed using a point scale (Macnish *et al.*, 2000): 1 = No/very slight fading; 2 = Moderate fading; 3 = Advanced fading.

4. **Solution Uptake**

   Solution uptake was calculated by measuring the reduction in vase solution volume relative to the initial level.

$$\text{Solution uptake (\%)} = \frac{Initial\ volume - Final\ Volume}{Final\ volume} \times 100$$

5. **Pathogen attack**

   Pathogen presence was observed visually as absence (no growth) and presence (white/black fungal or bacterial growth).

6. **Vase Life**

   Vase life was determined as the number of days from placement in solution until the flowers were deemed unmarketable (flower diameter reduction, freshness, petal discoloration and pathogen attack) following the criteria of Hassan (2014).

7. **Statistical Analysis**

   Data collected on different parameters were subjected to statistical analysis using STATISTIX 10 software. Analysis of variance (ANOVA) was performed to determine the significance. Treatment means were separated using Least Significant Difference (LSD) test at 1% and 5% level of probability (Gomez and Gomez, 1984).

Results and discussion

Effect of variety, preservative vase solutions and their interaction on flower diameter

Significant differences were observed due to variety, with V_2 exhibiting larger diameters (6.72 cm) than V_1 (6.11 cm) at 14th DAT. Flower diameter of gerbera also differs significantly due to preservative vase solutions during storage (Table 1). Flower diameter reduced slowly up to 6 DAT. At 14 DAT, after reducing, the highest diameter was observed from T_8 (6.93 cm) followed by T_3 (6.77 cm), T_9 (6.73 cm) and T_2 (6.6 cm) while T_0 showed the smallest diameter (5.93 cm) at 14 DAT. Interaction effect significantly influenced flower diameter at 4 to 14 DAT (Table 1). After reducing the diameter, V_2T_8 and V_2T_3 showed the largest diameters of 7.47 cm and 7.33 cm respectively at 14 DAT. Similar findings were reported by Kshirsagar *et al*. (2021) for chrysanthemum and Barooah (2011) for roses, highlighting the efficacy of sucrose and $AgNO_3$ combinations. Additionally, $AgNO_3$ treatments delayed senescence, enhanced water content and improved flower quality by reducing bent neck and petal abscission, consistent with prior studies (Kumar *et al.*, 2010).

Effect of variety, preservative vase solutions and their interaction on flower freshness

Gerbera flower freshness significantly differed by variety, with V_1 showing maximum petal shriveling (score 5) and V_2 showing minimum (score 4.5) at 14 DAT (Table 2). Preservative vase solutions showed significant variation at 14 DAT with T_1 and T_5 achieving the lowest freshness (score 5.0), while T_2 and T_0 maintained better freshness with the score of 4.5 (Table 2) The combined effect was significant at 8, 10, 12 and 14th DAT, with V_2T_2 and V_2T_0 scored the lowest (4). Consistent findings by Lakmali *et al*. (2016), Darandeh and Hadavi (2012) and Alam *et al*. (2023) underscore citric acid role in enhancing turgidity, longevity and quality by reducing fungal infection and improving solution uptake in cut flowers.

Effect of variety, preservative vase solutions and their interaction on petal discoloration

The petal discoloration scores did not show significant variation among gerbera varieties except at 12 DAT, which suggests that discoloration appeared earlier in V_1 flowers compared to V_2 (Table 3). Significant variation in discoloration was observed among vase solutions with maximum petal discoloration score (2.2) in T_1 compared to other treatments, which were found to have minimum discoloration score up to 12 days of preservation. The interaction effect was also found significant on petal discoloration during the entire observation period (Table 3). V_1T_1 combination showed the highest discoloration score (2.3) compared to other combinations at 14 DAT. These results are in aligned with the findings of Mehraj *et al*. (2013) and Kshirsagar *et al*. (2021) where they reported that sucrose solution delayed petal discoloration and increased longevity in chrysanthemums. Similarly, Khan *et al*. (2015) observed that sugar + salicylic acid treatment resulted in minimal petal discoloration and better freshness.

Table 1. Effect of flower variety, preservative vase solutions and their interaction on flower diameter of gerbera

Variety	Flower diameter (cm) at different days after treatment (DAT)						
	2	4	6	8	10	12	14
Main effect of flower variety							
V_1 (Red)	8.63	8.34	7.84	7.25	6.9	6.47	6.11
V_2 (White)	8.84	8.72	8.49	8.04	7.65	7.20	6.72
$LSD_{(0.05)}$	0.305	0.302	0.315	0.289	0.342	0.349	0.354
Level of significance	**NS**	*	**	**	**	**	**
Main effect of preservative vase solutions							
T_0	8.53	8.37	8.02	7.35	7.02	6.45	6.03
T_1	8.70	8.50	8.18	7.55	7.03	6.58	6.13
T_2	8.68	8.62	8.25	7.62	7.35	6.98	6.60
T_3	8.88	8.60	8.18	7.85	7.42	7.02	6.77
T_4	8.52	8.27	7.82	7.38	6.85	6.47	5.90
T_5	8.78	8.58	8.17	7.68	7.32	6.82	6.35
T_6	8.82	8.70	8.17	7.72	7.52	7.00	6.55
T_7	8.58	8.37	8.10	7.50	7.02	6.58	6.17
T_8	8.97	8.60	8.33	7.93	7.72	7.32	6.93
T_9	8.87	8.68	8.42	7.87	7.52	7.13	6.73
$LSD_{(0.05)}$	0.682	0.676	0.704	0.646	0.764	0.781	0.793
Level of significance	**NS**	**NS**	**NS**	**NS**	*	*	*
Interaction effect of variety and preservative vase solutions							
V_1T_0	8.30	8.10	7.63	6.97	6.77	6.30	6.13
V_1T_1	8.77	8.53	8.13	7.40	6.87	6.43	6.00
V_1T_2	8.53	8.40	7.90	7.17	6.90	6.50	6.13
V_1T_3	8.53	8.07	7.53	7.23	6.67	6.27	6.20
V_1T_4	8.37	7.93	7.33	6.80	6.33	5.87	5.40
V_1T_5	8.77	8.47	7.93	7.33	6.87	6.33	5.80
V_1T_6	8.90	8.80	8.13	7.83	7.63	7.23	6.83
V_1T_7	8.33	8.07	7.70	6.93	6.53	6.10	5.67
V_1T_8	8.90	8.43	7.93	7.33	7.13	6.77	6.40
V_1T_9	8.87	8.60	8.17	7.47	7.27	6.90	6.53
V_2T_0	8.77	8.63	8.40	7.73	7.27	6.60	5.93
V_2T_1	8.63	8.47	8.23	7.70	7.20	6.73	6.27
V_2T_2	8.83	8.83	8.6	8.07	7.80	7.47	7.07
V_2T_3	9.23	9.13	8.83	8.47	8.17	7.77	7.33
V_2T_4	8.67	8.60	8.30	7.97	7.37	7.07	6.40
V_2T_5	8.80	8.70	8.40	8.03	7.77	7.30	6.90
V_2T_6	8.73	8.60	8.20	7.60	7.40	6.77	6.27
V_2T_7	8.83	8.67	8.50	8.07	7.50	7.07	6.67
V_2T_8	9.03	8.77	8.73	8.53	8.30	7.87	7.47
V_2T_9	8.87	8.77	8.67	8.27	7.77	7.37	6.93
$LSD_{(0.05)}$	0.965	0.956	0.996	0.914	1.081	1.105	1.121
Level of significance	**NS**	*	**	**	**	**	**

**= Significant at 1% level of probability, *= Significant at 5% level of probability, NS= non-significant. V_1 = Red, V_2= White, T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm citric acid.

Table 2. Effect of flower variety, preservative vase solutions and their interaction on flower freshness of gerbera

Main effect of flower variety							
Variety	Flower freshness at different days after treatment (DAT)						
	2	4	6	8	10	12	14
V_1 (Red)	1.1	1.1	2.4	2.9	3.6	4.3	5.0
V_2 (White)	1.0	1.0	2.0	2.1	2.6	2.8	4.5
$LSD_{(0.01)}$	0.27	0.27	0.3	0.22	0.38	0.49	0.20
Level of significance	NS	NS	**	**	**	**	**
Main effect of preservative vase solutions							
T_0	1.0	1.0	2.3	2.3	3.0	3.3	4.5
T_1	1.5	1.5	2.3	2.8	3.5	4.3	5.0
T_2	1.0	1.0	2.1	2.5	3.1	3.5	4.5
T_3	1.0	1.0	2.1	2.5	3.1	3.6	4.8
T_4	1.0	1.0	2.1	2.6	3.0	3.6	4.6
T_5	1.0	1.0	2.3	2.5	3.0	3.6	5.0
T_6	1.0	1.0	2.1	2.5	3.1	4.0	4.8
T_7	1.0	1.0	2.1	2.5	3.1	3.3	4.6
T_8	1.0	1.0	2.1	2.5	3.0	3.3	4.8
T_9	1.0	1.0	2.1	2.5	2.8	3.3	4.8
$LSD_{(0.01)}$	0.60	0.60	0.75	0.49	0.84	1.10	0.45
Level of significance	NS	NS	NS	**	NS	*	*
Interaction effect of variety and preservative vase solutions							
V_1T_0	1.0	1.0	2.3	2.7	3.7	4.3	5.0
V_1T_1	2.0	2.0	2.6	3.3	4.0	5.0	5.0
V_1T_2	1.0	1.0	2.3	3.0	3.7	4.3	5.0
V_1T_3	1.0	1.0	2.3	3.0	3.7	4.7	5.0
V_1T_4	1.0	1.0	2.3	3.0	3.7	4.7	5.0
V_1T_5	1.0.	1.0	2.6	3.0	3.3	4.3	5.0
V_1T_6	1.0	1.0	2.3	2.7	3.3	4.3	5.0
V_1T_7	1.0	1.0	2.3	3.0	3.7	4.0	5.0
V_1T_8	1.0	1.0	2.3	3.0	3.7	4.0	5.0
V_1T_9	1.0	1.0	2.3	3.0	3.3	4.0	5.0
V_2T_0	1.0	1.0	2.3	2.0	2.3	2.3	4.0
V_2T_1	1.0	1.0	2.0	2.3	3.0	3.7	5.0
V_2T_2	1.0	1.0	2.0	2.0	2.7	2.7	4.0
V_2T_3	1.0	1.0	2.0	2.0	2.7	2.7	4.7
V_2T_4	1.0	1.0	2.0	2.3	2.3	2.7	4.3
V_2T_5	1.0	1.0	2.0	2.0	2.7	3.0	5.0
V_2T_6	1.0	1.0	2.0	2.3	3.0	3.7	4.7
V_2T_7	1.0	1.0	2.0	2.0	2.7	2.7	4.3
V_2T_8	1.0	1.0	2.0	2.0	2.3	2.7	4.7
V_2T_9	1.0	1.0	2.0	2.0	2.3	2.7	4.7
$LSD_{(0.01)}$	0.86	0.86	1.06	0.71	1.19	1.56	0.64
Level of significance	NS	NS	**	**	**	**	**

**= Significant at 1% level of probability, *= Significant at 5% level of probability, NS= non-significant. V_1 = Red, V_2= White, T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm citric acid. Score: 1 = Fresh flower; 2 = Slight petal curling; 3 = Noticeable curling; 4 = Petal shriveling; 5 = Severe shriveling.

Effect of variety, preservative vase solutions and their interaction on rate of solution uptake

The effect of variety on the rate of solution uptake in gerbera cut flowers was found significant, with higher uptake observed in V_1 (27.5%) and lower in V_2 (26.3%) at 14 DAT (Table 4). Solution uptake significantly varied among the vase solutions. The highest solution uptake was recorded in T_9 preservative solution which was statistically identical with T_1 and T_6, while the lowest solution uptake was observed in T_4. The interaction showed significant variation throughout the study period (Table 4). The highest solution uptake (31.6%) was found in the combination of V_1T_9, followed by V_1T_5 and V_1T_8 and the lowest uptake was recorded in the V_1T_4 combination. These findings are in consistent with Khan *et al*. (2015) who reported that sucrose + citric acid enhanced the highest solution uptake. Muraleedharan *et al*. (2019) and Singh and Singh (2023) also found increased solution uptake with sucrose. Bhanushree and Rao (2015) found that $AgNO_3$ increased water uptake and fresh weight in gerbera flowers.

Effect of variety and preservative vase solutions on pathogen attack

Both flower varieties were affected by pathogens, but preservative solutions like T_1, T_2, T_3, T_5, T_7, T_8 and T_9 showed no disease symptoms when combined with V_1 and V_2 (Table 5). In case of V_1T_4 preservative solution got attacked by pathogen at 12 DAT and pathogenic symptoms in V_2T_4 were observed at 14 DAT whereas symptoms of the same ere noticed in V_1T_6 and V_2T_6 at 10 DAT (Table 5). Treatment with silver nitrate inhibited bacterial proliferation as observed by Ohkawa *et al.* (1999), which supports our present findings. Belle *et al.* (2004) and Singh *et al*. (2000) found that citric acid inhibited microbial proliferation which is contradictory with present findings.

Effect of variety, preservative vase solutions and their interaction on vase life

Gerbera vase life varied significantly by flower variety. Longer vase life was observed in V_2 (12.7 days) (Fig. 1). Preservative vase solutions significantly influenced vase life where the longest (13.5 days) one was found in T_1 which was statistically similar in T_8 (Fig. 2). The shortest vase life was recorded in T_0. The combined effect of variety and solutions was highly significant where V_2T_2 had the longest vase life (13.5 days) and V_1T_5 had the shortest (10.3 days) of the same (Table 6). These findings aligned with the findings of Khan *et al*. (2015), Suganya *et al*. (2020) and Da Silva (2003). They also found that these treatments and their combinations enhanced vase life by reducing bacterial growth and improving water uptake.

Table 3. Effect of flower variety, preservative vase solutions and their interaction on petal discoloration of gerbera

Variety	Petal discoloration[e] at different days after treatment (DAT)						
	2	4	6	8	10	12	14
Main effect of flower variety							
V_1 (Red)	1	1	1	1	1.1	2	2
V_2 (White)	1	1	1	1	1	1	2
$LSD_{(0.01)}$	---	0.09	0.09	0.09	0.18	0.09	0.09
Level of significance	ND	NS	NS	NS	NS	**	NS
Main effect of preservative vase solutions							
T_0	1	1	1	1	1	1.5	2
T_1	1	1.2	1.2	1.2	1.3	1.7	2.2
T_2	1	1	1	1	1	1.5	2
T_3	1	1	1	1	1	1.5	2
T_4	1	1	1	1	1	1.5	2
T_5	1	1	1	1	1	1.5	2
T_6	1	1	1	1	1	1.5	2
T_7	1	1	1	1	1	1.5	2
T_8	1	1	1	1	1	1.5	2
T_9	1	1	1	1	1	1.5	2
$LSD_{(0.05)}$	---	0.15	0.15	0.15	0.29	0.15	0.15
Level of significance	ND	*	*	*	*	*	*
Interaction effect of variety and preservative vase solutions							
V_1T_0	1	1	1	1	1	2	2
V_1T_1	1	1.3	1.3	1.3	1.7	2.3	2.3
V_1T_2	1	1	1	1	1	2	2
V_1T_3	1	1	1	1	1	2	2
V_1T_4	1	1	1	1	1	2	2
V_1T_5	1	1	1	1	1	2	2
V_1T_6	1	1	1	1	1	2	2
V_1T_7	1	1	1	1	1	2	2
V_1T_8	1	1	1	1	1	2	2
V_1T_9	1	1	1	1	1	2	2
V_2T_0	1	1	1	1	1	1	2
V_2T_1	1	1	1	1	1	1	2
V_2T_2	1	1	1	1	1	1	2
V_2T_3	1	1	1	1	1	1	2
V_2T_4	1	1	1	1	1	1	2
V_2T_5	1	1	1	1	1	1	2
V_2T_6	1	1	1	1	1	1	2
V_2T_7	1	1	1	1	1	1	2
V_2T_8	1	1	1	1	1	1	2
V_2T_9	1	1	1	1	1	1	2
$LSD_{(0.01)}$	---	0.29	0.29	0.29	0.57	0.29	0.28
Level of significance	ND	**	**	**	**	**	**

**= Significant at 1% level of probability, *= Significant at 5% level of probability, ND= statistical analysis not done, NS= non-significant. V_1= Red, V_2=White, T_0-control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4-2% Lemon juice, T_5-150 ppm citric Acid+150 ppm $AgNO_3$, T_6-2% sucrose + 150 ppm citric acid, T_7-2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+100 ppm citric acid. [e] = Petal discoloration scale: 1= none/slight fading, 2= moderate fading and 3= advanced fading.

Table 4. Effect of flower variety, preservative vase solutions and their interaction on solution uptake rate (%) of gerbera

Main effect of flower variety							
Variety	**Rate of solution uptake (%) at different days after treatment (DAT)**						
	2	**4**	**6**	**8**	**10**	**12**	**14**
V_1 (Red)	3.5	7.1	10.1	13.8	17.4	21.3	27.5
V_2 (White)	3.2	6.0	9.1	12.5	16.4	20.1	26.3
$LSD_{(0.05)}$	0.39	0.40	0.54	0.84	0.98	1.13	1.44
Level of significance	NS	**	**	**	*	*	NS
Main effect of preservative vase solutions							
T_0	3.1	5.8	8.6	12.2	15.4	19.3	25.8
T_1	3.6	6.8	9.9	13.1	18.0	21.6	28.0
T_2	3.2	6.6	9.7	13.0	16.8	20.7	27.2
T_3	3.1	6.9	9.7	13.2	17.0	21.1	26.7
T_4	3.2	5.7	8.7	11.6	15.7	18.8	24.6
T_5	3.8	7.0	10.0	13.4	17.0	20.8	27.0
T_6	3.0	6.6	9.6	14.2	17.2	21.3	28.0
T_7	3.6	6.6	9.9	13.4	17.4	20.9	25.9
T_8	3.6	6.8	9.6	13.3	16.7	21.1	27.7
T_9	3.4	7.1	10.6	14.1	17.9	21.8	28.2
$LSD_{(0.05)}$	**0.87**	**0.90**	**1.19**	**1.87**	**2.21**	**2.53**	**3.22**
Level of significance	**NS**	*	**	**	*	*	*
Interaction effect of variety and preservative vase solutions							
V_1T_0	3.3	6.2	8.9	12.9	15.8	19.8	26.4
V_1T_1	4.2	7.3	10.7	14.2	19.1	22.2	27.8
V_1T_2	3.5	7.1	10	13.	16.7	20.4	26.7
V_1T_3	3.3	7.3	9.6	13.3	16.9	21.3	26.4
V_1T_4	3.3	5.5	8.7	11.6	14.9	17.8	23.6
V_1T_5	4	8.2	11.3	15.1	18.7	22.7	29.6
V_1T_6	2.7	6.6	9.3	13.6	16.9	20.9	27.1
V_1T_7	3.5	7.1	10.4	13.8	17.6	21.1	26.9
V_1T_8	3.5	7.3	10.0	14.2	17.8	22.2	29.1
V_1T_9	3.7	8	12.0	16.2	20.2	24.4	31.6
V_2T_0	2.9	5.3	8.2	11.6	15.1	18.9	25.1
V_2T_1	2.9	6.2	9.1	12.0	16.9	20.9	28.2
V_2T_2	2.9	6	9.3	12.9	16.9	20.9	27.8
V_2T_3	2.9	6.4	9.8	13.1	17.1	20.9	26.9
V_2T_4	3.1	5.7	8.7	11.6	16.4	19.8	25.6
V_2T_5	3.5	5.7	8.7	11.8	15.3	18.9	24.4
V_2T_6	3.3	6.4	9.8	14.9	17.6	21.8	28.9
V_2T_7	3.5	6	9.3	13.1	17.3	20.7	24.9
V_2T_8	3.5	6.2	9.1	12.4	15.8	20	26.2
V_2T_9	3.1	6.2	9.1	12	15.6	19.1	24.9
$LSD_{(0.05)}$	**1.22**	**1.28**	**1.69**	**2.64**	**3.12**	**3.58**	**4.55**
Level of significance	**	**	*	**	*	**	*

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = non-significant. V_1= Red, V_2= White, T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% Lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm CA

Table 5. Combined effects of flower variety and preservative vase solutions on pathogen attack of gerbera

Flower variety × Treatments	Pathogen attack at different days after treatment (DAT)						
	2	4	6	8	10	12	14
V_1T_0	-	-	-	-	-	-	-
V_1T_1	-	-	-	-	-	-	-
V_1T_2	-	-	-	-	-	-	-
V_1T_3	-	-	-	-	-	-	-
V_1T_4	-	-	-	-	-	+	+
V_1T_5	-	-	-	-	-	-	-
V_1T_6	-	-	-	-	+	+	+
V_1T_7	-	-	-	-	-	-	-
V_1T_8	-	-	-	-	-	-	-
V_1T_9	-	-	-	-	-	-	-
V_2T_0	-	-	-	-	-	-	-
V_2T_1	-	-	-	-	-	-	-
V_2T_2	-	-	-	-	-	-	-
V_2T_3	-	-	-	-	-	-	-
V_2T_4	-	-	-	-	-	-	+
V_2T_5	-	-	-	-	-	-	-
V_2T_6	-	-	-	-	+	+	+
V_2T_7	-	-	-	-	-	-	-
V_2T_8	-	-	-	-	-	-	-
V_2T_9	-	-	-	-	-	-	-

V_1 = Red, V_2 = White, T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% Lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm citric acid. No Pathogen Attack (-); Pathogen Attack (+).

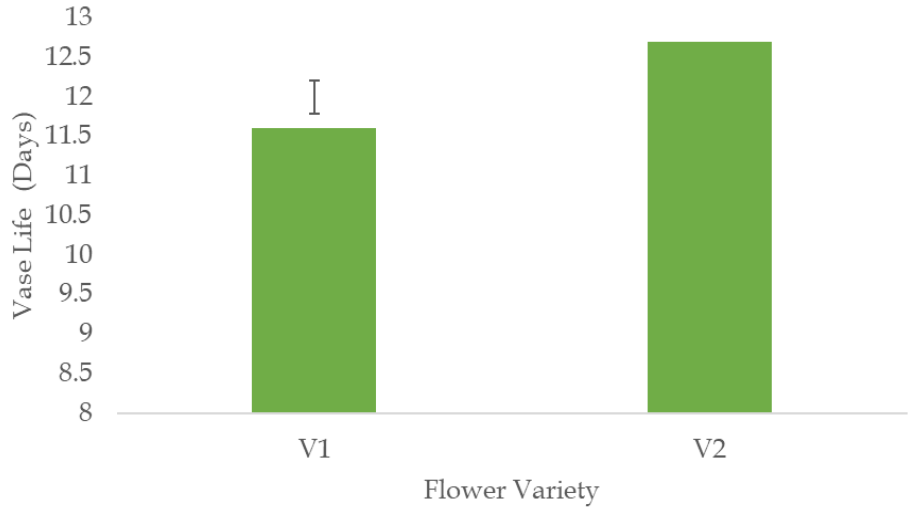

Fig. 1. Main effect of flower variety on vase life of gerbera. The vertical bar represents LSD at 5% level of significance.

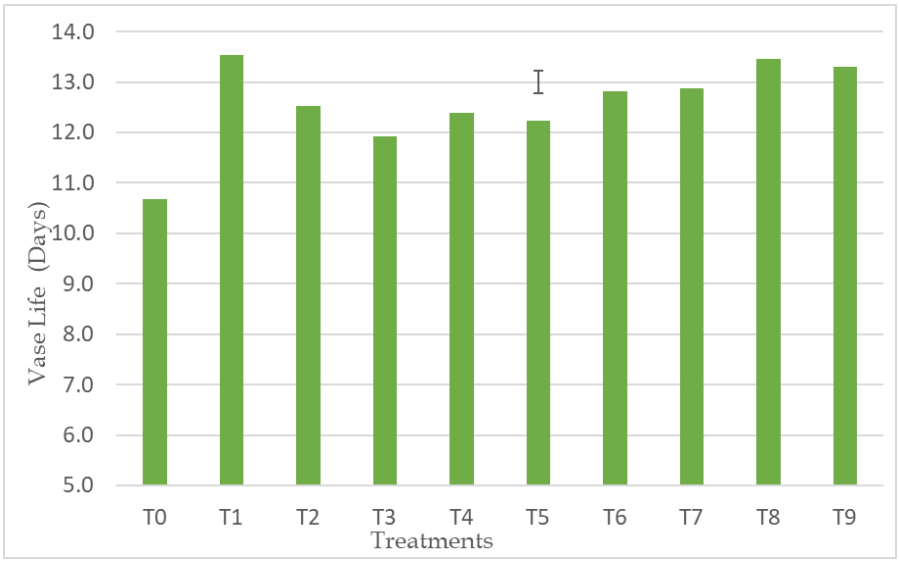

Fig. 2. Main effect of preservative vase solutions on vase life of gerbera.

The vertical bar represents LSD at 5% level of significance.

T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% Lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm CA.

Table 6. Combined effects of flower variety and preservative vase solutions on vase life of gerbera at different days after treatment (DAT)

Flower variety × Treatments	Vase life (Days)
V_1T_0	12.3
V_1T_1	11.5
V_1T_2	12.1
V_1T_3	10.7
V_1T_4	11.6
V_1T_5	10.3
V_1T_6	12.3
V_1T_7	11.6
V_1T_8	11.9
V_1T_9	12.4
V_2T_0	12.9
V_2T_1	12.8
V_2T_2	13.5
V_2T_3	12.0
V_2T_4	13.2
V_2T_5	11.7
V_2T_6	12.5
V_2T_7	13.1
V_2T_8	13.1
V_2T_9	12.9
$LSD_{(0.01)}$	**1.34**
$LSD_{(0.05)}$	**0.99**
Level of significance	**

**= Significant at 1% level of probability. V_1= Red, V_2= White, T_0- control (Tap water), T_1- 3% sucrose, T_2- 250 ppm citric acid, T_3- 250 ppm $AgNO_3$, T_4- 2% Lemon juice, T_5- 150 ppm citric Acid+ 150 ppm $AgNO_3$, T_6- 2% sucrose + 150 ppm citric acid, T_7- 2% sucrose + 150ppm $AgNO_3$, T_8- 1% sucrose + 100 ppm $AgNO_3$+ 1% Lemon juice and T_9- 1% sucrose + 100 ppm $AgNO_3$+ 100 ppm CA.

Conclusion

The study revealed significant variation in vase life of gerbera depending on flower variety and preservative solutions. Olivia white (V_2) showed longer vase life (12.7 days) compared to Sangria red (V_1) with 11.6 days. Among preservative vase solutions, 3% sucrose (T_1) and the combined solution of 1% sucrose + 100 ppm $AgNO_3$ + 1% lemon juice (T_8) were most effective, each extending vase life to 13.5 days. The best result was observed in the V_2T_2 combination (13.5 days). Therefore, citric acid alone or in combination is recommended for enhancing gerbera vase life, while further studies across varieties are suggested.

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