

## Optimization of Ascorbic Acid and Calcium Chloride Concentrations for Post-harvest Quality and Life of Gaillardia (*Gaillardia pulchella*)

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### ABSTRACT

The present study aimed at investigating the effects of different chemical sprays on the post-harvest life of Gaillardia (*Gaillardia pulchella*), an important annual used for garden decoration, cut and loose flower production. The treatments included different concentrations of calcium chloride and ascorbic acid, namely, ascorbic acid at 50, 100, 150, 200 and 250 ppm, and calcium chloride at 0.3, 0.4, 0.5, 0.6 and 0.7%, respectively. The results revealed that treatments T<sub>10</sub> (Calcium chloride 0.7%) and T<sub>2</sub> (Ascorbic acid 100 ppm) comparatively exhibited the highest weight percentage 17.33 and 15.85, respectively, at 72 h, while minimum was recorded in control. Regarding flower diameter, the T<sub>2</sub> treatment with ascorbic acid @ 100 ppm consistently displayed the largest diameter of 2.21 cm at the 72 h point. Moreover, T<sub>2</sub> (Ascorbic acid 100 ppm) exhibited the lowest percentage of shrinkage (57.48) at the same time frame. Assessing overall flower quality, the T<sub>10</sub> treatment (Calcium chloride 0.7%) scored the highest with a rating of 3, indicating "Fair" quality at the 72-h mark. Additionally, T<sub>10</sub> (Calcium chloride @ 0.7%) showed the longest post-harvest life of 2.26 days among all the treatments. Overall, the findings suggest that the application of calcium chloride at 0.7% (T<sub>10</sub>) and ascorbic acid at 100 ppm (T<sub>2</sub>) resulted in significantly enhancing the post-harvest longevity, visual appeal and quality of Gaillardia flowers.

**Key words:** Ascorbic acid, calcium chloride, TSS, shrinkage, post-harvest life

### INTRODUCTION

Gaillardia is used as loose flower, religious offering and garden decoration. Ascorbic acid (AsA) plays a vital role in protecting plants from oxidative stress caused by reactive oxygen species (ROS) and excessive light exposure. It acts as an antioxidant by eliminating ROS and maintaining the balance of antioxidants in the plant. Overall, AsA safeguards plants against oxidative stress and contributes to their ability to cope with high light intensity and prevent photooxidative damage (Hasanuzzaman and Fujita, 2022). AsA deficiency may accelerate senescence and affect flowering time through altered phytohormone levels, particularly gibberellins and abscisic acid, in a photoperiod dependent manner. Calcium is widely acknowledged as an indispensable nutrient for the overall growth and development of plants (Jing *et al.*, 2024). Thus, this research was planned to standardize the effective treatments that can be applied to the flowers after they have been harvested, thereby increasing their durability and enhancing their ability to remain fresh and vibrant for

an extended period of time. Therefore, an effort has been undertaken to investigate the use of specific chemicals such as ascorbic acid and calcium chloride in prolonging the longevity of Gaillardia loose flowers.

### MATERIALS AND METHODS

Experiment was conducted at Floriculture Experimental Laboratory, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab during the year 2023-24. The experiment was setup in completely randomized design (CRD), consisting of three replications and 11 treatments. The chemicals utilized in the experiment included calcium chloride and ascorbic acid viz, ascorbic acid T<sub>1</sub>-@ 50 ppm, T<sub>2</sub>-100 ppm, T<sub>3</sub>-150 ppm, T<sub>4</sub>-200 ppm, T<sub>5</sub>-250 ppm and calcium chloride T<sub>6</sub>-@ 0.3%, T<sub>7</sub>-0.4%, T<sub>8</sub>-0.5%, T<sub>9</sub>-0.6% and T<sub>10</sub>-0.7%.

### RESULTS AND DISCUSSION

The data on the percentage change in fresh weight of Gaillardia samples after applying

various sprays at 24, 48 and 72 h, visually illustrated changes over time. At the 24 h mark, the treatment with the highest percentage increase in weight was T<sub>1</sub> (Ascorbic acid 50 ppm) at 90.25%, while the lowest was recorded in T<sub>7</sub> (Calcium chloride 0.4%) with 82.11% (Table 1). Whereas the control showed a weight percentage of 83.15%. Moving to the 48 h mark, T<sub>2</sub> (Ascorbic acid 100 ppm) and T<sub>9</sub> (Calcium chloride 0.6%) displayed the highest percentage weight increase at 68.20 and 67.48%, respectively, and the lowest percentage change at 53.60% in control. Finally, at the 72 h, T<sub>10</sub> (Calcium chloride 0.7%) and T<sub>6</sub> (Calcium chloride 0.3%) had the maximum weight percentages of 17.33 and 16.76%, respectively. Overall, the data clearly demonstrated the varying effects of different sprays on the fresh weight of gaillardia flowers over the course of 24, 48 and 72 h. The lowest flower weight was observed in the control group, which recorded 1.03 g. The change in flower weight was basically due to the transpiration and respiration of flowers (Fanourakis *et al.*, 2021). Post-harvest spray of the calcium chloride and ascorbic acid on gaillardia helped in maintaining turgidity and sugar content in flowers ultimately supporting to improve the physiological loss in weight. Spoilage of gaillardia reduced due to antioxidant properties of calcium chloride which helped in maintaining the flower weight (Rakesh *et al.*, 2022). Similar results were recorded by Mohammadi *et al.* (2023) in Anthurium plants with different concentrations of ascorbic acid which improved growth parameters and reduced chilling injury. Ciriello *et al.* (2024)

**Table 1.** Effect of different chemical sprays on change in per cent fresh weight (%) of Gaillardia flowers

Treatment	24 h (%)	48 h (%)	72 h (%)
T <sub>1</sub> -Ascorbic acid 50 ppm	90.25	63.26	14.18
T <sub>2</sub> -Ascorbic acid 100 ppm	88.93	68.20	15.01
T <sub>3</sub> -Ascorbic acid 150 ppm	78.36	54.24	14.48
T <sub>4</sub> -Ascorbic acid 200 ppm	89.87	65.01	15.3
T <sub>5</sub> -Ascorbic acid 250 ppm	82.41	56.51	15.85
T <sub>6</sub> -Calcium chloride 0.3%	84.13	58.87	16.76
T <sub>7</sub> -Calcium chloride 0.4%	82.11	55.35	15.52
T <sub>8</sub> -Calcium chloride 0.5%	83.78	57.52	15.27
T <sub>9</sub> -Calcium chloride 0.6%	89.78	67.48	14.72
T <sub>10</sub> -Calcium chloride 0.7%	86.07	62.44	17.33
T <sub>11</sub> -Control	83.15	53.60	13.96
C. D. (P=0.05)	2.811	2.026	0.502
C. V.	1.94	1.98	1.93

also discovered least amount of weight loss in gerbera with pre-harvest calcium application. The maximum 5.2, 4.7, 3.72 and 2.21 cm flower diameter was recorded in treatment T<sub>2</sub> (Ascorbic acid 100 ppm) at 0, 24, 48 and 72 h consistently displaying the largest diameter among all the samples (Table 2). The minimum flower head diameters were observed in control. Heavy water loss from petal seems to be attributed due to flower shrinkage and smaller flower diameter in gaillardia. Water loss leads to local xylem failure and tissue damage in flowers (Carins-Murphy *et al.*, 2023). Less flower shrinkage meant maximum flower diameter which further led to minimising the respirational loss of carbohydrates and closure of stomata. This increment in floral diameter and dry weight of gaillardia flower might be due to foliar spray with ascorbic acid. Ascorbic acid is known for its ability to delay the aging process of flowers and increase the availability of respiratory sugar substrates. Similar results have been reported by Saeed (2020) in Gazania flower.

**Table 2.** Effect of different chemical sprays on the flower diameter of gaillardia flowers (cm)

Treatment	Fresh flower (cm)	24 h (cm)	48 h (cm)	72 h (cm)
T <sub>1</sub> -Ascorbic acid 50 ppm	5.20	4.30	3.32	2.13
T <sub>2</sub> -Ascorbic acid 100 ppm	5.20	4.70	3.72	2.21
T <sub>3</sub> -Ascorbic acid 150 ppm	4.90	4.40	3.41	2.07
T <sub>4</sub> -Ascorbic acid 200 ppm	5.00	4.20	3.20	2.01
T <sub>5</sub> -Ascorbic acid 250 ppm	4.80	4.30	3.30	1.90
T <sub>6</sub> -Calcium chloride 0.3%	4.80	4.20	3.21	1.95
T <sub>7</sub> -Calcium chloride 0.4%	5.00	4.20	3.22	2.02
T <sub>8</sub> -Calcium chloride 0.5%	5.10	4.25	3.26	2.00
T <sub>9</sub> -Calcium chloride 0.6%	5.20	4.44	3.43	1.97
T <sub>10</sub> -Calcium chloride 0.7%	4.90	4.55	3.52	1.98
T <sub>11</sub> -Control	5.00	4.02	3.01	1.90
C. D. (P=0.05)	0.16	0.09	0.04	0.04
C. V.	1.99	1.25	0.70	1.44

Minimum shrinkage percentage (10.3, 27.9 and 57.4) was observed in treatment T<sub>2</sub> (Ascorbic acid 100 ppm) in 24, 48 and 72 h, respectively, while T<sub>11</sub> (Control) recorded maximum shrinkage percentage (15.4, 39.5 and 62.1) in 24, 48 and 72 h, respectively (Table 3). The heavy water loss from petal seems to be attributed due to the flower shrinkage and minimum flower diameter of gaillardia. The lesser flower shrinkage further led to the minimized respirational loss of carbohydrates and closure of stomata (Carins-Murphy *et al.*, 2023). This increment in floral characteristics

**Table 3.** Effect of different chemical sprays on the flower shrinkage of gaillardia flowers (%)

Treatment	24 h (%)	48 h (%)	72 h (%)
T <sub>1</sub> -Ascorbic acid 50 ppm	13.74	34.06	58.99
T <sub>2</sub> -Ascorbic acid 100 ppm	10.35	27.96	57.48
T <sub>3</sub> -Ascorbic acid 150 ppm	10.56	30.43	57.75
T <sub>4</sub> -Ascorbic acid 200 ppm	15.18	35.37	59.72
T <sub>5</sub> -Ascorbic acid 250 ppm	10.58	31.41	60.34
T <sub>6</sub> -Calcium chloride 0.3%	12.49	32.66	59.37
T <sub>7</sub> -Calcium chloride 0.4%	14.68	35.55	59.48
T <sub>8</sub> -Calcium chloride 0.5%	16.32	37.35	60.61
T <sub>9</sub> -Calcium chloride 0.6%	14.82	33.72	61.86
T <sub>10</sub> -Calcium chloride 0.7%	8.50	27.55	59.61
T <sub>11</sub> -Control	15.40	39.59	62.12
C. D. (P=0.05)	0.42	0.40	0.43
C. V.	1.98	1.95	1.60

such as flower diameter and dry weight of flower was due to foliar spray with ascorbic acid. Similar results have been reported by Saeed (2020) in Gazania flower and by Rakesh *et al.* (2022) in gaillardia.

The impact of spraying on the overall flower quality was visually assessed based on factors such as freshness, turgidity and overall acceptability. The flowers were scored on a 5-point scale: 1-Dull, 2-Poor, 3-Fair, 4-Very good and 5-Excellent. The highest overall flower quality was observed in T<sub>10</sub> treatment (Calcium chloride 0.7%) with a score of 3, indicating a "Fair" quality (Table 4). On the other hand, the control group received the lowest score of 2, representing a "Poor" quality. Some of the treatments, namely, T<sub>2</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>7</sub>, T<sub>8</sub> and T<sub>9</sub>, all received similar scores of 2.66, indicating a "Fair" quality as well. The freshness index is a measure of the number of undamaged and healthy flowers. Ascorbic acid is known for its ability to delay the aging process of flowers and increase the availability of respiratory sugar substrates. This attributed to an improved

**Table 4.** Effect of different chemical sprays on overall quality of gaillardia flowers (visual basis)

Treatment	24 h	48 h	72 h
T <sub>1</sub> -Ascorbic acid 50 ppm	4.00	3.33	2.33
T <sub>2</sub> -Ascorbic acid 100 ppm	4.00	3.00	2.66
T <sub>3</sub> -Ascorbic acid 150 ppm	4.00	3.33	2.33
T <sub>4</sub> -Ascorbic acid 200 ppm	4.66	3.66	2.66
T <sub>5</sub> -Ascorbic acid 250 ppm	4.33	3.66	2.66
T <sub>6</sub> -Calcium chloride 0.3%	4.66	3.66	2.33
T <sub>7</sub> -Calcium chloride 0.4%	4.66	4.00	2.66
T <sub>8</sub> -Calcium chloride 0.5%	4.33	4.33	2.66
T <sub>9</sub> -Calcium chloride 0.6%	4.66	3.66	2.66
T <sub>10</sub> -Calcium chloride 0.7%	4.00	4.00	3.00
T <sub>11</sub> -Control	4.33	3.66	2.00

freshness index in gaillardia loose flowers. Similar positive outcomes were observed in earlier research conducted by Mu *et al.* (2022) with cut cauliflowers and by Reddy *et al.* (2016) with tuberose flowers.

Over the course of 24 h, the TSS (Total soluble solids) measurement showed the highest value in T<sub>3</sub> treatment (Ascorbic acid @ 150 ppm) at 2.83 Brix, while the lowest value was observed in T<sub>6</sub> treatment (Calcium chloride @ 0.3%) at 0.77 Brix (Table 5). Moving to the 48 h mark, T<sub>3</sub> treatment continued to exhibit the highest TSS value at 3.53 Brix, while the control group had the lowest value at 2.12 Brix. After 72 h, T<sub>3</sub> treatment once again had the highest TSS reading of 4.14 Brix, while the control group showed the lowest value at 3.02 Brix. The exogenous calcium chloride supply in brocolo is known to restrict the degradation of macro molecules and decrease the oxidative stress (Yan *et al.*, 2020) Thus, higher total dissolved solids in the petals pulse treated flowers can be attributed to lower degradation of cellular components by maintaining levels of macro and micro molecules in petal cells via turgidity due to foliar spray. As per earlier research (Tofighi *et al.*, 2021) calcium chloride played very important role in forming strong polymer bonds specially within tissue which menas it's a component of plant cell wall.

**Table 5.** Effect of different chemical sprays on TSS of gaillardia flowers (Brix)

Treatment	24 h	48 h	72 h
T <sub>1</sub> -Ascorbic acid 50 ppm	3.26	2.53	1.81
T <sub>2</sub> -Ascorbic acid 100 ppm	4.14	3.44	2.80
T <sub>3</sub> -Ascorbic acid 150 ppm	4.23	3.53	2.83
T <sub>4</sub> -Ascorbic acid 200 ppm	3.07	2.31	1.70
T <sub>5</sub> -Ascorbic acid 250 ppm	3.86	3.20	2.73
T <sub>6</sub> -Calcium chloride 0.3%	2.39	1.59	0.77
T <sub>7</sub> -Calcium chloride 0.4%	4.10	3.17	2.20
T <sub>8</sub> -Calcium chloride 0.5%	3.43	2.54	1.50
T <sub>9</sub> -Calcium chloride 0.6%	3.12	2.50	1.50
T <sub>10</sub> -Calcium chloride 0.7%	3.24	2.43	1.50
T <sub>11</sub> -Control	3.02	2.12	1.55
C. D. (P=0.05)	0.063	0.078	0.113
C. V.	1.94	1.72	1.93

At 72 h mark, the T<sub>2</sub> treatment with ascorbic acid @ 100 ppm showed the least percentage of spoilage (49.66), while the control group had a considerably higher percentage of spoilage (60). The lower percentage of spoilage in the T<sub>2</sub> treatment suggests that there were fewer damaged, wilted and rotten flowers compared to the control group (Table 6). Calcium chloride had antioxidant properties which played very

important role in forming strong polymer bonds specially within tissue (Shah *et al.*, 2022). Ultimately calcium chloride and ascorbic acid spray reduced the spoilage and damage of flowers and helped in delaying senescence. Delaying gaillardia senescence and improving market quality will directly help in farmers income level. Similar type of research was also recorded by Rakesh *et al.* (2022) in gaillardia and Saeed (2020) in gazania flower.

**Table 6.** Effect of different chemical sprays on percentage spoilage of gaillardia flowers (%)

Treatment	24 h (%)	48 h (%)	72 h (%)
T <sub>1</sub> -Ascorbic acid 50 ppm	23.99	42.33	56.33
T <sub>2</sub> -Ascorbic acid 100 ppm	22.33	25.43	49.66
T <sub>3</sub> -Ascorbic acid 150 ppm	25.36	30.83	52.43
T <sub>4</sub> -Ascorbic acid 200 ppm	27.66	36.66	53.33
T <sub>5</sub> -Ascorbic acid 250 ppm	25.40	37.66	54.13
T <sub>6</sub> -Calcium chloride 0.3%	27.49	44.00	56.33
T <sub>7</sub> -Calcium chloride 0.4%	26.16	36.46	57.33
T <sub>8</sub> -Calcium chloride 0.5%	26.00	36.33	52.99
T <sub>9</sub> -Calcium chloride 0.6%	23.36	30.32	52.66
T <sub>10</sub> -Calcium chloride 0.7%	22.68	26.34	53.33
T <sub>11</sub> -Control	27.66	44.76	60.00
C. D. (P=0.05)	0.82	0.96	1.69
C. V.	1.92	1.60	1.83

T<sub>10</sub> treatment (Calcium chloride @ 0.7%) exhibited the longest post-harvest life of 2.26 days (Table 7). This was followed by T<sub>9</sub> treatment (Calcium chloride @ 0.6%), which showed a post-harvest life of 2.23 days. In contrast, the control group had the shortest post-harvest life, lasting for only 0.97 days. The maximum post-harvest life was recorded in calcium chloride and ascorbic acid treated gaillardia which might be due to the initial continued metabolic activities like respiration and transpiration. Due to antioxidant properties of calcium chloride flower tissues developed strong polymer bonds specially within tissue meaning this helped in plants cell wall (Shah *et al.*, 2022). This further helped in closure of stomata and minimized the flower respirational loss from flowers (Zeltzer *et al.*, 2021). Similar studies were also recorded by Reddy *et al.* (2016) in tuberose flowers and by Rakesh *et al.* (2022) in gaillardia. Moreover, maximum total phenol content was recorded in ascorbic acid and calcium chloride sprayed gaillardia flowers as compared to control (Table 7). The higher level of total phenols during the post-harvest life of gaillardia which has been suggested to be due to ascorbic acid and calcium chloride antioxidant properties and

**Table 7.** Effect of different chemical sprays on electrolyte leakage (mS/s), total phenol content (mg/g) and post-harvest life (days) of gaillardia flowers

Treatment	Total phenol (mg/g)	Post-harvest life (days)
T <sub>1</sub> -Ascorbic acid 50 ppm	1.87	1.18
T <sub>2</sub> -Ascorbic acid 100 ppm	1.83	1.40
T <sub>3</sub> -Ascorbic acid 150 ppm	1.82	1.17
T <sub>4</sub> -Ascorbic acid 200 ppm	1.83	2.08
T <sub>5</sub> -Ascorbic acid 250 ppm	1.85	1.36
T <sub>6</sub> -Calcium chloride 0.3%	1.84	2.05
T <sub>7</sub> -Calcium chloride 0.4%	1.04	1.73
T <sub>8</sub> -Calcium chloride 0.5%	1.04	2.27
T <sub>9</sub> -Calcium chloride 0.6%	1.70	2.23
T <sub>10</sub> -Calcium chloride 0.7%	1.25	2.26
T <sub>11</sub> -Control	1.29	0.97
C. D. (P=0.05)	0.062	1.212
C. V.	1.91	1.19

oxidase enzymatic activity. Breda *et al.* (2025) also recorded the similar results in edible flowers like rose and marigold.

## CONCLUSION

Thus, it can be concluded that the chemical spray of ascorbic acid and calcium chloride significantly influenced the post-harvest quality and life of gaillardia flowers. Overall, the study suggested that the spraying of calcium chloride at 0.7% and ascorbic acid at 100 ppm hold promise in delaying senescence and enhancing the post-harvest longevity. Moreover, it boosted the flower weight, flower diameter, visual appeal, TSS and total phenol leading to the improvement in quality of gaillardia flowers. Improvement in all these parameters offers potential benefits to the farmers and horticulturists in the flower industry.

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