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Influence of floral preservative solutions on postharvest physiology, floret opening, senescence and vase life of *Gladiolus* (*Gladiolus grandiflorus* L.) cv. Saffron

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Abstract
The postharvest performance of gladiolus cv. Saffron was evaluated at Indira Gandhi Krishi Vishwavidyalaya, Raipur, during 2019–2020. Eighteen holding solutions, including a tap-water control, were compared in a completely randomized design with three replications. Treatments combined lime juice, tamarind juice or coconut water with Disprin, Listerine, rifampin or ampicillin; citric acid was also tested. The recorded outcomes included spike length, last-flower fading, initial floret wilting, petal shedding, vase life and spike longevity. According to the supplied tables, T_{15}, comprising rifampin with 30 mL each of lime juice, coconut water and tamarind juice, recorded a vase life of 12.56 days and longevity of 14.56 days, compared with 7.00 and 9.00 days in the control. Its first wilting and petal-shedding observations occurred at 7.44 and 8.11 days. Spike-length differences were reported as non-significant. The findings identify T_{15} as a promising treatment under the experimental conditions, subject to verification of discrepancies in the original results narrative.

Keywords: *Gladiolus*, Floral preservatives, Floret wilting, Vase life, Spike longevity

Introduction

The commercial value of a cut gladiolus spike depends on how well its florets retain their appearance after harvest. *Gladiolus grandiflorus* L., a member of the Iridaceae, is widely grown for ornamental use, including the cut-flower market in India. Its elongated inflorescence makes sequential floret development and the timing of deterioration particularly relevant to display quality (Bai *et al.*, 2009) [1]. A spike may remain presentable only while water supply and tissue condition are sufficient to sustain its developing and open florets.

Once a spike is detached from the plant, its water and substrate supply depend on stored reserves and the holding environment. Water uptake can decline if the stem base or conducting tissues become obstructed. Loss of turgor, changes in metabolism and deterioration of floral tissues can then reduce the useful display period. Harvest timing, cooling, transport, storage and the composition of the vase solution therefore need to be considered together rather than as independent operations (De *et al.*, 1999; Nowak *et al.*, 1990) [2, 3].

Holding solutions are intended to maintain conditions that favour continued hydration and floral development. Their ingredients may supply carbohydrates, influence acidity or limit microbial multiplication. The response depends on the flower crop and the concentration and combination of ingredients. A formulation that delays one visible symptom of deterioration does not necessarily improve every quality measure. Separate observations of wilting, petal loss and total vase life are consequently useful when comparing treatments.

Postharvest handling also determines how much of the quality established during cultivation is retained through marketing and display. Sangama (1997) [4] discussed losses associated with inadequate handling of ornamental crops. For growers and users, readily obtainable ingredients may be attractive, but accessibility alone does not establish their effectiveness. Experimental comparison with a water control is needed before a formulation can be considered useful.

Lime and lemon juices provide citric acid, making them potential ingredients for modifying the acidity of holding water; the citric acid content of these juices has been examined by Penniston *et al.* (2008) [5]. Coconut water was included in the present experiment as a locally available natural ingredient. Its proposed influence on senescence was part of the rationale for testing it, rather than a mechanism directly measured in this study.

This investigation compared natural ingredients and commercial or synthetic products, used alone or in combinations, for maintaining harvested gladiolus cv. Saffron. The principal aim was to identify which tested so

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lution produced the most favourable pattern of visible postharvest responses relative to tap water.

Materials and Methods

Experimental setting and design

The laboratory experiment was carried out during 2019–2020 in the Department of Floriculture and Landscape Architecture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. Eighteen treatments were arranged in a completely randomized design, with three replications. The manuscript reports maximum temperatures of 22.3–27.7 °C and minimum temperatures of 12.6–14.9 °C. The reported ranges of maximum and minimum relative humidity were 87.5–88.3% and 28.1–30.4%, respectively. These environmental values are retained from the supplied account; they are not additional measurements.

Plant material and preparation of spikes

Corms of cv. Saffron obtained from IGKV, Raipur, were treated with a systemic fungicide, shade-dried and planted at the departmental instructional farm. Spikes were collected in the morning at the tight-bud stage, when colour was visible in one to three basal buds. The original manuscript attributes this harvest criterion to De *et al.* (2000) [6]. Immediately after cutting, spikes were transferred to cold water and taken to the laboratory.

The stem portion between the basal cut and the lowest bud was standardized to 40 cm. The harvested material was randomized into 162 units, as stated in the original methods. Fresh weight was recorded before individual spikes were placed in glass bottles of 250 mL capacity containing 250 mL of the assigned holding solution. Each treatment had three replications. The relationship between the 162 units, the number of spikes per replication and the statistical experimental unit requires author confirmation.

Holding solutions and observations

Table 1 lists the eighteen formulations and their treatment codes. The water control is designated T_0, while T_1–T_{17} identify the other solutions. Treatment names, ingredient amounts and all tabulated numerical observations have been preserved from the submitted article. Product strengths, final concentrations and the distinction between bottle volume and solution volume should be confirmed where the source description does not provide sufficient detail.

Table 1. Formulations evaluated as holding solutions

S. No.	Notation	Treatment
1	T_1	Disprin tablet + Lime juice 30 ml
2	T_2	Disprin tablet + Coconut water 30 ml
3	T_3	Disprin tablet + Tamarind juice 30 ml
4	T_4	Listerine 20 ml + Lime juice 30 ml
5	T_5	Listerine 20 ml + Coconut water 30 ml
6	T_6	Listerine 20 ml + Tamarind juice 30 ml
7	T_7	Rifampin capsule + Lime juice 30 ml
8	T_8	Rifampin capsule + Coconut water 30 ml
9	T_9	Rifampin capsule + Tamarind juice 30 ml
10	T_{10}	Ampicillin capsule + Lime juice 30 ml
11	T_{11}	Ampicillin capsule + Coconut water 30 ml
12	T_{12}	Ampicillin capsule + Tamarind juice 30 ml
13	T_{13}	Dispirin tablet + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml
14	T_{14}	Listerine 20 ml + Tamarind Juice 30 ml + Coconut water 30 ml + Lime juice 30 ml
15	T_{15}	Rifampin capsule + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml
16	T_{16}	Ampicillin capsule + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml
17	T_{17}	Citric acid 300 ppm
18	T_0	Tap water

The recorded variables were cut-spike length, time to fading of the final flower, time to first floret wilting, time to first petal shedding, vase life and spike longevity. Results are presented using the original treatment means, standard errors and critical differences. The supplied article does not state the operational endpoint for every variable or the significance level used for the critical differences. Statistical interpretation is therefore confined to the information shown in the tables.

Results and Discussion

Spike length and fading of the final flower

Table 2 records spike lengths from 53.78 cm in T_9 to 85.62 cm in T_7; T_{15} measured 62.35 cm. The critical-difference entry for this variable is NS, indicating that the table reports no significant treatment effect on spike length. Accordingly, the numerical ranking does not support identifying T_{15}, or any other treatment, as significantly superior for this characteristic.

For fading of the final flower, T_{15} had the highest tabulated value, 6.63 days, followed by T_{16} at 5.48 days. The control value was 3.20 days. The difference between T_{15} and T_{16} was 1.15 days, exceeding the reported critical difference of 0.90 days. The manuscript narrative originally gave 29.78 days for T_{15}; that figure is inconsistent with Table 2 and must be checked against the primary records. The present account follows the table provisionally.

Retention of floral colour contributes to display quality, but the experiment did not measure pigment stability, membrane integrity or lipid peroxidation. Earlier work on salicylic acid in gladiolus and salicylic acid–sucrose solutions in *Antigonon* provides context for studying senescence and appearance (Hatamzadeh *et al.*, 2012; Hariri *et al.*, 2019) [7, 8]. These reports do not, by themselves, establish how the rifampin–juice–coconut-water mixture acted in this experiment.

Table 2. Spike length and time to fading of the final flower

Notation	Treatments	Length of Cut Spike (cm)	Days of fading of last flower
T_1	Disprin tablet + Lime juice 30 ml	61.57	3.78
T_2	Disprin tablet + Coconut water 30 ml	55.24	3.86
T_3	Disprin tablet + Tamarind juice 30 ml	54.67	3.57
T_4	Listerine 20 ml + Lime juice 30 ml	62.05	3.27
T_5	Listerine 20 ml + Coconut water 30 ml	60.74	4.50
T_6	Listerine 20 ml + Tamarind juice 30 ml	62.78	3.37
T_7	Rifampin capsule + Lime juice 30 ml	85.62	4.38
T_8	Rifampin capsule + Coconut water 30 ml	63.16	4.28
T_9	Rifampin capsule + Tamarind juice 30 ml	53.78	4.28
T_{10}	Ampicillin capsule + Lime juice 30 ml	55.63	3.66

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Notation	Treatments	Length of Cut Spike (cm)	Days of fading of last flower
T_{11}	Ampicillin capsule + Coconut water 30 ml	62.41	3.77
T_{12}	Ampicillin capsule + Tamarind juice 30 ml	68.53	3.60
T_{13}	Disprin tablet + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	62.25	4.39
T_{14}	Listerine 20 ml + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	60.32	4.38
T_{15}	Rifampin capsule + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	62.35	6.63
T_{16}	Ampicillin capsule + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	60.08	5.48
T_{17}	Citric acid 300 ppm	59.36	3.39
T_0	Tap water	67.46	3.20
S.Em±	S.Em±	0.93	0.38
CD	CD	NS	0.90

Initial floret wilting and petal shedding

The first floret wilted after 7.44 days in T_{15}, compared with 2.67 days in T_0 (Table 3). T_{16} and T_7 recorded 7.00 and 6.89 days, respectively. Although T_{15} had the highest mean, its differences from these two treatments were smaller than the listed critical difference of 1.04 days. Thus, the available table supports delayed wilting relative to the control, but not a statistically distinct advantage over every alternative formulation.

The highest mean time to first petal shedding was also recorded in T_{15}, at 8.11 days. T_{14} followed at 6.89 days, whereas the control recorded 2.78 days. The T_{15}–T_{14} difference of 1.22 days exceeds the reported critical difference of 0.89 days. Both the wilting and petal-shedding values differ from the 4.62-day figure repeated in the original narrative; the tabulated means have been used here pending verification.

Reduced microbial obstruction is one possible explanation for improved hydration in some holding solutions. The postharvest principles discussed by Nowak *et al.* (1990) [3] are consistent with examining this possibility. However, microbial counts and xylem conductance were not reported, so neither bacterial suppression nor improved vascular flow can be claimed as a demonstrated treatment mechanism.

Oxidative processes may also contribute to floral ageing, as discussed in the literature cited by the original article (Panavas *et al.*, 1998; Alaey *et al.*, 2011; Yamane, 1999) [10, 9, 11]. The present observations concern visible wilting and petal shedding. They do not establish changes in peroxidase activity, reactive oxygen species or membrane properties, because these variables were not measured.

Table 3. Time to first floret wilting and first petal shedding

Notation	Treatments	Days of first floret wilting	Days of first Petal Dropping
T_1	Disprin tablet + Lime juice 30 ml	3.67	3.78
T_2	Disprin tablet + Coconut water 30 ml	4.11	4.33
T_3	Disprin tablet + Tamarind juice 30 ml	4.00	4.22
T_4	Listerine 20 ml + Lime juice 30 ml	3.46	6.35
T_5	Listerine 20 ml + Coconut water 30 ml	3.57	6.44
T_6	Listerine 20 ml + Tamarind juice 30 ml	3.27	3.36
T_7	Rifampin capsule + Lime juice 30 ml	6.89	5.42
T_8	Rifampin capsule + Coconut water 30 ml	6.67	6.56
T_9	Rifampin capsule + Tamarind juice 30 ml	6.33	4.38
T_{10}	Ampicillin capsule + Lime juice 30 ml	6.56	5.60
T_{11}	Ampicillin capsule + Coconut water 30 ml	5.67	5.33
T_{12}	Ampicillin capsule + Tamarind juice 30 ml	6.00	6.78
T_{13}	Disprin tablet + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	6.44	6.67
T_{14}	Listerine 20 ml + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	6.67	6.89
T_{15}	Rifampin capsule + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	7.44	8.11
T_{16}	Ampicillin capsule + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	7.00	6.78
T_{17}	Citric acid 300 ppm	6.36	6.00
T_0	Tap water	2.67	2.78
S.Em±	S.Em±	0.55	0.37
CD	CD	1.04	0.89

Vase life and spike longevity

T15 recorded the highest mean vase life, 12.56 days, while the tap-water control recorded 7.00 days (Table 4). T_{16} gave 12.11 days and T_7 gave 11.89 days. The differences between T_{15} and these two treatments were 0.45 and 0.67 days, both below the listed critical difference of 0.76 days. The results therefore show a higher numerical mean for T_{15} without establishing that it differed significantly from

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T_{16} or T_7.

The longevity values followed a similar pattern. T_{15} reached 14.56 days, T_{16} reached 14.11 days and the control reached 9.00 days. The 0.45-day difference between T_{15} and T_{16} was below the reported critical difference of 0.68 days. Vase life and longevity are retained as distinct variables because they were separately tabulated in the submission; their precise assessment criteria need to be supplied by the authors.

The combined formulation could have influenced solution chemistry, microbial activity or water relations. Studies of antibiotic-containing solutions in chrysanthemum and citric-acid sources provide relevant background (Hashemabadi *et al.*, 2013; Penniston *et al.*, 2008) [12, 5]. Nevertheless, the present design does not isolate the contribution of each ingredient within T_{15}. The observed benefit cannot be attributed specifically to rifampin, lime juice, coconut water or tamarind juice.

General reviews of cut-flower postharvest performance, including da Silva (2003) [13], offer a framework for interpreting these outcomes. For this experiment, the defensible inference is that the tested mixture was associated with delayed visible deterioration relative to water. Claims that it lowered pH, changed viscosity or prevented vascular blockage require measurements that are absent from the submitted account.

Table 4. Vase life and longevity of harvested spikes

Notation	Treatments	Vase life of spike (days)	Longevity of spike (days)
T_1	Disprin tablet + Lime juice 30 ml	10.89	12.78
T_2	Disprin tablet + Coconut water 30 ml	11.67	12.77
T_3	Disprin tablet + Tamarind juice 30 ml	11.33	13.22
T_4	Listerine 20 ml + Lime juice 30 ml	11.67	13.11
T_5	Listerine 20 ml + Coconut water 30 ml	11.33	12.86
T_6	Listerine 20 ml + Tamarind juice 30 ml	11.33	13.33
T_7	Rifampin capsule + Lime juice 30 ml	11.89	13.67
T_8	Rifampin capsule + Coconut water 30 ml	10.78	13.67
T_9	Rifampin capsule + Tamarind juice 30 ml	11.00	13.00
T_{10}	Ampicillin capsule + Lime juice 30 ml	11.33	13.33
T_{11}	Ampicillin capsule + Coconut water 30 ml	11.33	13.33
T_{12}	Ampicillin capsule + Tamarind juice 30 ml	10.89	12.89
T_{13}	Disprin tablet + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	11.44	13.44
T_{14}	Listerine 20 ml + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	11.33	13.33
T_{15}	Rifampin capsule + Lime juice 30 ml + Coconut water 30 ml + Tamarind juice 30 ml	12.56	14.56
T_{16}	Ampicillin capsule + Tamarind juice 30 ml + Coconut water 30 ml + Lime juice 30 ml	12.11	14.11
T_{17}	Citric acid 300 ppm	11.22	13.22
T_0	Tap water	7.00	9.00
S.Em±	S.Em±	0.26	0.23
CD	CD	0.76	0.68

Conclusion

Several holding solutions produced longer display periods than tap water in the supplied dataset for gladiolus cv. Saffron. T_{15}, containing rifampin with 30 mL each of lime juice, coconut water and tamarind juice, had the highest tabulated means for final-flower fading, first wilting, first petal shedding, vase life and longevity. Its vase life and longevity were 12.56 and 14.56 days, respectively. These numerical advantages were not statistically distinct from all competing treatments, and spike-length differences were reported as nonsignificant.

The findings support further evaluation of the formulation under clearly defined experimental conditions. They do not establish the physiological or antimicrobial mechanism involved. Before publication, discrepancies between the original prose and tables, missing treatment strengths and incomplete assessment criteria should be resolved using the experimental records.

Author verification required before submission

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Check Table 2 against the primary records: the original narrative gives 29.78 days for fading of the final flower, while the table gives 6.63 days for T_{15}. For first wilting and petal shedding, the narrative repeats 4.62 days, whereas Table 3 gives 7.44 and 8.11 days. This revision provisionally uses the tables; no table values were altered.

Clarify the 162 units, the number of spikes in each replication and the statistical experimental unit. Give the statistical procedure and significance level, and define the endpoints used for fading, vase life and longevity.

Confirm tablet/capsule strengths and final concentrations. The original conclusion mentions rifampin 200 mg, but the treatment table does not specify that strength. Confirm whether lime or lemon juice was actually used and explain how 250 mL of solution was held in a nominally 250 mL bottle.

Verify all reference details against the original publications. The De *et al.* (2000) [6] entry appears to combine unrelated bibliographic information; the Yamane (1999) [11] entry is incomplete. The original discussion cited Darandeh and Hadavi (2010), but no corresponding reference was supplied, so that untraceable comparison has not been re

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