



RESEARCH ARTICLE

Optimisation of postharvest treatments for enhancing shelf life and quality of *Ixora* genotypes

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Abstract

This study aimed to optimise postharvest management practices for improving the shelf life and quality of *Ixora* flowers under ambient and refrigerated storage conditions. Three commercial semi-tall *Ixora* genotypes, namely yellow, white and red semi-tall types, were evaluated during 2023–24. Flower cymes were subjected to six postharvest treatments involving boric acid (2 % and 4 %) under ambient and refrigerated storage (5 °C). Visual quality traits, including freshness index (FI), flower opening index (FOI), colour retention index (CRI) and shelf life, along with physiological parameters such as moisture content, relative water content (RWC) and physiological weight loss (PWL), were assessed on the 3rd, 6th and 9th days of storage. Red semi-tall (G₃) recorded higher FI, CRI, moisture content, RWC and lower PWL compared with the other genotypes. Among the treatments, T₄ (2 % boric acid + refrigeration at 5 °C) recorded the highest FI, CRI, moisture content, RWC and shelf life. The G₃T₄ combination recorded the longest shelf life (230.40 hr) while maintaining favourable visual and physiological quality attributes. The enhanced postharvest performance observed under T₄ may be attributed to improved membrane stability, reduced transpiration, better water retention and delayed senescence. The findings indicate that the combined application of 2 % boric acid and refrigerated storage at 5 °C is an effective approach for maintaining postharvest quality and extending the shelf life of *Ixora* flowers under commercial storage conditions.

Keywords: boric acid; *Ixora* genotypes; quality preservation; shelf life; storage conditions

Introduction

Ixora is a genus of flowering plants belonging to the family Rubiaceae, comprising tropical evergreen trees and shrubs. It includes more than 500 species, with its greatest diversity found in Tropical Asia and throughout the world (1). *Ixora* is widely cultivated as an ornamental shrub in gardens and landscape systems due to its attractive floral display (2). The plants have dense branching with dark green, oblong leaves. Their terminal inflorescences form dense corymbs, each containing 15–50 tubular florets with 4 or 5 calyx lobes. Red and red-orange are the most common flower colours. However, varieties with white, yellow, salmon or pink flowers are also common and are now widely cultivated and sold in flower markets (3). In Tamil Nadu, *Ixora* is commercially grown as a loose flower, primarily in the districts of Karur, Tiruchirappalli, Salem and Dindigul (4). The blooms are used for religious offerings, floral decorations and as value-added products like garland making, often combined with other flowers.

Effective postharvest management of ornamental plants like *Ixora* is essential for preserving their quality and extending shelf life. Optimising postharvest practices is essential to minimise physiological and biochemical changes that lead to wilting, discoloration and reduced flower longevity. Various factors, including storage conditions, handling techniques and treatment with preservatives significantly influence the shelf life of *Ixora* genotypes. Identification of effective postharvest strategies can improve freshness, visual quality and marketability of flowers.

Previous studies have highlighted the importance of postharvest treatments in maintaining flower quality and extending shelf life in ornamental crops. In jasmine (*Jasminum sambac* (L.) Aiton), the application of boric acid, suitable packaging materials and refrigerated storage significantly improved freshness, colour retention and flower longevity (5–8). Similarly, in tuberose (*Polianthes tuberosa* L.), chemical preservatives and storage treatments were found to reduce physiological deterioration and

enhance postharvest quality (9). Studies in carnation (*Dianthus caryophyllus* L.) and rose (*Rosa* spp.) have shown that the use of floral preservatives and low-temperature storage effectively delayed senescence, maintained water balance and prolonged vase life (10). In gerbera (*Gerbera jamesonii* Adlam), postharvest treatments involving preservative solutions and controlled storage conditions improved water uptake, reduced microbial growth and enhanced flower longevity (11). These studies demonstrate that appropriate postharvest treatments are essential for preserving flower quality and reducing postharvest losses in ornamental species. However, similar information on standardised postharvest management practices for *Ixora* is limited, necessitating further investigation.

The present study was undertaken to evaluate and optimise postharvest treatments for improving the shelf life and quality of *Ixora* genotypes. Despite the commercial importance of *Ixora*, limited information is available on standardised postharvest treatments for extending shelf life under different storage conditions. The study hypothesised that boric acid application combined with refrigerated storage could improve postharvest quality and extend the shelf life of *Ixora* flowers. Identification of suitable storage conditions and postharvest treatments may help growers and retailers reduce post-harvest losses and improve flower quality.

Materials and Methods

The present investigation was carried out during 2023–24 at the Laboratory of the Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The study was undertaken to evaluate the effectiveness of different postharvest treatments in extending the shelf life and maintaining the quality of *Ixora* flowers under ambient and refrigerated storage conditions. Three commercially important semi-tall *Ixora* genotypes, namely Yellow (G_1), White (G_2) and Red (G_3), were selected from the germplasm collection maintained at the department. Freshly harvested and fully opened flower cymes of uniform size and maturity were collected during the morning hours for the experiment (Fig. 1). Flowers were stored under ambient laboratory conditions ($25 \pm 2^\circ\text{C}$ and 65–70 % relative humidity (RH)) or under refrigerated conditions ($5 \pm 1^\circ\text{C}$ and 85–90 % RH). Storage was carried out in a laboratory refrigerator and temperature was monitored using a digital thermometer. Boric acid solutions (2 %

and 4 %) were prepared by dissolving 20 g and 40 g of boric acid, respectively, in distilled water and making up the volume to 1 L. After treatment application, flower cymes were packed in low-density polyethylene (LDPE) bags (approximately 30×20 cm; 200-gauge thickness) and stored according to the respective treatments. Each replication consisted of 10 flower cymes, resulting in 30 flower cymes per treatment across 3 replications. Flower cymes were randomly assigned to treatments and replications following the principles of a factorial completely randomised design (FCRD). Observations were taken on postharvest days 3rd, 6th and 9th. Parameters considered under visual quality assessment included freshness index (FI), flower opening index (FOI), colour retention index (CRI) and shelf life. Freshness index, FOI, CRI, shelf life, moisture content, relative water content (RWC) and physiological weight loss (PWL) were assessed using standard procedures. Flower opening index was obtained from a three-point evaluation process consisting of unopened, partly opened and totally opened flowers. Colour retention index was rated on a visual basis, scored from 1–9, whereby high scores were indicative of better colour retention. Shelf-life was measured in terms of total time (in hours) within which more than 50 % of the flowers stayed fresh and marketable. Flowers were considered unmarketable when more than 50 % of florets showed wilting, browning, discolouration or loss of turgidity. Some physiological indices used for data collection included moisture content, RWC and PWL. Moisture content was computed as a ratio of fresh and dry weight following oven drying at 70°C . Relative water content was calculated by fresh, turgid and dry weight of flower samples. Physiological weight loss on the other hand was obtained from changes in fresh weight due to storage. This study employed FCRD in its experimental design with 3 replications. Data were analysed using factorial analysis of variance (ANOVA) under FCRD. Treatment means were compared using the critical difference (CD) test at $p \leq 0.05$.

Visual quality parameters

Freshness index (FI)

The number of flowers that remained fresh without signs of petal necrosis, drooping or browning was recorded. The results are expressed as the percentage of fresh flowers or as a FI.

Freshness index =

$$\frac{\text{Number of flowers remained fresh}}{\text{Total number of flowers}} \times 100$$

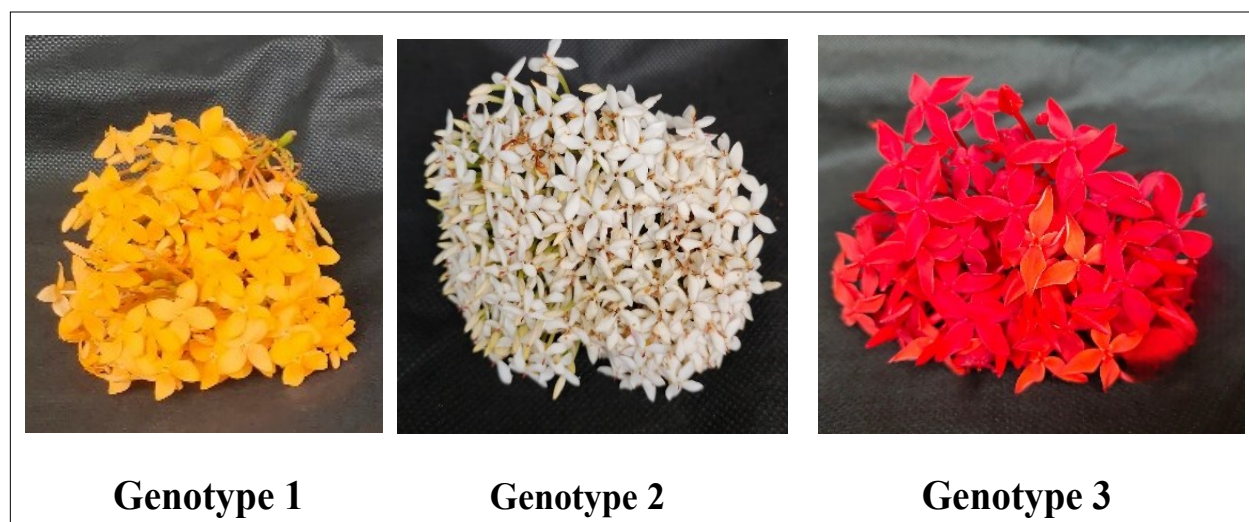


Fig. 1. *Ixora* genotypes used in the study.

Flower opening index (FOI)

The flower opening index (FOI) was calculated using the following formula:

$$\text{Flower opening index} = \frac{(0 \times X_1) + (1 \times X_2) + (2 \times X_3)}{(X_1 + X_2 + X_3)} \times 100$$

Colour retention index

The retention of various colours of *Ixora* flowers was recorded using the following scoring system:

Colour retention index (CRI) was recorded by using the following formula:

$$\text{CRI} = \frac{(9 \times X_1) + (8 \times X_2) + (7 \times X_3) + (6 \times X_4) + (5 \times X_5) + (4 \times X_6) + (3 \times X_7) + (2 \times X_8) + (1 \times X_9)}{(X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9) \times 9} \times 100$$

where X_1 – X_9 represent flowers assigned to colour retention scores ranging from 9 (excellent retention) to 1 (complete discolouration).

Shelf life

The shelf life of flowers was determined by recording the number of hours during which 50 % or more of the blooms remained fresh, beyond which necrotic signs appear and the petals began to wilt and fade.

Physiological parameters

Moisture content

Moisture content of opened *Ixora* flowers was determined by measuring their fresh and dry weight after drying at 70 °C in a hot air oven. It was expressed as a percentage of fresh weight and mean values of repeated samples were calculated.

$$\text{Moisture content} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Relative water content (%)

Flower bunches were weighed fresh, floated on water for 2 hr, then re-weighed after blotting. Dry weight was measured after drying at 70 °C. Relative water content (RWC) was calculated as a percentage,

using the mean of replicated samples.

$$\text{RWC} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Turgid weight} - \text{dry weight}} \times 100$$

Physiological weight loss (%)

The percentage of physiological weight loss (PWL) of the entire flower buds was calculated using the following formula:

$$\text{PWL} = \frac{\text{Fresh weight (1st day)} - \text{Weight (2nd day)}}{\text{Fresh weight (1st day)}} \times 100$$

The

observations were taken on the 3rd, 6th and 9th day after treatment. Data were subjected to factorial ANOVA using OPSTAT software and treatment means were separated using the CD test at $p \leq 0.05$.

Results and Discussion

Among the three genotypes, red semi-tall (G_3) recorded significantly higher values for FI and CRI than the other genotypes, showing the highest mean FI (90.72 %, 80.55 % and 69.41 %) (Table 1) and CRI (91.33 %, 83.80 % and 73.51 %) (Table 2) on the 3rd, 6th and 9th days of storage of *Ixora* flowers. The lowest FI and CRI were recorded in genotype 2 (white semi-tall), with the values of (86.36 %, 75.87 % and 64.08 %) and (87.00 %, 78.90 % and 67.20 %), respectively. In terms of flower opening of *Ixora*, red semi-tall (G_3) exhibited the lowest mean FOI on the same storage days (20.82 %, 37.58 % and 47.62 %) while genotype 2 (white semi-tall) had the highest (28.69 %, 43.67 % and 53.60 %) (Table 3). Regarding shelf life, red semi-tall (G_3) had the longest mean shelf life of 191.11 hr, followed by genotype 1 (yellow semi-tall) with 186.24 hr, while genotype 2 (white semi-tall) had the shortest of 172.08 hr. The extended shelf life observed in G_3 may be associated with higher moisture retention and reduced PWL during storage, resulting in delayed senescence and improved postharvest quality.

In terms of physiological parameters, red semi-tall (G_3) was recorded the highest mean moisture content (68.84 %, 58.49 % and 48.55 %) (Table 4) and highest mean RWC (91.68 %, 81.61 % and 71.65 %) respectively on the 3rd, 6th and 9th days of storage (Table 5) whereas the genotype 2 (white semi-tall) recorded the lowest moisture content (62.02 %, 51.17 % and 41.34 %) and mean RWC

Table 1. Freshness index (%) of *Ixora* genotypes during storage period

Factors		Freshness index (%)											
Genotypes		3 rd day				6 th day				9 th day			
Treatments		G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁		82.29	79.31	83.71	81.77	70.22	68.00	73.03	70.42	59.65	55.92	60.90	58.82
T ₂		85.02	82.05	85.09	84.05	72.45	70.88	75.56	72.96	61.87	59.02	64.49	61.79
T ₃		89.38	88.59	92.58	90.18	78.99	78.45	82.78	80.07	68.45	66.44	70.81	68.57
T ₄		94.50	92.60	98.12	95.07	85.03	82.03	88.44	85.16	76.93	72.09	78.77	75.93
T ₅		86.00	86.54	89.39	87.31	77.42	76.99	79.21	77.87	65.92	64.03	67.45	65.80
T ₆		90.05	89.07	95.45	91.52	80.11	78.87	84.29	81.09	71.38	67.00	74.03	70.80
Mean		87.87	86.36	90.72		77.37	75.87	80.55		67.37	64.08	69.41	
Treatments		G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)		0.68	0.96	1.66		0.67	0.94	1.63		0.61	0.86	1.49	
CD (0.05)		1.38	1.96	3.43		1.36	1.92	3.30		1.24	1.75	3.07	

Table 2. Colour retention index (%) of *Ixora* genotypes during the storage period

Factors		Colour retention index (%)											
Genotypes		3 rd day				6 th day				9 th day			
Treatments		G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁		83.15	81.19	86.15	83.50	75.34	73.39	78.18	75.64	64.64	59.23	65.76	63.21
T ₂		85.72	84.40	87.12	85.75	76.80	76.92	80.43	78.05	66.92	62.03	69.90	66.28
T ₃		88.15	85.72	88.51	87.46	80.01	78.28	82.51	80.27	70.18	66.00	72.40	69.53
T ₄		95.00	92.01	99.53	95.51	86.67	84.70	91.72	87.70	75.45	75.45	82.89	77.93
T ₅		89.21	88.54	89.52	89.09	80.02	79.00	81.92	80.13	69.09	68.78	71.67	69.85
T ₆		92.15	90.12	97.13	93.13	82.00	81.09	88.04	83.71	72.00	71.71	78.45	74.05
Mean		88.90	87.00	91.33		80.14	78.90	83.80		69.71	67.20	73.51	
Treatments		G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)		0.75	1.06	1.83		0.63	0.89	1.55		0.60	0.85	1.48	
CD (0.05)		1.52	2.15	3.79		1.29	1.82	3.09		1.23	1.74	3.01	

Table 3. Flower opening index (%) of *Ixora* genotypes during storage period

Factors	Flower opening index (%)											
Genotypes	3 rd day				6 th day				9 th day			
Treatments	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁	29.34	35.44	25.09	29.96	44.00	50.03	40.34	44.79	54.34	60.29	50.29	54.97
T ₂	28.56	33.00	23.28	28.28	43.56	48.29	38.29	43.38	53.66	57.61	48.01	53.09
T ₃	26.00	28.66	22.33	25.66	41.22	43.44	37.03	40.56	51.34	53.03	47.83	50.73
T ₄	17.86	20.56	14.23	17.55	32.19	35.20	39.62	35.67	42.30	45.45	49.49	45.75
T ₅	25.19	30.28	21.56	25.68	40.39	45.59	36.49	40.82	50.76	55.99	46.31	51.02
T ₆	22.98	24.23	18.45	21.89	37.81	39.48	33.71	37.00	47.61	49.22	43.77	46.87
Mean	24.99	28.69	20.82		39.86	43.67	37.58		50.00	53.60	47.62	
Treatments	G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)	0.22	0.32	0.55		0.24	0.34	0.58		0.48	0.68	1.18	
CD (0.05)	0.46	0.65	1.12		0.49	0.69	1.19		0.98	1.39	2.41	

Table 4. Moisture content (%) of *Ixora* genotypes during the storage period

Factors		Moisture content (%)											
Genotypes		3 rd day				6 th day				9 th day			
		G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
Treatments		G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁		54.86	52.12	59.82	55.60	43.23	43.12	48.34	44.90	34.13	32.09	38.67	34.96
T ₂		61.57	59.71	64.48	61.92	50.34	48.67	54.67	51.22	40.11	38.29	44.32	40.91
T ₃		65.02	63.92	70.87	66.60	54.02	52.19	60.61	55.61	43.67	43.70	50.17	45.85
T ₄		73.80	68.32	76.45	72.86	62.89	59.01	65.34	62.41	53.39	49.34	55.45	52.73
T ₅		64.30	62.82	69.31	65.48	54.37	49.00	59.71	54.36	42.24	39.45	49.62	43.77
T ₆		68.12	65.23	72.10	68.48	57.25	55.03	62.27	58.18	46.00	45.20	53.08	48.09
Mean		64.61	62.02	68.84		53.68	51.17	58.49		43.26	41.34	48.55	
Treatments		G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)		0.65	0.92	1.60		0.44	0.62	1.08		0.38	0.54	0.94	
CD (0.05)		1.33	1.88	3.59		0.90	1.27	2.20		0.78	1.10	1.91	

Table 5. Relative water content (%) of *Ixora* genotypes during the storage period

Factors	Relative water content (%)											
Genotypes	3 rd day				6 th day				9 th day			
Treatments	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁	81.10	78.54	85.49	81.71	71.25	68.45	75.43	71.71	61.45	58.73	65.33	61.84
T ₂	83.35	80.45	88.51	84.10	73.55	70.67	78.24	74.15	63.78	60.44	68.11	64.11
T ₃	90.22	89.51	92.54	90.76	80.33	79.23	82.45	80.67	70.23	69.21	72.88	70.77
T ₄	94.80	92.02	97.80	94.87	84.56	82.05	87.66	84.76	74.62	72.00	77.56	74.73
T ₅	87.52	85.46	90.51	87.83	77.23	75.29	80.53	77.69	67.22	65.23	70.56	67.67
T ₆	93.34	90.05	95.20	92.86	83.50	80.22	85.34	83.02	73.67	70.87	75.45	73.33
Mean	88.71	86.00	91.68		78.40	75.99	81.61		68.50	66.08	71.65	
Treatments	G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)	0.94	1.32	2.29		0.65	0.92	1.60		0.63	0.89	1.54	
CD (0.05)	1.91	2.70	4.58		1.33	1.88	3.29		1.28	1.81	3.18	

(86.00 %, 75.99 % and 66.08 %) on the same days. Red semi-tall (G₃) recorded the lowest mean PWL during storage with values of 6.88 %, 14.93 % and 22.94 % on the 3rd, 6th and 9th days respectively (Table 6). In contrast, genotype 2 (white semi-tall) showed the highest mean PWL, recording 8.93 %, 17.07 % and 25.02 % on the same days. Among the postharvest treatments, T₄ (2 % boric acid + refrigeration at 5 °C) recorded the highest FI (95.07 %, 85.16 % and 75.93 %), CRI (95.51 %, 87.70 % and 77.93 %), moisture content (72.86 %, 62.41 % and 52.73 %), RWC (92.86 %, 83.02 % and 73.33 %) and shelf life (214.64 hr). In contrast, T₁ (control) recorded the lowest values for these parameters during storage. Various preservatives and methods were evaluated to extend the shelf life of flowers, focusing on indicators such as FI, CRI and longevity. This study explored the use of boric acid at different concentrations, both with and without refrigeration, to enhance the postharvest life of flowers. Boric acid improved membrane stability, increased resistance to senescence and elevated protein content (12). In terms of visual quality, treatment T₄ (boric acid 2 % + refrigeration at 5 °C) proved most effective, followed by T₆ (boric acid 4 % + refrigeration at 5 °C). Freshness index, CRI, FOI and overall shelf life were highest in G₃T₄, aligning with findings on jasmine, where low-temperature storage and chemical treatments reduced decay rates (13). Higher freshness indices indicated better water retention and cellular integrity, delaying senescence and supporting metabolic activity. In contrast, a low FOI suggested slower metabolic rates, contributing to longer floral longevity. Colour retention is crucial for maintaining pigment stability, influencing photosynthesis and energy production (14).

Wilting and tissue dehydration were linked to reduced RWC, reflecting the moisture status of flower petals (15). Also noted that boric acid treatments and polypropylene bag storage extended jasmine shelf life.

As storage duration increased, the effects of treatments on PWL became more pronounced (16). Flowers are susceptible to stresses like insufficient warmth, dehydration and mechanical damage, which can alter colour, shorten lifespan and reduce visual appeal. Ethylene, a natural plant hormone, contributes to colour degradation (17). Flowers treated with boric acid exhibited better colour retention and less phenol deposition than controls. Some findings have confirmed the positive impact of boric acid on postharvest longevity in jasmine (18). As a mineral salt, boric acid enhances water balance, osmotic concentration and pressure potential in flower petal cells, extending the vase life of cut flowers (10). Among all treatments, T₄ had the most significant effect on extending the shelf life (Fig. 2) of *Ixora* flowers, likely due to improved sugar retention and transport to the corolla, alongside the anti-ethylene properties of boric acid. The investigation found that on the 9th day post-packaging, the G₃T₄ treatment (red semi-tall (G₃) + 2 % boric acid + refrigeration at 5 °C) demonstrated the highest moisture and RWC, along with the lowest PWL. Flowers with RWC and moisture levels exhibited lower PWL, thereby maintaining better freshness and turgidity during storage (19). Increased PWL reduced fresh weight, resulting in wilting and deterioration of flower quality (20).

The current results are especially relevant due to the lack of data on postharvest handling of *Ixora* and other plants from the

Table 6. Physiological weight loss (%) of *Ixora* genotypes during the storage period

Factors	Physiological weight loss (%)											
Genotypes	3 rd day				6 th day				9 th day			
	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean	G ₁	G ₂	G ₃	Mean
T ₁	9.62	10.55	8.00	9.39	17.73	18.67	16.02	17.47	25.84	26.51	24.08	25.48
T ₂	9.22	10.02	7.85	9.03	17.23	18.23	15.89	17.12	25.30	26.11	23.92	25.11
T ₃	7.98	8.85	6.89	7.91	15.99	16.93	14.94	15.95	23.98	24.95	22.96	23.96
T ₄	6.35	7.01	5.02	6.13	14.56	15.37	13.02	14.32	22.54	23.39	21.03	22.32
T ₅	8.52	9.02	7.50	8.35	16.34	17.06	15.67	16.36	24.44	25.04	23.60	24.36
T ₆	7.22	8.12	6.00	7.11	15.33	16.13	14.01	15.16	23.56	24.14	22.06	23.25
Mean	8.15	8.93	6.88		16.20	17.07	14.93		24.28	25.02	22.94	
Treatments	G	T	G × T		G	T	G × T		G	T	G × T	
SE (d)	0.05	0.08	0.13		0.12	0.17	0.29		0.21	0.29	0.50	
CD (0.05)	0.11	0.15	0.27		0.24	0.34	0.59		0.42	0.59	1.01	

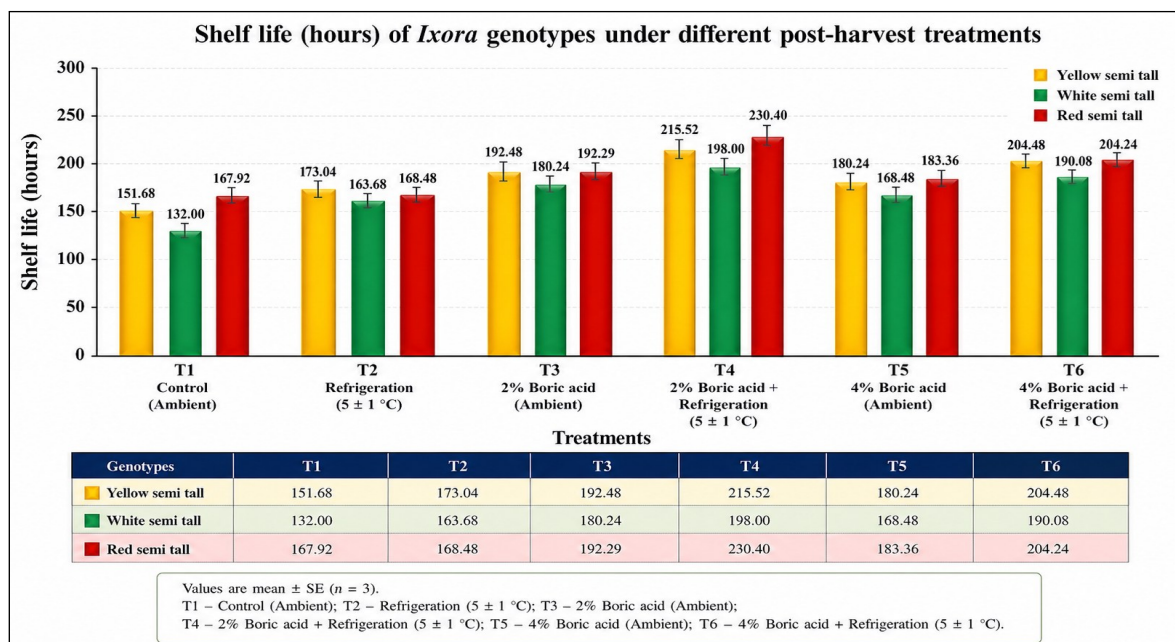


Fig. 2. Shelf life (hours) of *Ixora* genotypes during storage period.

family Rubiaceae. As compared with the other ornamental plants of the *Rubia* genus, the current research shows that *Ixora* flowers were positively influenced by the combination of boric acid and cooling, which led to extended shelf life, as well as better preservation of visual and physiological indicators. It should be noted that similar effects were observed for the other related ornamental Rubiaceae species, namely *Gardenia jasminoides* Ellis; the latter showed that low temperatures helped reduce the rate of respiration, delayed petal senescence and maintained floral appearance (21). The role of cell membrane integrity and water balance in delaying flower senescence for the ethylene-sensitive ornamental plant families, including Rubiaceae, was also emphasised (22). Lower evaporation rates and regulated storage temperatures were found to contribute to better survival and retardation of deterioration of tissues in flowers of *Coffea arabica* (23). Similar results have been noted during an experiment on *Pentas lanceolata* in which cool storage conditions along with anti-senescence treatments contributed to better water and pigment retention in the flowers (24). In comparison to the previous studies, the current study showed higher shelf lives, with 214.64 hr shelf life for treatment T₄ (2 % boric acid + cool storage at 5 °C) and 230.40 hr shelf life for treatment G₃T₄. This could be due to better osmoregulation and delayed ethylene-induced senescence owing to boric acid treatment in refrigerated storage.

The application of boric acid (2 % and 4 %) combined with refrigeration at 5 °C effectively prolonged the postharvest life of *Ixora* flowers. Treatment T₄ (boric acid 2 % + refrigeration) was the most successful in maintaining freshness, reducing weight loss and extending the shelf life. Red semi-tall (G₃) recorded significantly higher values for FI and CRI than the other genotypes. Overall, boric acid treatments improved membrane integrity and water balance, helping maintain flower longevity. These findings provide valuable insights for optimising the storage and handling of *Ixora* flowers in commercial floriculture. The effect of postharvest treatments on physiological parameters such as moisture content, RWC and PWL are illustrated in Fig. 3. Among treatments, T₄ (2 % boric acid + refrigeration) consistently maintained higher moisture and RWC with significantly lower PLW, indicating superior postharvest performance. The effects of postharvest treatments on different

genotypes are showed in Fig. 4a, 4b and 4c. The value addition observed yellow semi-tall (G₁), white semi-tall (G₂) and red semi-tall (G₃) are presented in the Fig. 5.

Conclusion

The study demonstrated that postharvest treatments significantly influenced the shelf life and quality of *Ixora* flowers. Among all tested genotypes, red semi-tall (G₃) recorded higher freshness index (FI), colour retention, moisture content and relative water content (RWC) than the other genotypes. As far as postharvest treatment is concerned, application of boric acid especially at a concentration of 2 % along with cooling at 5 °C (Treatment 4) recorded the highest values for the measured postharvest quality parameters, increasing membrane stability, minimising water loss, delaying senescence and extending shelf life up to 214.64 hr. The combined application of boric acid and refrigerated storage may serve as an effective strategy for improving postharvest quality and reducing storage losses in commercial *Ixora* flower production. These findings may contribute to the development of standardised postharvest handling protocols for the floriculture industry. Future studies should evaluate additional preservative combinations and storage environments under commercial-scale conditions.

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Authors' contributions

VM conceptualised and supervised the research work, guided the experimental design and approved the final manuscript. VK contributed to summarising, editing and revising the manuscript. AP

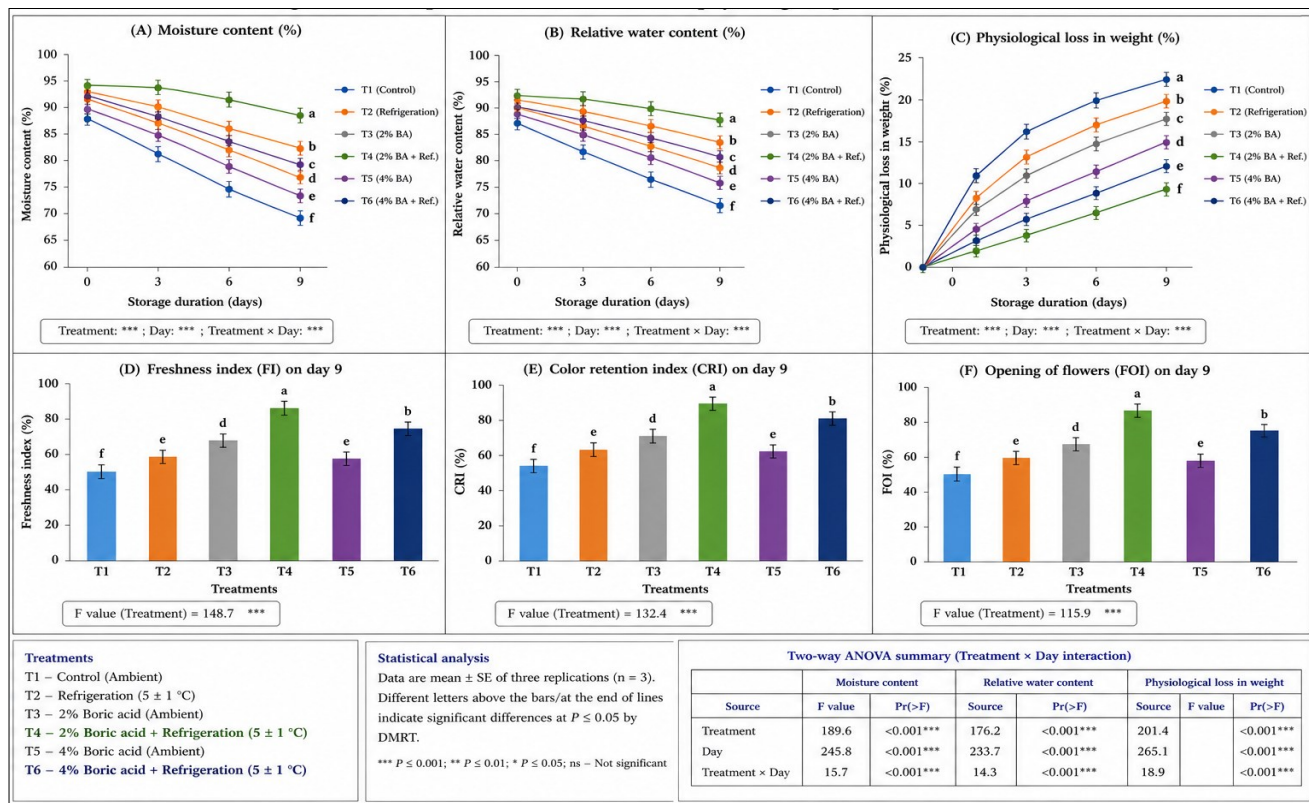


Fig. 3. Effect of postharvest treatments on physiological parameters of *Ixora* flowers.



Fig. 4a. Postharvest treatment- yellow semi-tall (G₁).

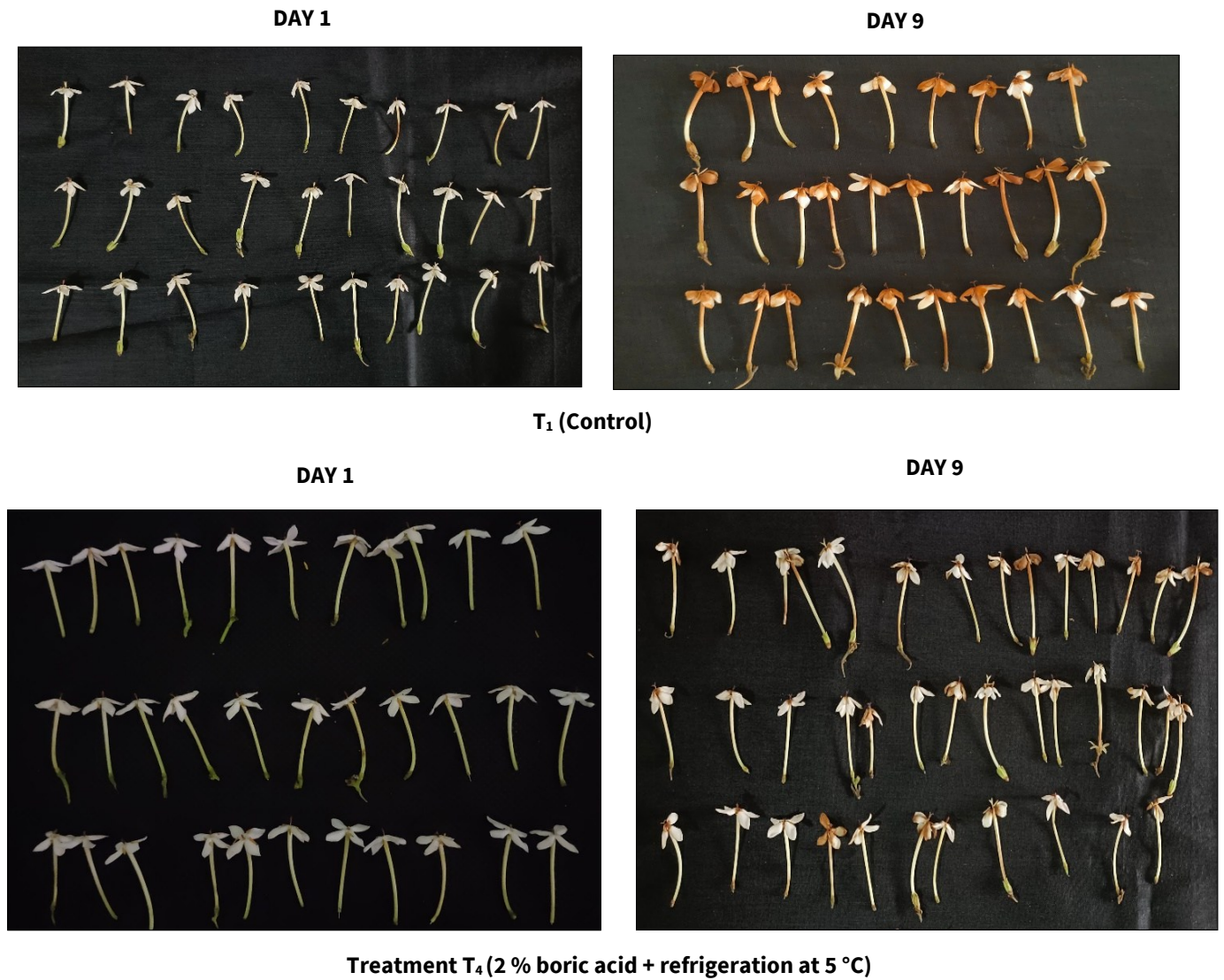
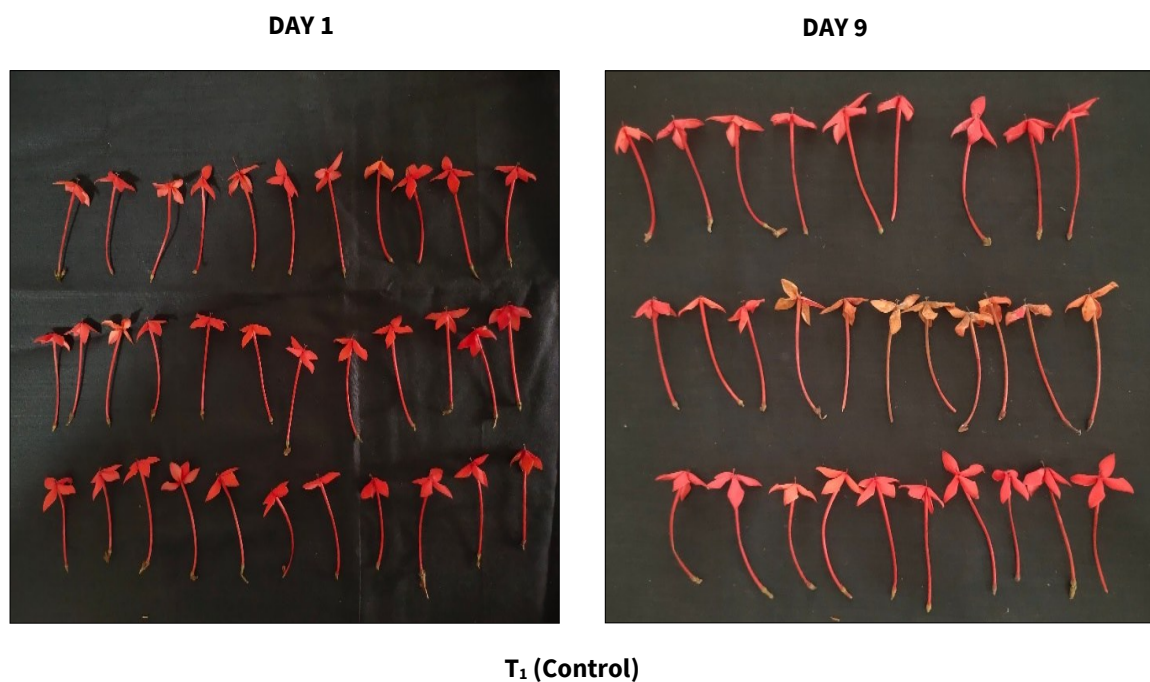


Fig. 4b. Postharvest treatment- white semi-tall (G₂).



DAY 1



DAY 9



Treatment T₄ (2 % boric acid + refrigeration at 5 °c)

Fig. 4c. Postharvest treatment- red semi-tall (G₃).

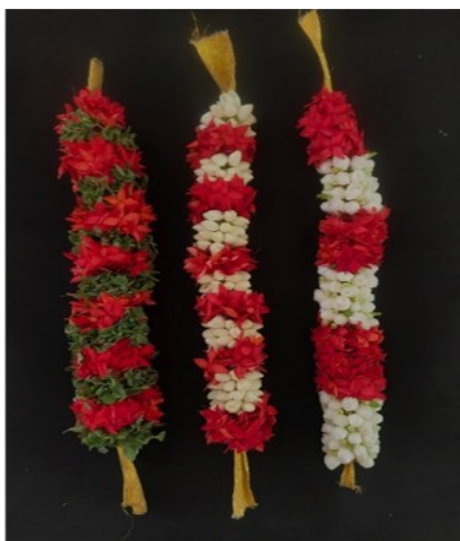


Fig. 5. Value addition in yellow semi-tall (G₁), white semi-tall (G₂) and red semi-tall (G₃).

carried out the experiment, recorded observations, analysed the data and prepared the initial draft of the manuscript. GM assisted in conducting the experiment and contributed to editing and revision of the manuscript. SVA assisted in procuring research support and contributed to manuscript improvement. TSP, GS, SS and KR assisted in data collection, literature review and manuscript preparation. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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