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Influence of packaging and storage temperature on the shelf life of jasmine (Cv. Ramanathapuram Gundumalli) flowers

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Abstract
The effect of packaging and storage temperature on the shelf life of jasmine flowers were studied under ambient and refrigerated storage condition during 2020 at Coimbatore, Tamil Nadu. Storage of the jasmine flowers (cv. Ramanathapuram Gundumalli) packed in polythene bags under the refrigerated condition were significantly increased the shelf life of jasmine flowers. Packing of harvested jasmine flower buds in 200 gauge black polythene bag without ventilation and stored under refrigerated condition at 10 °C retain more moisture content, very less physiological loss of weight, less solute leakage, more freshness index, retention of colour and long shelf life of 70.73 hrs. From the results of this experiment, we concluded that packing the harvested flower buds in 200 gauge black polythene bag without ventilation and stored in the refrigerated condition at 10 °C has improved the physiological and visual quality parameters.

Keywords: Jasmine, packaging, shelf life, and storage temperature

Introduction
Floriculture is one of the fastest-growing segments of horticulture, having huge potential for providing assured returns to the farmers. Flowers are the vibrant element in decorative flowering plants and they look awesome where we live (Tariq *et al.*, 2012) [20]. *Jasminum sambac* Ait. (Gundumalli) is one of the commercial flower crops of India, Pakistan, Afghanistan and Indonesia. The genus *Jasminum* belongs to the family Oleaceae. Although more than 2,000 species are known, 40 species have been identified in India, and 20 are cultivated in South India (Bhattacharjee, 1980) [4] which comprises mainly shrubs and climbers.
The area coverage under flower crops in India is 3,03,000 ha with a production of 2,263 MT of loose flowers and 647 Lakhs cut flowers (2018-2019). In South India, Tamil Nadu plays a key role in loose flower production, produced 34,365 MT of loose flowers from the area of 55,030 ha (2015-2016) (Source: www.nhb.org.in). Due to the improper packaging and storage techniques the post-harvest loss of flowers was raised about nearly 20-40%.
Packaging is a tool for maintaining flower quality in the distribution chain from growers to consumers. Apart from preventing mechanical damage, the package serves as a barrier between the conditions inside and outside the package. It protects the flowers from unfavorable outside conditions and enables a micro-climate to develop inside the package (Nowak *et al.*, 1991) [16]. To enhance the storage life and keeping quality, the main packaging principles such as lowering the rate of transpiration, respiration, and cell division during transportation and storage should be kept under control. The great attention through specialized and advanced packaging technologies is needed to keep the flowers fresh since they are delicate, perishable in nature, and to fulfil the consumer's preference. Hence, the advanced and appropriate packaging technology needs to be developed for jasmine flowers (Bhattacharjee, 1997) [5].
Jasmine flowers pre-treated with 4% boric acid and packed in 60 µ polypropylene bags and packed in corrugated fibreboard boxes was found to be significantly high with the shelf life of 75.22 hours (Thamaraiselvi, 2009) [21]. Packaging jasmine flowers (*Jasminum multiflorum* cv. Kakada) in 300 gauge polythene bags after spraying with water is beneficial in extending the shelf life and retention of white colour and freshness. And further reported that packaging in 200 gauge polythene bags without ventilation maintained freshness, retained white colour and

extended the shelf life of flowers up to 3.33 days as against one day in control (Nirmala and Reddy, 1993) [15]. There is lacking standardization of suitable packaging combined with optimum storage temperature. With this view, in order to standardize the suitable packaging and storage temperature for extending the shelf life of jasmine flowers, the current study was carried out.

Materials and Methods

The flower buds were harvested in the early morning 6'o clock and were subjected to post-harvest treatments to study the shelf life of flowers. The experiment includes 9 treatment combinations *viz*., 200 and 400 gauge black polythene bags with and without ventilation under ambient (23 °C) and the refrigerated condition (10 °C). The experiment was conducted in a completely randomized design and replicated thrice.

Measurements

The packed flowers were subjected to estimation of physiological parameters *viz*., moisture content, physiological loss in weight, and solute leakage. The moisture content of the whole flower was estimated after recording the fresh weight and dry weight of flower buds (Kept in a hot air oven at 70 °C). Moisture content was expressed in fresh weight basis in percentage.

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

The physiological loss in the weight (%) of whole flowers was calculated from the mean of the replicated packages using the following formula

$$\text{PLW} = \frac{\text{Fresh weight (I day)} - \text{Weight (II day)}}{\text{Fresh weight (I day)}} \times 100$$

Membrane integrity was estimated based on the percentage of solute leakage. The percentage of solute leakage was calculated using the following formula,

$$\text{Percentage of solute leakage} = \frac{\text{Final OD at 273 nm} - \text{Initial OD at 273 nm}}{\text{Final OD at 273 nm}} \times 100$$

Visual observations were recorded as sensory evaluation scoring based on Madhu (1999) [13]. Uniformly 50 flower buds per treatment were studied. The number of flowers that retained freshness without exhibiting petal necrosis, wilting and browning was measured by visual observation using the following score expressed as a percentage of fresh flowers or freshness index.

The following score expressed as a percentage of fresh flowers or freshness index.

Condition of flowers	Score	Number of flower buds under this score
Almost all buds turgid	7	X_1
Partial to half-open flowers, turgid	6	X_2
Half to fully open flowers, turgid	5	X_3
Partial to half-open flowers, slightly wilted	4	X_4
Half to fully open flowers, slightly wilted	3	X_5
Partial to half-open flowers, fully wilted	2	X_6
Half to fully open flowers fully wilted	1	X_7

$$FI = \frac{(7 \times X_1) + (6 \times X_2) + (5 \times X_3) + (4 \times X_4) + (3 \times X_5) + (2 \times X_6) + (1 \times X_7)}{(X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7) \times 7} \times 100$$

The flower opening index was calculated by using the following score chart,

Stage of flowers	Score	Number of flower buds under this score
Unopened buds	0	X_1
Slightly opened	1	X_2
Half opened	2	X_3
Fully opened	3	X_4

Flower opening index (FOI) was computed using the following formula,

$$FOI = \frac{(0 \times X_1) + (1 \times X_2) + (2 \times X_3) + (3 \times X_4)}{(X_1 + X_2 + X_3 + X_4) \times 4} \times 100$$

The retention of white colour of *Jasminum sambac* flowers was recorded by the following score,

Flower colour development during storage	Score	Number of flower buds under this score
Bright white	9	X_1
Dull white	8	X_2
Cream or yellowish	7	X_3
1 to 10% brown	6	X_4
11 to 15% brown	5	X_5
16 to 50% brown	4	X_6
51 to 75% brown	3	X_7
76 to 90% brown	2	X_8
All brown (100%)	1	X_9

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

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

The fragrance released by the flowers was computed based on the following score chart.

Fragrance level	Ranking
Least and undesirable	1
Mild	2
Strong	3
Very strong	4

The shelf life of flowers was assessed by recording the number of hours up to which 50 percent or more flowers were kept fresh (50% of Freshness index score).

Results and Discussion

Significant influence of packaging and storage condition on moisture content was observed (Graph 1). The maximum moisture content (65.72% and 58.44% on the first and second day of treatment) was recorded in the treatment T_7 and followed by packing of flowers in 200 gauge polythene bags with ventilation and kept in refrigerated condition (T_6) 63.97% and 54.38% during the first and second day after treatment respectively. The treatment T_1 (Water soaking) was recorded the lowest moisture content (47.42% and 32.22%) during the first and second day after harvesting respectively. The retention of higher moisture content in the flowers may be due to packaging and refrigerated storage condition.

The physiological loss in weight of flower was significantly influenced by the packaging and storage condition (Graph 2). The minimum physiological loss in the weight (4.06% and 6.39% on the first and second day) was recorded in the treatment T_7 and followed by the treatment T_6 was recorded the physiological loss in the weight of 4.26% and 7.00% on the first and second day after treatment. The treatment (T_1 - Water soaking) recorded the maximum physiological loss in the weight (7.11% and 12.12%). The less physiological weight loss in the best treatment may be due to the packaging, which reduces respiration by decreasing oxygen and increasing carbon di oxide level. Reduction in physiological loss of the weight of the flowers might be due to maintenance of optimum humidity temperature and required a combination of CO_2 and O_2 concentration, which in turn slows down the process of respiration and transpiration and ultimately reduced the physiological loss of the weight. This result was in line with the findings of Gwiyeen and Ahn (1997) [1], Yathindra HA (2018) [23], Jawaharlal *et al.*, (2012) [11], and Nirmala and Venkatesha Reddy (1993) [15].

The membrane integrity was measured in terms of solute leakage. The minimum values for solute leakage can be the highest membrane integrity. The minimum solute leakage value (40.41% and 47.32%) was recorded in the treatment (T_7) and followed by the treatment T_6 was recorded the solute leakage value of 40.52% and 48.50% at first and second day after harvesting. The treatment (T_1 - Water soaking) was recorded the highest solute leakage (51.12% and 76.92% on the first and second day after harvesting) (Graph 3).

Among the different treatments, the packing of flowers in 200 gauge polythene bags without ventilation and kept in refrigerated condition (T_7) recorded a higher freshness index (93.09 and 74.45) after 24 and 48 hours of treatment. This was followed by packing of flowers in 200 gauge polythene bags with ventilation and kept in refrigerated condition (T_6) with freshness index of 92.89 and 74.05 after 24 and 48 hours of treatment respectively. The lowest freshness index was observed in control (T_1 – Water soaking) with the values 64.78 and 45.74 after 24 and 48 hours of treatment respectively (Table 1).

The results of post-harvest treatments on the flower opening index of flowers were presented in Table 1. Among the different treatments, packing of flowers in 200 gauge polythene bags without ventilation and kept in refrigerated condition (T_7) recorded lowest flower opening index (22.33 and 30.60) at the end of first and second day after treatment. This was followed by packing of flowers in 200 gauge polythene bags with ventilation and kept in refrigerated condition (T_6) with flower opening index of 22.45 and 31.40 on first and second day after treatment. Highest flower opening index was observed in control (T_1 – Water soaking) with the values 32.52 and 42.44 on first and second day after treatment respectively.

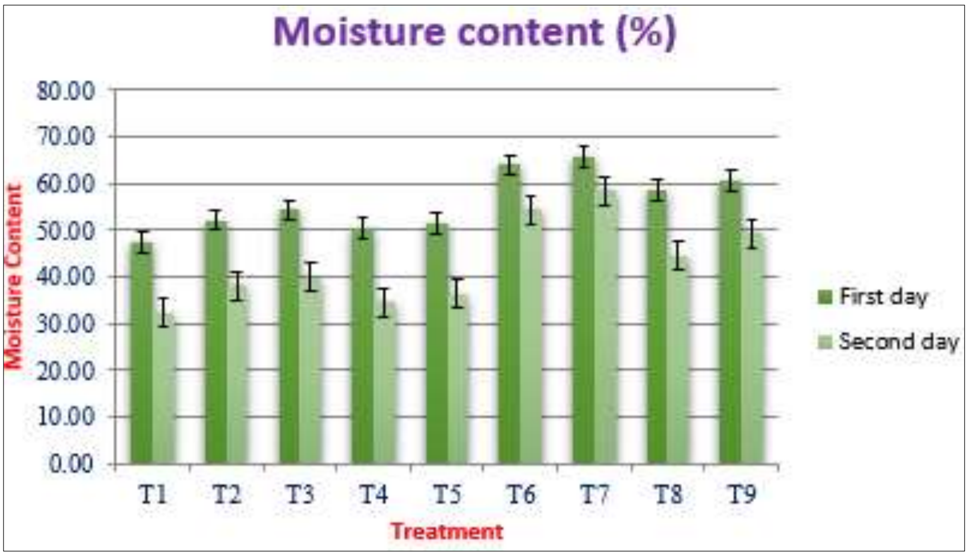
Data pertaining to the influence of post-harvest treatment on colour retention index of flowers are furnished in Table 2. Among the different treatments, packing of flowers in 200 gauge polythene bags without ventilation and kept in refrigerated condition (T_7) recorded higher colour retention index (96.94 and 76.94) and followed by the treatment packing of flowers in 200 gauge polythene bags with ventilation and kept in refrigerated condition (T_6) with colour retention index of 95.54 and 76.55 at the end of first and second day after treatment. Lowest colour retention index was observed in control (T_1 – Water soaking) with the values 74.86 and 60.62 respectively.

The influence of post-harvest treatment on the fragrance index of flowers was presented in Table 2. Among the different treatments, the packing of flowers in 200 gauge polythene bags without ventilation and kept in refrigerated condition (T_7) recorded a higher fragrance index (Score 3.0 and 2.0) at the end of the first and second day after treatment. This was followed by packing of flowers in 200 gauge polythene bags with ventilation and kept in refrigerated condition (T_6) with a fragrance index score of 2.9 and 1.9 at the end of the first and second day after treatment. The lowest fragrance index was observed in control (T_1 – Water soaking) with the values 2.3 and 1.2 respectively.

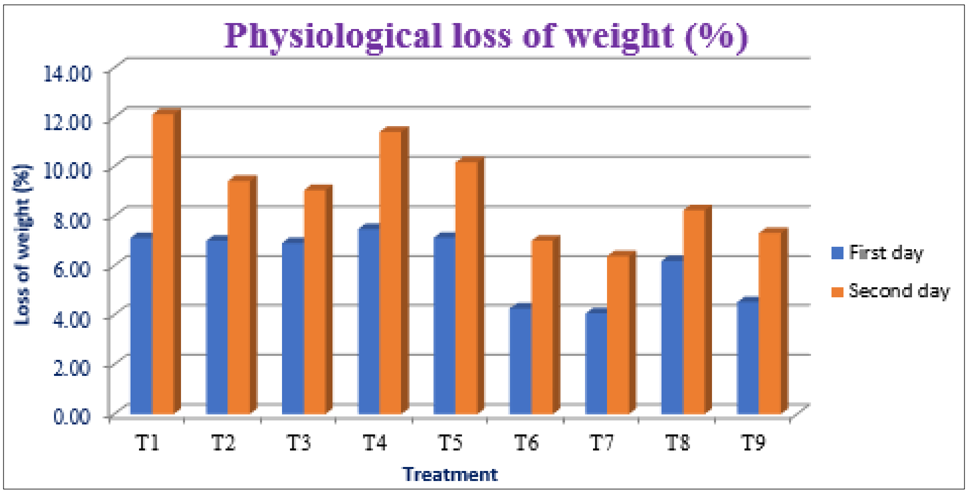
The data on the influence of post-harvest treatment on the shelf life of flowers is presented in Table 3. The maximum shelf life (70.73 hrs) was recorded by the treatment, which harvested flowers packed in 200 gauge polythene bags without ventilation and kept at refrigerated condition (T_7). This was followed by T_6 recorded higher shelf life (69.43 hrs) by packing of flowers in 200 gauge polythene bags with ventilation and kept at refrigerated condition. The lowest shelf life (48.40 hrs) was observed in control (T_1 – Water soaking).

The inter-related traits like physiological loss in weight (PLW), moisture content, relative water content (RWC), and membrane integrity of flowers will affect the shelf life of flowers. A high level of physiological loss of weight in flowers leads to a decrease in the fresh weight of flowers, which expresses visually as symptoms of flower senescence as reported on carnation (Nichols, 1966) [4] and on *Rosa damascena* (Sharma, 1981) [17].

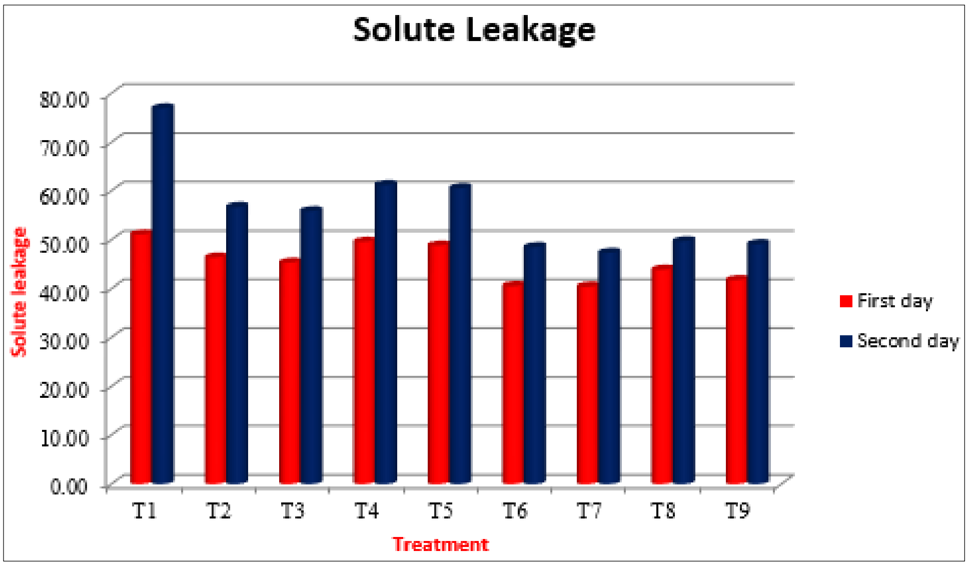
Improved values for freshness index, fragrance index, colour retention index, shelf life, and lesser flower opening index were recorded by the treatment T_7 (Packaging of flower buds in 200 gauge polythene without ventilation and storage in the refrigerator at 10 °C). This might be due to the interaction effect of relative water content, tissue water, turgor pressure of the cell, and suitable packaging.



Graph 1: Influence of post-harvest treatment on moisture content (%) of jasmine flowers



Graph 2: Influence of post-harvest treatment on physiological loss of weight (%) of jasmine flowers



Graph 3: Influence of post-harvest treatment on solute leakage (Membrane integrity) of jasmine flowers

Plate 1: Treatment (T7) Flower opening index

Plate 2: Treatment (T7) Freshness index

Table 1: Influence of post-harvest treatment on freshness index and flower opening index of jasmine flowers

Treatment	Treatment details	Freshness index		Flower opening index	
		After 24 hrs	After 48 hrs	After 24 hrs	After 48 hrs
T_1	Control (Water soaking)	64.78	45.74	32.52	42.44
T_2	200 gauge polythene bags + with ventilation + ambient condition	76.94	57.60	27.08	34.82
T_3	200 gauge polythene bags + without ventilation + ambient condition	77.74	58.75	26.48	33.41
T_4	400 gauge polythene bags + with ventilation + ambient condition	66.82	48.11	28.54	37.32
T_5	400 gauge polythene bags + without ventilation + ambient condition	67.18	49.01	27.64	36.12
T_6	200 gauge polythene bags + with ventilation + refrigerated condition	92.89	74.05	22.45	31.40
T_7	200 gauge polythene bags + without ventilation + refrigerated condition	93.09	74.45	22.33	30.60
T_8	400 gauge polythene bags + with ventilation + refrigerated condition	83.02	63.86	24.46	31.86
T_9	400 gauge polythene bags + without ventilation + refrigerated condition	84.42	65.54	24.36	31.55
SEd		2.2792	2.2885	1.2878	1.8306
CD @ 0.05		4.7885	4.8081	2.7057	3.8459

Table 2: Influence of post-harvest treatment on colour retention index and fragrance index of jasmine flowers

Treatment	Treatment details	Colour retention index		Fragrance index	
		After 24 hrs	After 48 hrs	After 24 hrs	After 48 hrs
T_1	Control (Water soaking)	74.86	60.62	2.3	1.2
T_2	200 gauge polythene bags + with ventilation + ambient condition	91.75	75.11	2.6	1.5
T_3	200 gauge polythene bags + without ventilation + ambient condition	92.37	75.35	2.7	1.6
T_4	400 gauge polythene bags + with ventilation + ambient condition	89.43	74.45	2.5	1.4
T_5	400 gauge polythene bags + without ventilation + ambient condition	90.84	74.85	2.6	1.5
T_6	200 gauge polythene bags + with ventilation + refrigerated condition	95.54	76.55	2.9	1.9
T_7	200 gauge polythene bags + without ventilation + refrigerated condition	96.94	76.94	3.0	2.0
T_8	400 gauge polythene bags + with ventilation + refrigerated condition	94.61	75.67	2.8	1.8
T_9	400 gauge polythene bags + without ventilation + refrigerated condition	95.20	76.35	2.9	1.9
SEd		0.8693	3.8617	0.1207	0.2536
CD @ 0.05		8.1292	8.1133	0.0816	0.1715

Table 3: Influence of post-harvest treatment on shelf life of jasmine flowers (hrs)

Treatment	Treatment details	Shelf life (hrs)
T_1	Control (Water soaking)	48.40
T_2	200 gauge polythene bags + with ventilation + ambient condition	58.13
T_3	200 gauge polythene bags + without ventilation + ambient condition	59.23
T_4	400 gauge polythene bags + with ventilation + ambient condition	56.50
T_5	400 gauge polythene bags + without ventilation + ambient condition	57.39
T_6	200 gauge polythene bags + with ventilation + refrigerated condition	69.43
T_7	200 gauge polythene bags + without ventilation + refrigerated condition	70.73
T_8	400 gauge polythene bags + with ventilation + refrigerated condition	62.57
T_9	400 gauge polythene bags + without ventilation + refrigerated condition	63.31
SEd		3.9814
CD @ 0.05		8.3648

Conclusion
Keeping the packed flowers in 200 gauge polythene bags without ventilation and storage under the refrigerated condition at 10 °C was recorded a very less physiological loss of weight, more moisture content, a higher freshness, retention of colour and long shelf life of 70.73 hrs. The results indicated that reduced temperature and maintenance of high relative humidity around the produce improved the quality.

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