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Studies on Post-Harvest Handling of Loose Flowers of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) Cultivars 'SolanShringar' & 'Surf'

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A B S T R A C T

The present investigations entitled, "Studies on postharvest handling of loose flowers of chrysanthemum (*Dendranthema grandiflora* Tzvelve) cultivars 'SolanShringar' and 'Surf" were carried out at Department of Floriculture and Landscape Architecture, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) during 2016-2017.Study done to find best packaging material in different storage durations and conditions. Experiments were conducted in a Completely Randomized Design (factorial). Studies revealed that pre-harvest sprays of BA 50 ppm at bud stage resulted in maximum shelf life of 3.73 days in 'SolanShringar' and 4.27 days in 'Surf' in polyethylene packaging. Best freshness index maximum per cent moisture content, minimum per cent weight gain and per cent spoilage of flowers was also observed in the flowers packed in cardboard boxes lined with the polyethylene. Among storage durations, maximum shelf life was observed in three day storage in both the cultivars. In case of storage conditions, more shelf life was observed in cold storage than the flowers stored at room temperature in both the cultivars. While comparing both cvs, i.e. 'SolanShringar' and 'Surf' were found at par for shelf life and freshness index.

Introduction

Flowers, by nature attract every human being. The importance of flowers in socio-cultural and religious life of the Indian people is beyond imagination. Though flower cultivation has been practiced in India since time immemorial, floriculture has blossomed into a viable and profitable business only in recent years. The major constituent of Indian domestic floriculture trade is traditional flowers. The important traditional flowers grown in India include marigold, chrysanthemum, aster, tuberose, jasmine and crossandra. Despite of huge production and domestic consumption of flowers, the post-harvest losses are estimated to be more than 30-35%. Considering the potential of this sector in generating income and employment opportunities to farmers, studies needs to be carried out to reduce post-harvest losses and make it more profitable.

The present study was carried out on postharvest handling of chrysanthemum (*Dendranthema grandiflora* Tzvelve), an

important loose flower crop. The flower head of chrysanthemum is composed of many florets borne on a receptacle. The outer ray florets usually have a coloured strap-shaped corolla, developed around the outer rim of receptacle and are pistillate and fertile. The disc florets are less conspicuous and have vase-shaped corolla. They are generally found in the centre of the bloom although they may be interspersed to some extent with ray florets and are perfect and fertile. Wide variations are exhibited by large number of cultivars of chrysanthemum in respect of growth habit, size, colour and shape of the bloom.

According to Bhattacharjee and De (2005) also, loose flowers are generally used for making garlands, used at marriages, festivals, religious offerings, death rituals and for extraction of essential oils. Loose flowers constitute an important part in Indian floriculture trade. Chrysanthemum is one of the most important loose flower crops which is being cultivated and traded throughout country. Improper postharvest handling sometimes causes serious damage to the final produce and causes loss to the farmers. In case of loose flowers, it becomes difficult to treat loose flowers with chemical preservative solutions after harvesting, as an increase in moisture content may lead to spoilage of flowers.

Materials and Methods

Studies on postharvest handling of loose flowers of chrysanthemum (*Dendranthema grandiflora* Tzvelve) cultivars 'SolanShringar' and 'Surf' were carried out in the Post-Harvest Laboratory of Department of Floriculture and Landscape Architecture of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan during 2016-2017. The crop was grown in the experimental farm of the department, which is situated in hilly areas of Western Himalayas at an altitude of 1276 m above mean sea level having latitude of 30° 52'2" North and longitude 70° 11' 30" East. The climate of area is typically semi temperate. Two separate experiments were conducted with following methodology: Two cultivars of chrysanthemum namely; 'SolanShringar' and 'Surf' were used to carry out the investigations.

Healthy and disease free shoot tip cutting were rooted in first week of May, following standard propagation practices. The rooted cuttings were planted in a well prepared field (raised beds) during the 1st week of June, 2016, at a spacing of 30 x 30cm from row to row and plant to plant, respectively. The crop was grown following recommended cultural practices like weeding, hoeing, irrigation, fertilization, spraying against insect-pests and diseases, pinching, disbudding, de-shooting, staking etc. Flower buds when attained a size of 13-15mm in diameter were sprayed with solution of Benzyl Adenine (25 and 50 ppm) till droplet formation. In control, the buds were sprayed with distilled water. Loose flowers were harvested at standard stage i.e. fully opened flowers. In this experiment flowers were kept in cardboard boxes of above mentioned specifications lined with different packaging materials like cellophane, newspaper and polyethylene as per technical programme and maintained under two storage conditions i.e. cold storage (4^0C) and at prevailing room temperature different storage durations. After removal from storage the boxes were opened and kept at prevailing room for temperature conditions in well ventilated room and various shelf life parameters were recorded.

Stock solution of BA 250 ppm was prepared by dissolving 250 mg of BA in 1N NaOH and final volume was made one litre in distilled water. Freshly harvested flowers were kept in cardboard boxes lined with 3 different materials i.e. cardboard box lined with

newspaper, cardboard box lined with cellophane and cardboard box lined with polyethylene. After packing the flowers in boxes, these were maintained under 2 storage conditions i.e. cold storage (4°C) and room temperature for 3 durations i.e. 3, 6 and 9 days. Shelf life studies were carried out at room temperature. Observations recorded are per cent weight gain, shelf life (days) appearance (colour, freshness index & per cent wilting) of loose flower, per cent spoilage, per cent moisture content

Results and Discussion

The present investigation comprised of two experiments on post-harvest handling of loose flowers chrysanthemum cultivars 'SolanShringar' and 'Surf'. Pre-harvest spray of BA (Benzyle Adenine) @ 25 and 50 ppm was done at bud stage (13-15mm). In this experiment flowers were harvested at fully opened stage and were packed in the cardboard boxes lined with newspaper, cellophane and polyethylene, sheets respectively. After packaging these cardboard boxes were stored for 3 different durations (3, 6 and 9 days) at two conditions i.e. cold storage (4°C) and room temperature. After storage, flowers are kept in open in well ventilated room and various shelf life parameters were recorded. The salient results are described parameter-wise.

Per cent weight gain

Table 1a shows the significant effect of packaging materials and storage on weight gain in loose flowers of chrysanthemum cv. 'Surf'. Among the wrapping materials, minimum weight gain was observed in flowers wrapped in polyethylene (4.98%). Maximum weight gain was, however observed in the flowers kept in newspaper lined boxes (6.87%). Among storage durations, a gradual increase in flower weight was noticed with increasing the duration. Least weight gain was observed in 3 days storage (4.99%) whereas height gain was maximum nine days storage (6.88%). Further flowers kept at room temperature showed significantly more gain in flower weight (6.34%) in comparison to the flowers kept in refrigerated (5.34%).

Interaction between packaging materials and storage durations show that minimum weight gain (4.02%) was noted when flowers were stored for three days in the cardboard boxes lined with the polyethylene. In contrast, maximum weight was gain when the flowers were packed in the boxes lined with newspaper and stored for nine days (7.78%).

Interaction between storage durations and storage conditions reveal that minimum (4.40%) weight gain was noted, when flowers were cold stored for 3 days. In contrast maximum weight gain (7.30%) was observed when the flowers were stored for nine days at room temperature.

Data on interaction of the storage conditions and packaging materials show that least weight gain (4.58%) of flowers was observed when these were packed in cardboard boxes lined with polyethylene and stored under cold storage (4°C). On the other hand, weight gain was observed maximum (7.43%) when the flowers were packed in boxes lined with newspaper and stored for nine days at room temperature conditions.

Interaction effect of packaging materials, storage durations and storage conditions on weight gain (%) of chrysanthemum loose flowers indicated that weight gain was minimum (3.77%) when the flowers were packed in cardboard boxes lined with the polyethylene and stored for 3 days under cold storage (4°C), Table 1b. In contrast, weight gain was noted maximum (8.33%) in the

flowers packed in cardboard boxes lined with the newspaper and stored for nine days at room temperature conditions.

Our results suggests that polyethylene was the best resulting in less weight gain (%) after storage of loose flowers both the cultivars i.e. 'SolanShringar'&'Surf'.

Results obtained also show that minimum weight gain was observed when the flowers were packed in the polyethylene packaging throughout the storage. These results are in close agreement with Madaiah and Reddy (1994) who reported that packaging of tuberose florets in polyethylene resulted in the minimum physiological loss in weight. Similar results were obtained by Varu and Barad (2008) who while working on tuberose and reported that minimum weight loss was observed with the polyethylene (200 gauge) packaging. Further, a higher weight gain was noted in flowers stored at room temperature than in refrigerated conditions which could be attributed to the low metabolic activities of flowers at refrigerator conditions than in open.

Shelf life (days)

Table 2a shows the significant effect of packaging materials and storage on shelf life of loose flowers of chrysanthemum cv. 'SolanShringar'. Among the packaging materials, maximum shelf life (2.73 days) of flowers was observed in the boxes lined with the polyethylene while minimum (1.93 days) was noted in flowers kept in cardboard boxes lined with newspaper. Further, data also reveals that shelf life of flowers decreased with increasing storage duration. Shelf life (2.90 days) was observed maximum in three day storage while nine days storage resulted in least shelf life (1.77 days). In case of storage conditions, more shelf life (2.96 days) was observed when flowers were stored in cold storage than the flowers stored at room temperature (1.80 days).

Interaction of packaging materials and storage durations reveal that maximum shelf life (3.30 days) was observed when the flowers were packed in boxes lined with polyethylene and stored for three days. On the other hand, shelf life was minimum (1.50 days) when the flowers were packed in boxes lined with newspaper and stored for nine days.

Further, interaction data of storage durations and storage conditions depicts that maximum shelf life (3.53 days) was observed when the flowers were cold stored for three days. In contrast, minimum shelf life (1.80 days) was noted when the flowers were stored for nine days at room temperature.

Interaction of packaging materials and storage conditions was found to be non-significant. However, maximum shelf life (3.33 days) was observed when the flowers were packed in the boxes lined with polyethylene and cold stored, whereas minimum shelf life (1.40 days) was observed when the flowers were packed in boxes lined with newspaper and kept at room temperature.

Perusal of data presented in Table 2b on interaction effect of packaging materials, storage durations and storage conditions on shelf life of chrysanthemum loose flowers indicates that maximum shelf life of 4.00 days was observed when the flowers were packed in boxes lined with polyethylene and cold stored for three days. In contrast, minimum shelf life (1.00 days) was observed when the flowers were packed in boxes lined with newspaper and stored for nine days at room temperature.

Table 2a shows the significant effect of packaging materials and storage on shelf life of loose flowers chrysanthemum cv. 'Surf'.

Among the packaging materials, maximum shelf life (3.27 days) of flowers was observed in the boxes lined with the polyethylene and minimum (2.07 days) was observed in cardboard boxes lined with newspaper. Further, data also reveals that shelf life decreased with increasing storage duration. Shelf life (3.43 days) was noted maximum in three day storage while nine days storage resulted in best shelf life (1.93 day) In case of storage conditions, least shelf life (3.24 days) was observed when flowers were stored in cold storage than the flowers stored at room temperature (2.13 days).

Interaction of packaging materials and storage durations reveal that maximum shelf of loose flowers life (4.10 days) was obtained when the flowers were packed in boxes lined with polyethylene and stored for three days. On the other hand, shelf life was minimum (1.50 days) when flowers were packed in boxes lined with newspaper and stored for nine days.

Further, interaction data of storage durations and storage conditions show that maximum shelf life (4.01 days) was observed when the flowers were cold stored for three days. In contrast, minimum shelf life (1.40 days) was noted when the flowers were stored for nine days at room temperature.

Interaction of packaging materials and storage conditions was found to be non-significant. However, maximum shelf life (4.00 days) was observed when the flowers were packed in the boxes lined with polyethylene and cold stored whereas minimum shelf life (1.67 days) was observed when the flowers were packed in boxes lined with newspaper at room temperature (Table 3a).

Perusal of data presented in Table 3b on interaction effect of packaging materials, storage durations and storage conditions on shelf life of chrysanthemum loose flowers indicates that maximum shelf life of 5.00 days was observed when the flowers were packed in boxes lined with polyethylene and cold stored for three days. In contrast, minimum shelf life (1.00 days) was observed when the flowers were packed in cardboard boxes lined with newspaper and stored for nine days under room temperature conditions.

Similar trend was observed for both the cultivars i.e. 'SolanShringar' & 'Surf' for shelf life (days). Polyethylene was found most superior packaging material loose flowers of chrysanthemum than cellophane and newspaper, polyethylene

According to Nirmala and Reddy (1993) packaging of jasmine flowers in bags resulted in the extension of shelf life to 3 days (*Jasminum sambac*) and to 7 days (*J multiflora*). Similar results were obtained by Madaiah and Reddy (1994) who reported that packaging of tuberose florets in the 300 gauge polyethylene bags extends the shelf life of flowers.

These results are also in close conformity with the results of Varu and Barad (2008) who while working on tuberose reported that packing in 200 gauge polyethylene sheet results in the longest vase life (14.43 days).

Freshness index

Table 4a shows the significant effect of packaging materials and storage conditions on freshness index of loose flower chrysanthemum cv. 'SolanShringar'. Among the packaging materials, highest score (3.87 out of 5) for freshness index was obtained by the flowers packed in boxes lined with polyethylene. On the other hand, lowest score (3.54) was obtained by the flowers packed in boxes lined with newspaper. Further, freshness index decreased with increasing

duration of storage. Maximum score (4.23 out of 5) was obtained by the flowers stored for three days. Lowest score, on the other hand was obtained (3.10) by the flowers stored for the days. In case of storage conditions, more score (3.70) was obtained by the flowers stored at 4°C than the lowest score obtained (3.69 out of 5) flowers stored under room temperature conditions.

Interaction data between storage durations and packaging materials show that maximum score (4.37 out of 5) was obtained by the flowers packed in the cardboard boxes lined with the polyethylene and stored for three days. In contrast, minimum score (3.54) was obtained by the flowers packed in the boxes lined with the newspaper and stored for nine days.

It is also evident from interaction of storage durations and storage conditions that flowers cold stored for three days gets the highest score (4.27) for freshness index. On the other hand, lowest score (1.40) was obtained by the flowers stored for nine days at room temperature conditions.

Further, interaction of the storage conditions and packaging materials show that maximum score (3.93) was obtained by flowers packed in the cardboard boxes lined with polyethylene and stored under cold storage. In contrast, minimum score (3.50) was obtained by the flowers packed in the cardboard boxes lined with the newspaper and cold stored at room temperature conditions.

Perusal of data presented in Table 4b on Interaction effect of packaging materials, storage durations and storage conditions on freshness index of chrysanthemum loose flowers showed that highest score (4.40) for freshness index was obtained by the flowers packed in cardboard boxes lined with the polyethylene and stored for 3 days under refrigerated conditions. In contrast, minimum score (2.87) was obtained by the flowers packed in cardboard boxes lined with the newspaper and stored for nine days at room temperature conditions.

Table 5a shows the significant effect of packaging materials and storage conditions on freshness index of loose flowers of chrysanthemum cv . 'Surf'. Among the packaging materials, highest score (3.71 out of 5) for freshness index was obtained by the flowers packed in boxes lined with polyethylene. On the other hand, lowest score (3.32) was obtained by the flowers packed in boxes lined with newspaper. Among storage durations maximum score (4.20) was obtained by the flowers stored for three days. Freshness index reduced with increasing duration of storage with minimum (2.62) of it noted in flowers stored for nine days. In case of storage conditions, more score (3.75) was obtained by the flowers stored cold than the flowers stored (3.30) at room temperature.

Interaction of the storage durations and packaging materials reveal that maximum score (4.10) was obtained by the flowers packed in boxes lined with the polyethylene and stored for three days. In contrast, minimum score (2.07) was obtained by the flowers packed in boxes lined with newspaper and stored for nine days.

Interaction of storage durations and storage conditions show that flowers cold stored for three days obtained the highest score (4.07) of freshness. On the other hand, lowest score of 1.40 was obtained by the flowers stored at room temperature for nine days.

Interaction of the storage conditions and packaging materials show that maximum score (4.00) was obtained by the flowers packed in boxes lined with polyethylene and cold stored. In contrast, minimum score (1.67)

was obtained by the flowers packed in boxes lined with newspaper and kept at room temperature conditions.

Perusal of data presented in Table 5b on Interaction effect of packaging materials, storage durations and storage conditions on freshness index of chrysanthemum loose flowers reveals that highest score (4.37 out of 5) for freshness index was obtained by the flowers packed in cardboard boxes lined with the polyethylene and cold stored for 3 days. In contrast, minimum score (1.80) was obtained by the flowers packed in boxes lined with the newspaper and stored for nine days at room temperature conditions.

Table.1a Effect of packaging and storage on weight gain (%) of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	5.90	6.82	7.78	**6.87**	6.20	7.43
Cellophane	4.77	5.93	6.85	**5.82**	5.34	6.39
Polyethylene	4.02	4.83	5.80	**4.98**	4.58	5.39
Mean	**4.99**	**5.89**	**6.88**	-	**5.34**	**6.34**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	4.40	5.37	6.36	**M: 0.07**	**D × M: 0.01**	
Room temperature	5.39	6.42	7.30	**D: 0.07**	**C × D: 0.06**	
				C: 0.08	**C × M: 0.06**	

Table.1b Interaction effect of packaging materials, storage conditions and storage durations on weight gain (%) of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	5.37	6.20	7.13	6.53	7.33	8.33
Cellophane	4.27	5.33	6.33	5.27	6.53	7.47
Polyethylene	3.77	4.37	5.40	4.37	5.30	6.30
$CD_{0.05}$ for M × D × C: 0.15						

Table.2a Effect of packaging and storage on shelf life (days) of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	2.40	1.90	1.50	**1.93**	2.47	1.40
Cellophane	3.00	2.60	1.80	**2.47**	3.07	1.87
Polyethylene	3.30	2.90	2.00	**2.73**	3.33	2.13
Mean	**2.90**	**2.47**	**1.77**	**-**	**2.96**	**1.80**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	3.53	3.00	2.33	**M: 0.53**	**D × M: 0.01**	
Room temperature	2.27	1.93	1.80	**D: 0.53**	**C × D: 0.04**	
				C: 0.03	**C × M: 0.04**	

Table.2b Interaction effect of packaging materials, storage conditions and storage durations on shelf life (days) of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	3.00	2.40	2.00	1.80	1.40	1.00
Cellophane	3.60	3.20	2.40	2.40	2.00	1.20
Polyethylene	4.00	3.40	2.60	2.60	2.40	1.40
$CD_{0.05}$ for M × D × C: 0.19						

Table.3a Effect of packaging and storage on shelf life (days) of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	2.60	2.10	1.50	**2.07**	2.47	1.67
Cellophane	3.60	2.70	1.90	**2.73**	3.27	2.20
Polyethylene	4.10	3.30	2.40	**3.27**	4.00	2.53
Mean	**3.43**	**2.70**	**1.93**	**-**	**3.24**	**2.13**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	4.07	3.20	2.47	**M: 0.13**	**D × M: 0.19**	
Room temperature	2.80	2.20	1.40	**D: 0.13**	**C × D: 0.16**	
				C: 0.04	**C × M: 0.16**	

Table.3b Interaction effect of packaging materials, storage conditions and storage durations on shelf life (days) loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	3.00	2.40	2.00	2.20	1.80	1.00
Cellophane	4.20	3.20	2.40	3.00	2.20	1.40
Polyethylene	5.00	4.00	3.00	3.20	2.60	1.80
$CD_{0.05}$ for M × D × C: 0.23						

Table.4a Effect of packaging and storage on freshness index of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	4.07	3.63	2.93	**3.54**	3.59	3.50
Cellophane	4.27	3.83	3.10	**3.73**	3.79	3.68
Polyethylene	4.37	3.97	3.27	**3.87**	3.93	3.80
Mean	**4.23**	**3.81**	**3.10**	**-**	**3.70**	**3.69**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	4.27	3.84	3.20	**M: 0.01**	**D × M: 0.02**	
Room temperature	4.20	3.78	3.00	**D: 0.01**	**C × D: 0.06**	
				C: 0.09	**C × M: 0.06**	

Table.4b Interaction effect of packaging materials, storage conditions and storage durations on freshness index of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	4.10	3.67	3.00	4.03	3.60	2.87
Cellophane	4.30	3.87	3.20	4.23	3.80	3.00
Polyethylene	4.40	4.00	3.40	4.33	3.93	3.13
$CD_{0.05}$ for M × D × C: 0.08						

Table.5a Effect of packaging and storage on freshness index of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	4.03	3.57	2.37	**3.32**	3.53	3.11
Cellophane	4.23	3.77	2.60	**3.53**	3.73	3.33
Polyethylene	4.33	3.90	2.90	**3.71**	3.88	3.54
Mean	**4.20**	**3.74**	**2.62**	-	**3.75**	**3.30**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	4.23	3.78	3.13	**M: 0.03**	**D × M: 0.08**	
Room temperature	4.17	3.71	2.11	**D: 0.03**	**C × D: 0.07**	
				C: 0.07	**C × M: 0.07**	

Table.5b Interaction effect of packaging materials, storage conditions and storage durations on freshness index of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	4.07	3.60	2.93	4.00	3.53	1.80
Cellophane	4.27	3.80	3.13	4.20	3.73	2.07
Polyethylene	4.37	3.93	3.33	4.30	3.73	2.47
$CD_{0.05}$ for M × D × C: 0.01						

Table.6a Effect of packaging and storage on per cent spoilage of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	23.33 (28.86)	36.65 (37.22)	54.97 (47.85)	**38.32 (37.94)**	34.97 (35.92)	41.67 (40.07)
Cellophane	18.65 (25.34)	29.97 (33.12)	46.67 (43.67)	**31.76 (33.84)**	27.74 (31.21)	35.78 (36.58)
Polyethylene	19.67 (47.85)	26.67 (30.92)	40.00 (39.22)	**28.78 (32.18)**	24.22 (29.15)	33.33 (35.01)
Mean	**20.55 (26.77)**	**31.19 (33.75)**	**47.21 (43.35)**	-	**28.98 (32.02)**	**36.96 (37.29)**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	16.43 (23.83)	26.63 (30.99)	43.87 (41.46)	**M: 0.30**	**D × M: 0.51**	
Room temperature	24.67 (29.71)	35.56 (36.52)	50.56 (45.34)	**D: 0.30**	**C × D: 0.47**	
				C: 0.29	**C × M: 0.47**	

Table.6b Interaction effect of packaging materials, storage conditions and storage durations on per cent spoilage of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	20.00 (26.54)*	33.33 (34.95)	51.67 (45.98)	26.67 (30.93)	40.00 (39.26)	58.33 (49.72)
Cellophane	13.33 (21.16)	26.67 (30.93)	43.33 (41.18)	24.00 (29.28)	33.33 (35.24)	50.00 (44.92)
Polyethylene	16.00 (23.50)	20.00 (26.54)	36.67 (37.20)	23.33 (28.83)	33.33 (35.24)	43.33 (41.18)
$CD_{0.05}$ for M × D × C: 0.88						

***** Figure in parenthesis are angular transformed values.

Table.7a Effect of packaging and storage on percent rotting of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	32.50 (34.77)	46.67 (43.05)	64.95 (53.76)	**48.04 (43.89)**	44.98 (42.02)	51.10 (45.66)
Cellophane	26.65 (31.04)	40.95 (39.76)	56.65 (48.89)	**41.42 (39.86)**	37.73 (37.60)	45.10 (42.03)
Polyethylene	19.15 (25.84)	36.65 (37.14)	48.30 (44.00)	**34.70 (35.63)**	29.43 (32.35)	39.97 (38.91)
Mean	**26.10 (30.58)**	**41.42 (40.05)**	**56.63 (48.85)**	-	37.45 (37.36)	45.46 (42.27)
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	22.77 (28.22)	36.64 (37.18)	52.73 (46.58)	**M:0.27**	**D × M: 0.42**	
Room temperature	29.43 (32.75)	46.20 (42.82)	60.53 (51.13)	**D: 0.27**	**C × D: 0.37**	
				C: 0.28	**C × M:0.37**	

Table.7b Interaction effect of packaging materials, storage conditions and storage durations on per cent spoilage of loose flowers of chrysanthemum cv. 'Surf'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	30.00 (33.18)*	43.33 (41.18)	61.60 (51.72)	35.00 (36.27)	50.00 (44.92)	68.30 (55.71)
Cellophane	23.30 (33.18)	36.60 (37.28)	53.30 (46.80)	30.00 (33.18)	45.30 (42.33)	60.00 (50.78)
Polyethylene	15.00 (22.77)	30.00 (33.18)	43.30 (41.10)	23.30 (28.81)	43.30 (41.10)	53.30 (46.80)
$CD_{0.05}$ for M × D × C: 0.63						

***** Figures in parenthesis are angular transformed values.

Table.8a Effect of packaging and storage on per cent moisture content of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage durations (D)				Storage conditions (C)	
	3 days	6 days	9 days	Mean	Cold Storage (4°C)	Room temperature
Newspaper	76.17	68.38	56.62	**67.02**	69.33	64.71
Cellophane	78.10	70.28	58.95	**69.11**	71.26	66.97
Polyethylene	80.52	73.60	64.17	**72.73**	74.81	70.64
Mean	**78.29**	**70.72**	**59.94**	**-**	**71.80**	**67.47**
Storage conditions (C)				**$CD_{0.05}$ for**		
Cold Storage (4°C)	80.56	72.30	62.64	**M:0.65**	**D × M: 1.47**	
Room temperature	75.93	69.14	57.24	**D: 0.65**	**C × D: 0.85**	
				C: 0.44	**C × M: NS**	

Table.8b Interaction effect of packaging materials, storage conditions and storage durations on per cent moisture content of loose flowers of chrysanthemum cv. 'SolanShringar'

Packaging materials (M)	Storage conditions (C)					
	Cold Storage (4°C)			Room temperature		
	3 days	6 days	9 days	3 days	6 days	9 days
Newspaper	77.87	70.63	59.50	74.37	66.13	53.83
Cellophane	80.23	71.60	61.93	76.07	68.97	55.97
Polyethylene	83.47	74.87	66.30	77.57	72.43	61.93
$CD_{0.05}$ for M × D × C: 1.41						

Table.9a Comparison of cultivars 'SolanShringar' and 'Surf' of chrysanthemum for effect of packaging material on shelf life of loose flowers after storage by using Fisher's t-test

Characters studied	'Solan Shringar'	'Surf'	t Stat (calculated)
Per cent weight gain	5.01	5.18	0.48
Shelf life (days)	3.13	3.43	2.21
Freshness index (colour retention, percent wilting)	3.74	3.69	-0.59
Per cent spoilage	16.78	21.22	1.79*
Per cent moisture content	75.99	78.53	2.84*

*significant at 5% level of significance

Table.9b Comparison of cultivars 'SolanShringar' and 'Surf' of chrysanthemum for effect of storage on shelf life of loose flowers by using Fisher's t-test

Characters studied	'SolanShringar'	'Surf'	t Stat (calculated)
Per cent weight gain	4.98	5.89	3.92
Shelf life (days)	2.38	2.69	2.02
Freshness index (colour retention, percent wilting)	3.71	3.52	-0.54
Per cent spoilage	31.27	41.09	3.33*
Per ent moisture content	69.67	72.37	2.82*

*significant at 5% level of significance

Our results suggest that polyethylene was the best for freshness index both the cultivars, i.e. 'SolanShringar' and 'Surf'.

Polyethylene reduces the permeability to moisture thereby leading to the reduction in the loss of moisture and preventing the wilting of flowers thus maintaining the freshness of flowers by delaying the symptom of senescence. These results are in close conformity with the findings of Varu and Barad (2008) who have reported that maximum freshness of tuberose flowers was obtained in polyethylene packaging.

Similar result was obtained by Madaiah and Reddy (1994) in tuberose. They found that packaging in 300 gauge polyethylene bags was found most effective for maintaining the highest quality of tuberose flowers. Similar results were obtained by Nirmala and Reddy (1993) while working on jasmine flowers.

Per cent spoilage

Table 6a shows the significant effect of packaging materials and storage on spoilage (%) of loose flowers of chrysanthemum cv. 'SolanShringar'. Among the packaging materials minimum spoilage was observed in flowers packaged in polyethylene (28.78%). Maximum spoilage, on other hand was observed in the flowers wrapped in newspaper (38.32%). Among storage durations, spoilage of flowers was increased with increasing their storage. Least spoilage was observed in three days storage (20.55%) whereas maximum flower spoilage (47.21%) was noted when stored upto nine days. In storage conditions, lesser spoilage was observed in the cold storage (28.98%) than room temperature (36.96%).

Interaction between packaging materials and storage durations reveal that least spoilage (19.67%) was observed when the flowers were stored for three days in the cardboard boxes lined with the polyethylene. In contrast, maximum spoilage was noted in flowers packed in the boxes lined with the newspaper and stored for nine days (54.97%).

Further, interaction between storage durations and storage conditions reveal that minimum spoilage (16.43%) was noted when the flowers were cold stored for three days. In contrast, maximum spoilage (50.56%) was observed when the flowers were stored for nine days at room temperature.

Data on interaction of the storage conditions and packaging materials show that minimum spoilage (24.22%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and cold stored. on the other hand, maximum spoilage (41.67%) was

noted when the flowers were packed in the boxes lined with newspaper and stored for nine days at room temperature conditions.

Interaction data (Table 6b) shows the effect of packaging material, storage durations and storage conditions on spoilage (%) of chrysanthemum loose flowers indicates that minimum spoilage (16.00%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and cold stored for 3 days. Maximum spoilage, on the other hand, was observed (58.33%) when flowers were packed in cardboard boxes lined with newspaper and stored for nine days at room temperature conditions.

Table 7a shows the significant effect of packaging materials and storage on spoilage (%) of chrysanthemum loose flowers cv. 'Surf'. Among the packaging materials, minimum spoilage was observed in polyethylene (34.70%) packaging whereas, maximum spoilage was noted in flowers kept in boxes lined with newspaper (48.04%). Further, it has been observed that flower spoilage was increased with increasing storage duration. Least spoilage was observed in three days storage (26.10%), whereas maximum spoilage was noted in nine day storage (56.63%). It has also been noted that lesser spoilage of flowers was observed in the cold stored flowers (37.45%) than the flowers stored at room temperature (45.46%).

Interaction between packaging materials and storage durations reveal that minimum spoilage (19.15%) was observed when the flowers were stored for three days in the cardboard boxes lined with the polyethylene. In contrast, spoilage was noted maximum when the flowers were packed in the boxes lined with the newspaper and stored for nine days (64.95%). Interaction between storage durations and conditions reveals that minimum spoilage (22.77%) was noted when the flowers were cold stored for three days. In contrast, maximum spoilage (60.53%) was observed when the flowers were stored for nine days at room temperature.

Interaction of storage conditions and packaging materials show that least spoilage (29.43%) was noted when the flowers were packed in boxes lined with polyethylene and cold stored. on the other hand, maximum spoilage (51.40%) was observed when the flowers were packed in the boxes lined with newspaper and stored for nine days at room temperature conditions.

Interaction effect of packaging materials, storage durations and storage conditions on spoilage (%) of chrysanthemum loose flowers indicates that minimum spoilage (15.00%) was observed when the flowers were packed in cardboard boxes lined with the polyethylene and stored for 3 days under cold storage (4°C) (Table 7b). On the other hand, maximum spoilage was observed (68.30%) when the flowers were packed in cardboard boxes lined with the newspaper and stored for nine days at room temperature conditions.

Per cent moisture content

Table 8a shows the significant effect of packaging materials and storage on the moisture content (%) of loose flowers chrysanthemum cv. 'SolanShringar' after storage. Among the packaging materials, maximum moisture content (72.73%) was noted in flowers stored in the cardboard boxes lined with polyethylene. On the other, minimum moisture content (67.02%) was observed in cardboard boxes lined with newspaper. Moisture content decreased with increasing storage duration with maximum moisture content (78.29%) was observed in three day storage and minimum in nine days (59.94%). In case of storage conditions, more moisture content (71.80%) was observed in

cold stored flowers than the flowers stored at room temperature (67.47%).

Interaction of packaging materials and storage durations reveal that maximum moisture content (80.52%) was observed when the flowers were packed in the cardboard boxes lined with polyethylene and stored for three days. On the other hand, minimum moisture (56.62%) was observed when the flowers were packed in the cardboard boxes lined with newspaper and stored for nine days.

Further, interaction of storage durations and storage conditions show that maximum moisture content (80.56%) was observed when the flowers were stored under cold storage for three days. In contrast, minimum moisture content (57.24%) was observed when the flowers were stored for nine days under room temperature conditions.

Interaction of packaging materials and storage conditions was found to be non-significant. However, maximum moisture content (74.81%) was observed when the flowers were packed in the boxes lined with polyethylene and cold stored whereas minimum moisture content (64.71%) was observed when the flowers were packed in the cardboard boxes lined with newspaper at room temperature conditions.

Perusal of data presented in Table 8b on interaction effect of packaging materials, storage durations and storage conditions on percent moisture content of chrysanthemum loose flowers indicates that maximum moisture content (83.47%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and stored for three days under cold storage (4°C).

In contrast, minimum moisture content (53.83%) was noted when the flowers were packed in cardboard boxes lined with newspaper and stored for nine days at room temperature conditions.

Table 9a shows the significant effect of packaging materials and storage on the moisture content (%) of chrysanthemum loose flowers of cultivar 'Surf' after storage. Among the packaging materials, maximum moisture content (75.32%) was observed in the cardboard boxes lined with the polyethylene. Least moisture content (69.87%) was, however observed in flowers kept in cardboard boxes lined with newspaper. Moisture of flowers decreased with increasing the storage duration. Highest moisture content (80.45%) was observed in three day storage whereas minimum was found in nine days storage (63.28%). In case of storage conditions more moisture content (74.28%) was observed in cold storage than the flowers stored at room temperature (70.56%). Similar trend of results was observed for both the cultivars i.e. i.e. 'SolanShringar' and 'Surf' for per cent moisture content.

Results obtained shows that flowers packed in the polyethylene packaging was observed with the minimum spoilage and also helpful in retaining the moisture content of the flowers. This might be due to gaseous balance created by the polyethylene packaging between the CO_2 and O_2 thus reducing the transpiration and respiration rate which leads to the reduction in the loss of moisture from the flowers packed in polythene. The reduction in moisture loss prevents the wilting of flowers which delays the senescence. Furthermore, polyethylene covering also reduces the permeability to air. It might be a reason for less spoilage of flowers in the polyethylene packaging. These results are in agreement with the Nagaraja *et al.,* (1999) who reported that polyethylene packaging helps in retaining the moisture content thereby reducing wilting of flowers.

Between the storage conditions, minimum weight loss, maximum shelf life and maximum moisture content was observed when flowers are stored under refrigerated conditions. Similar results were obtained by the Srivastava *et al.,* (2015) who reported that minimum weight loss and maximum vase life of chrysanthemum flowers were observed under refrigerated conditions. This may be due to the fact that water loss which accounts for physiological weight was less when cut flowers were stored at lower temperature because vapour pressure deficit was smaller at lower temperature thereby causing less moisture as well as lees weight loss.

Results obtained shows that minimum weight loss, maximum moisture content and minimum spoilage was obtained in three days storage. Similar results were obtained by Nagaraja *et al.,* (1999) in tuberose flowers packaged in 200 gauge polyethylene. They also reported the increase in wilting percentage with the storage duration. This might be reason for the increase in spoilage as the storage duration increases.

The performance of cultivar 'SolanShringar' is at par with 'Surf' (Table 9b) for shelf life characters under study. Cultivar 'Surf' was significantly superior over 'SolanShringar' for higher moisture content in flowers till end. However the cultivars did not differ significantly for weight gain, freshness index. More flower spoilage, on the other hand was noted in loose flowers of 'Surf' than 'SolanShringar'.

The variations could be attributed to the genotypic differences between the cultivars. Similar results in vase life studies of cut chrysanthemum flowers were reported by Kavita (2016).

The performance of two cultivars of chrysanthemum 'SolanShringar' and 'Surf' showed significant difference among them for some characters during storage of loose flowers.

During storage, loose flowers of 'SolanShringar' gained less weight in comparison to 'Surf'. Non-significant results were obtained w.r.t. shelf life. Spoilage of flowers during storage was more in 'Surf' in compassion to 'SolanShringar'. Similarly higher moisture content was noted in flowers of 'Surf' than 'SolanShringar'

Genotypic differences between the cultivars are responsible for variation which is also confirmed by vase life studies of cut chrysanthemum reported by Kavita (2016).

Based on the present findings, it can be concluded that spraying the buds of chrysanthemum (15mm diameter) with BA showed a considerably increased shelf life of loose flowers in cultivars 'SolanShringar' and 'Surf'.

Among packaging materials, storage of loose flowers in cardboard box lined with polyethylene recorded maximum shelf life in cvs 'SolanShringar' and 'Surf'. Same material also resulted in maximum freshness index.

Flowers stored under refrigerated conditions (4°C) was found to have better shelf life over flowers stored under room temperature in both cultivars.

While comparing cvs, i.e. 'SolanShringar' and 'Surf' were found at par for shelf life and freshness index of loose flowers.

Based on the present findings, Among packaging materials, storage of loose flowers in cardboard box lined with polyethylene recorded maximum shelf life in cvs 'SolanShringar' and 'Surf'. Same material also resulted in maximum freshness index.

Flowers stored under refrigerated conditions (4°C) was found to have better shelf life over flowers stored under room temperature in both cultivars. While comparing cvs, i.e. 'SolanShringar' and 'Surf' were found at par for shelf life and freshness index of loose flowers.

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