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Studies on storage and packaging of marigold flowers

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Abstract
The present investigations entitled, "Studies on packaging and storage of marigold flowers" 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. The objective of the study was to find out the suitable packaging material for the marigold flowers. Polyethylene, cellophane and newspaper were used as packaging materials. Experiments were conducted in a Completely Randomized Design (factorial). Results revealed that among packaging materials maximum shelf life (4.13 days) with best freshness index, maximum moisture content, minimum weight loss and minimum spoilage of flowers was observed in the cardboard boxes lined with polyethylene as compared to flowers packed in cardboard boxes lined with newspaper and cellophane. More shelf life (5.00 days) at room temperature was observed in three day storage than the six days storage (3.25 day). In case of storage conditions more shelf life (3.81 days) was observed in flowers stored in cold storage than the flowers stored at room temperature (2.56 days).

Keywords: Packaging materials, ambient storage, refrigerated storage, storage durations, storage conditions

Introduction
Marigold (*Tagetes erecta*) is one of the most important loose flower crop grown commercially in different parts of India especially in the plains. It is a short duration, free blooming crop belonging to family Asteraceae and is native to Central and South America especially Mexico. It has gained popularity because of adaptability to various soils and climatic conditions and longer blooming period. Area under marigold flower production in India is 55890 hectares (Anonymous 2015) [1]. Flowers of marigold are sold in market as loose flowers or after making into garlands. Marigold known for its multiferous and diverse germplasm is associated with festive occasions, marriages, religious ceremonies and social functions. The flower is endured with a wide spectrum of attractive colours, shape and size having good keeping quality. Besides its pristine uses, nowadays marigold is being used as a stem less cut flower for interior decoration, in hanging basket, for decoration of temples and pandals on special occasions and also for decoration of cars in marriages. Flowers are made into garlands and are offered to the gods and to honoured guests. The high demand of the marigold flowers in the market during festival seasons from Navratras to Dussehra, Diwali and New Year has made this a farmer friendly crop.

In flower crops, round the year production of flowers is made possible through highly developed technologies in production and post harvest management. The production of flowers is increasing every year. However handling of flowers is a huge task even today. Nearly 70 percent of the potential lasting quality of flowers is predetermined at harvest, while post-harvest factors influence 30 percent of the effects. All along the marketing channel, there is enormous loss in value of cut flowers and loose flowers, which could be 50 percent of the farm value (Bhattacharjee and De, 2005) [3].

Packaging is a fundamental tool for post harvest management of highly perishable commodities and adequate packaging protects the produce from physical, physiological and pathological deterioration during transport and marketing and enhancing their shelf life by retaining their attractiveness (Krishnamoorthy, 1990) [6]. Further, storage of the flowers at low temperatures enhances the post-harvest life of the flowers.

As a general practice, after harvesting loose flowers are packed in gunny bags or bamboo baskets. It is a crude method which makes flowers vulnerable to huge post harvest losses. Despite of large scale cultivation and huge production and consumption, scanty work has been done and reported on post harvest handling of loose flowers. The present investigations were, therefore planned to reduce the spoilage by finding out suitable packaging material and enhance the post harvest longevity of loose flowers.

Material and methods

Studies on "Packaging and storage of marigold flowers" 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. Marigold cv. 'Pusa Narangi Gainda' was selected for the study. 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.

For raising the crop nursery beds of 1.0 x 1.0 m were prepared thoroughly. After preparing nursery beds, the seeds of marigold cv. 'Pusa Narangi Gainda' were sown in the beds. The nursery beds were covered with soil, mixed with compost to ensure proper germination. Seedlings were regularly watered and timely plant protection measures were taken up. After the preparation of experimental plots the healthy and uniform seedlings of twenty five to thirty days old were transplanted in the main field at 4 leaf stage during evening hours. Light irrigation was given after transplanting for better establishment of seedlings in the main field. 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.

Flowers after harvesting were kept in cardboard boxes (37.5×16.4×12.5 cm) with 3 different storage materials i.e. Cardboard box lined with newspaper, Cardboard box lined with cellophane and Cardboard box lined with polyethylene. Packed boxes were maintained under 2 storage conditions i.e. cold storage (4^0C) and room temperature with 4 storage durations like 3, 6, 9 and 12 days. Flowers under 9 and 12 days duration were spoiled hence the data was recorded and analysed for 3 and 6 days duration only. Shelf life and other observations were recorded after storage at room temperature conditions.

Results and discussion

1. Weight change (%)

Table 1a shows the significant effect of packaging materials and storage on weight change of marigold flowers. Among the packaging material minimum weight loss was observed in polyethylene (10.03%) and maximum weight loss was observed in the newspaper (13.64%). Between the storage duration less weight loss was observed in the 3 days storage (9.90%) than the six day storage (13.87%). In storage conditions lesser weight loss was observed in the cold storage (7.23%) than room temperature (16.53%).

Table 1a: Effect of packaging material and storage on weight loss (%) of marigold flowers after storage

Packaging material (M)	Storage durations (D)			Storage conditions (C)	
	3 days	6 days	Mean	Cold Storage (4 °C)	Room temperature
Polyethylene	8.15	11.92	10.03	6.04	14.03
Cellophane	9.82	14.13	11.98	7.00	16.95
Newspaper	11.72	15.57	13.64	8.67	18.62
Mean	9.90	13.87		7.23	16.53
Storage conditions (C)			$CD_{0.05}$ for		
Cold Storage (4°C)	5.80	8.67	M: 0.08 D × M: 0.11		
Room temperature	13.99	19.08	D: 0.06 C × D: 0.09		
			C: 0.06 C × M:0.11		

Interaction between packaging materials and storage duration shows that minimum weight loss (8.15%) was observed when the flowers were stored for three days in the cardboard boxes lined with the polyethylene. In contrast, maximum weight loss was observed when the flowers were packed in the boxes lined with the newspaper and stored for six days (15.57%).

Interaction between storage duration and storage conditions reveals that minimum (5.80%) weight loss was observed when the flowers were stored under cold storage for 3 days. In contrast maximum weight loss (19.08%) was observed when the flowers were stored for six days at room temperature.

Interaction of the storage conditions and packaging materials shows that minimum weight loss (6.04%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and stored under cold storage (4^0C). on the other hand maximum weight loss (18.62%) was observed when the flowers were packed in the boxes lined with newspaper and stored for six days under room temperature conditions.

Table 1b: Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on weight loss (%) of marigold flowers after storage

Packaging material (M)	Storage conditions (C)			
	Cold Storage (4°C)		Room temperature	
	Storage duration (D)		Storage duration (D)	
	3 days	6 days	3 days	6 days
Polyethylene	4.74	7.33	11.57	16.50
Cellophane	5.33	8.67	14.30	19.60
Newspaper	7.33	10.00	16.10	21.13
$CD_{0.05}$ for M x C x D: 0.16				

Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on weight loss (%) of marigold flowers indicates that minimum weight change (4.74%) was observed when the flowers were packed in cardboard boxes lined with the polyethylene and stored for 3 days under cold storage (4^0C). And maximum weight loss was observed (21.13%) when the flowers were packed in cardboard boxes lined with the newspaper and stored for six days under room temperature conditions.

Results obtained shows that minimum weight loss was observed when the flowers were packed in the polyethylene packaging through out the storage. This might be due to the

fact that the thickness of polyethylene bags reduce the permeability of polyethylene covering to the moisture and air thereby reducing the physiological loss in weight which may be due to reduction in loss of moisture as well as respiration of produce (Bhullar and Farmohan, 1980) [4]. These results are in close agreement with Madaiah and Reddy (1994) [7] 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) [11] who while working on tuberose reported that minimum weight loss was observed with the polyethylene (200 gauge) packaging.

2. Shelf life

Table 2a shows the significant effect of packaging material and storage on shelf life of marigold flowers. Among the packaging materials maximum shelf life (4.13 days) of flowers was observed in the cardboard boxes lined with the polyethylene and minimum (2.38 days) shelf life was observed in cardboard boxes lined with the newspaper. Between the storage duration, more shelf life (3.94 days) was observed in three days storage than the six day storage (2.42 days) In case of storage conditions more shelf life (3.81 days) was observed in cold storage than the flowers stored at room temperature (2.56 days).

Table 2a: Effect of packaging material and storage on shelf life of marigold flowers

Packaging material (M)	Storage durations (D)			Storage conditions (C)	
	3 days	6 days	Mean	Cold Storage (4 °C)	Room temperature
Polyethylene	5.00	3.25	4.13	4.75	3.50
Cellophane	3.67	2.42	3.04	3.75	2.33
Newspaper	3.17	1.58	2.38	2.92	1.83
Mean	3.94	2.42		3.81	2.56
Storage conditions (C)			$CD_{0.05}$ for		
Cold Storage (4°C)	4.44	3.17	M: 0.19 D × M: 0.26		
Room temperature	3.44	1.67	D: 0.15 C × D: 0.22		
			C: 0.15 C × M:NS		

Interaction of packaging material and storage duration reveals that maximum shelf life (5.00 days) was observed when the flowers were packed in the cardboard boxes lined with polyethylene and stored for three days. On the other hand minimum shelf life (1.58 days) was observed when the flowers were packed in the cardboard boxes lined with newspaper and stored for six days.

Interaction of storage duration and storage conditions shows that maximum shelf life (4.44 days) was observed when the flowers were stored under cold storage for three days. In contrast minimum shelf life (1.67 days) was observed when the flowers were stored for six days under room temperature conditions.

Interaction of packaging material and storage conditions was found to be non significant.

Table 2b: Interaction effect of Packaging material (M), storage duration (D) and storage conditions (C) on shelf life of marigold flowers

Packaging material (M)	Storage conditions (C)			
	Cold Storage (4 °C)		Room temperature	
	Storage duration (D)		Storage duration (D)	
	3 days	6 days	3 days	6 days
Polyethylene	5.33	4.16	4.67	2.33
Cellophane	4.33	3.17	3.00	1.67
Newspaper	3.67	2.16	2.67	1.00
$CD_{0.05}$ for M x C x D: 0.37				

Perusal of data presented in Table 2b on interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on shelf life of marigold flowers indicates that maximum shelf life (5.33 days) was observed when the flowers were packed in cardboard boxes lined with polyethylene and stored for three days under cold storage (4^0C). In contrast, minimum shelf life (1.00 day) was observed when the flowers were packed in cardboard boxes lined with newspaper and stored for six days under room temperature conditions.

Maximum shelf life was obtained in the flowers packed and stored in the polyethylene packaging. The result may be due the reason that polyethylene sheet provide modified atmosphere, which increased the CO_2 concentration as well as humidity and slowed down the transpiration inside the package leading to slow down of the respiration process (Hardenburg, 1971) [5]. Furthermore, it might have more amount of carbohydrates and energy because of permeability of polyethylene sheet which may lead to increase in the shelf life of flowers. These results are in close conformity with the results of Varu and Barad (2008) [11] who while working on tuberose reported that the packing in 200 gauge polyethylene sheet results the longest vase life (14.43 days).

According to Nirmala and Reddy (1993) [9] packaging of jasmine flowers in polythene bags resulted in the extension of shelf life to 3 days (*Jasminum sambac*) and to 7 days (*J multiflora*).

3. Freshness index

Table 3a shows the significant effect of packaging material and storage conditions on freshness index of marigold flowers. Among the packaging materials highest score (3.93 out of 5) for freshness index was obtained by the flowers packed in cardboard boxes lined with polyethylene. On the other hand, lowest score (3.17 out of 5) was obtained by the flowers packed in boxes lined with newspaper. Between the storage duration more score (3.76 out of 5) was obtained by the flowers stored for three days than the flowers stored for the six days. In case of storage conditions, more score (3.84) was obtained by the flowers stored under cold storage ($4\ ^0$C) than the flowers stored under room temperature conditions.

Table 3a: Effect of packaging material and storage on freshness index of marigold flowers

Packaging material (M)	Storage durations (D)			Storage conditions (C)	
	3 days	6 days	Mean	Cold Storage (4 °C)	Room temperature
Polyethylene	4.10	3.75	3.93	4.10	3.75
Cellophane	3.86	3.40	3.63	3.93	3.33
Newspaper	3.33	3.00	3.17	3.50	2.84
Mean	3.76	3.38		3.84	3.31
Storage conditions (C)			$CD_{0.05}$ for		
Cold Storage (4°C)	3.97	3.71	M: 0.06 D × M: NS		
Room temperature	3.55	3.06	D: 0.04 C × D: 0.07		
			C: 0.04 C × M:0.08		

Interaction of the storage duration and packaging material was fond to be non significant.

Interaction of storage duration and storage conditions shows that flowers stored for three days under cold storage (4 ^{0}C) obtained the highest score (3.97 out of 5) for freshness index. On the other hand lowest score (3.06) was obtained by the flowers stored for six days under room temperature conditions.

Interaction of the storage conditions and packaging material shows that maximum score (4.10 out of 5) was obtained by the flowers packed in the cardboard boxes lined with polyethylene and stored under cold storage. In contrast, minimum score (2.84) was obtained by the flowers packed in the cardboard boxes lined with the newspaper and stored under room temperature conditions.

Table 3b: Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on freshness index of marigold flowers

Packaging material (M)	Storage conditions (C)			
	Cold Storage (4°C)		Room temperature	
	Storage duration (D)		Storage duration (D)	
	3 days	6 days	3 days	6 days
Polyethylene	4.20	4.00	4.00	3.50
Cellophane	4.06	3.80	3.66	3.00
Newspaper	3.66	3.33	3.00	2.67
$CD_{0.05}$ for M x C x D: 0.12				

Perusal of data presented in Table 3b on interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on freshness index of marigold flowers reveals that highest score (4.20 out of 5) for freshness index was obtained by the flowers packed in cardboard boxes lined with the polyethylene and stored for 3 days under cold storage. In contrast minimum score (2.67) was obtained by the flowers packed in cardboard boxes lined with the newspaper and stored for six days under room temperature conditions.

Results obtained shows that the highest score was obtained by the flowers packed in the polyethylene packaging. This might be due to the reason that packaging maintains the high humidity and proper balance between the carbon di oxide and oxygen concentration which slows down the process of respiration (Anzueto and Rizvi 1985) [2]. Furthermore, it might have more freshness, contains more amount of carbohydrates and energy because of reduced permeability of polyethylene sheet. The polyethylene reduce 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 Varu and Barad (2008) [11] who while working on tuberose flowers reported that maximum freshness of flowers was reported in polyethylene.

4. Spoilage (%)

Table 4a shows the significant effect of packaging materials and storage on spoilage (%) of marigold flowers. Among the packaging materials minimum spoilage was observed in polyethylene (18.76%) and maximum spoilage was observed in the newspaper (24.66%). Between the storage duration less spoilage was observed in the 3 days storage (15.03%) than the six day storage (28.49%). In storage conditions lesser spoilage was observed in the cold storage (17.06%) than room temperature (26.46%).

Table 4a: Effect of packaging material and storage on spoilage (%) of marigold flowers

Packaging material (M)	Storage durations (D)			Storage conditions (C)	
	3 days	6 days	Mean	Cold Storage (4 °C)	Room temperature
Polyethylene	12.53 (20.72)	24.98 (29.74)	18.76 (25.23)	14.83 (22.53)	22.68 (27.92)
Cellophane	14.89 (22.68)	28.83 (32.21)	21.86 (27.44)	17.02 (24.27)	26.71 (30.62)
Newspaper	17.66 (24.83)	31.67 (34.00)	24.66 (29.41)	19.33 (26.01)	29.99 (32.81)
Mean	15.03 (22.74)	28.49 (31.98)		17.06 (24.27)	26.46 (30.45)
Storage conditions (C)			$CD_{0.05}$ for		
Cold Storage (4°C)	14.01 (21.93)	20.11 (26.61)	M: 0.26 D × M: NS		
Room temperature	16.05 (23.55)	36.88 (37.35)	D: 0.21 C × D: 0.30		
			C: 0.21 C × M:0.37		

Figures in parentheses are angular transformed values.

Interaction between packaging materials and storage duration was found to be non significant. Interaction between storage duration and storage conditions reveals that minimum spoilage (14.01%) was observed when the flowers were

stored under cold storage for 3 days. In contrast maximum rotting (36.88%) was observed when the flowers were stored for six days at room temperature.

Interaction of the storage conditions and packaging materials shows that minimum spoilage (14.83%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and stored under cold storage (4^{0}C). On the other hand maximum spoilage (29.99%) was observed when the flowers were packed in the boxes lined with newspaper and stored for six days under room temperature conditions.

Table 4b: Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on spoilage (%) of marigold flowers

Packaging material (M)	Storage conditions (C)			
	Cold Storage (4°C)		Room temperature	
	Storage duration (D)		Storage duration (D)	
	3 days	6 Days	3 Days	6 Days
Polyethylene	11.80 (20.08)	17.87 (24.99)	13.27 (21.35)	32.10 (34.50)
Cellophane	13.90 (21.88)	20.13 (26.65)	15.88 (23.48)	37.53 (37.77)
Newspaper	16.33 (23.83)	22.33 (28.19)	18.99 (25.83)	41.00 (39.80)
$CD_{0.05}$ for M x C x D: 0.52				

Figures in parentheses are angular transformed values

Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on spoilage (%) of marigold flowers indicates that minimum spoilage (11.80%) was observed when the flowers were packed in cardboard boxes lined with the polyethylene and stored for 3 days under cold storage (4 ^{0}C). Maximum spoilage was observed (41.00%) when the flowers were packed in cardboard boxes lined with the newspaper and stored for six days under room temperature conditions.

5. Moisture content (%)

Table 5a shows the significant effect of packaging material and storage on the moisture content (%) of marigold flowers after storage. Among the packaging materials maximum moisture content (79.92%) was observed in the cardboard boxes lined with the polyethylene and minimum moisture content (74.58%) was observed in cardboard boxes lined with the newspaper. Between the storage duration, more moisture content (80.17%) was observed in three days storage than the six day storage (74.44%). In case of storage conditions more moisture content (79.72) was observed in cold storage than the flowers stored at room temperature (74.89%).

Interaction of packaging material and storage duration reveals that maximum moisture content (82.83%) 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 (71.50%) content was observed when the flowers were packed in the cardboard boxes lined with newspaper and stored for six days.

Table 5a: Effect of packaging material and storage on moisture content (%) of marigold flowers after storage

Packaging material (M)	Storage durations (D)			Storage conditions (C)	
	3 days	6 days	Mean	Cold Storage (4 °C)	Room temperature
Polyethylene	82.83	77.00	79.92	82.17	77.67
Cellophane	80.00	74.83	77.42	79.50	75.33
Newspaper	77.67	71.50	74.58	77.50	71.67
Mean	80.17	74.44		79.72	74.89
Storage conditions (C)			$CD_{0.05}$ for		
Cold Storage (4°C)	82.11	77.33	M: 0.29 D × M: 0.41		
Room temperature	78.22	71.56	D: 0.24 C × D: 0.33		
			C: 0.24 C × M:0.41		

Interaction of storage duration and storage conditions shows that maximum moisture content (82.11%) was observed when the flowers were stored under cold storage for three days. In contrast minimum moisture content (71.56%) was observed when the flowers were stored for six days under room temperature conditions.

Interaction of packaging material and storage conditions indicates that maximum moisture content (82.17%) was observed when the flowers were packed in the cardboard boxes lined with polyethylene and stored under cold storage (4 ^{0}C). On the other hand minimum moisture content (71.67%) was observed when the flowers were packed in the cardboard boxes lined with newspaper under room temperature condition.

Table 5b: Interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on moisture content (%) of marigold flowers

Packaging material (M)	Storage conditions (C)			
	Cold Storage (4 °C)		Room temperature	
	Storage duration (D)		Storage duration (D)	
	3 days	6 days	3 days	6 Days
Polythene	85.00	79.33	80.67	74.67
Cellophane	81.67	77.33	78.33	72.33
Newspaper	79.67	75.33	75.67	67.67
$CD_{0.05}$ for M x C x D: 0.58				

Data presented in Table 5b on interaction effect of packaging material (M), storage duration (D) and storage conditions (C) on moisture content (%) of marigold flowers indicates that maximum moisture content (85.00%) was observed when the flowers were packed in cardboard boxes lined with polyethylene and stored for three days under cold storage (4 ^{0}C). In contrast, minimum moisture content (67.67%) was observed when the flowers were packed in cardboard boxes lined with newspaper and stored for six days under room temperature conditions.

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 the air. It might be a reason for the less spoilage of flowers in the polyethylene packaging. These results are in agreement with the Nagaraja *et al.* (1999) [8] 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) [10] 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) [8] in tuberose flowers packaged in 200 gauge polyethylene. He 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.

Conclusion

Based on the present findings on Studies on packaging and storage of marigold cv. 'Pusa Narangi Gainda' it can be concluded that flowers packed in polyethylene had more shelf life (4.13 days) over cellophane (3.04 days) and newspaper (2.38 days). Flowers stored for 3 days were observed with better shelf life than the six day storage. Shelf life of flowers stored under refrigerated storage was better as compared to room temperature.

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