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Extension of the Storage-life of Marigold cv. 'Calcutta Gainda' using Cold Room

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A B S T R A C T

An investigation to evaluate the storage-life of Marigold cv. 'Calcutta Gainda' at room conditions and inside cold storage was undertaken at Ecofrost Technologies Pvt. Ltd. Tathawade, Pune (MH), India during the monsoon 2016-17. The best flowers from a farmer's field were selected based on quality and the effect of cold storage (4°C and 93% RH) and packaging on the storage-life of these flowers was studied. The experiment showed flowers kept inside cold storage to have minimum weight loss (lb), minimum shrivelling percentage, minimum rot percentage, better appearance and brighter colour. Some Marigold flowers were stored in cold storage inside black polythene bags (BPBs) and showed greater retention of storage life, less rotting and shrivelling percentages, better appearance and colour than air-stored flowers at ordinary room conditions. The BPBs were found to reduce weight-loss. Flowers in BPBs kept inside cold storage had a shelf life of 8 days compared to 3.5 days for flowers kept in ordinary room conditions. Post-storage life was recorded to be 2 days for flowers in BPB's kept inside cold storage.

Introduction

The African marigold (*Tagetes erecta* L.), belonging to the *Asteraceae* family or *Compositae*, is the most commonly grown loose flower and is extensively used in religious and social function. Marigolds come in different colours, yellow and orange being the most common. Most marigold flowers have a strong, pungent odour and have great value in cosmetic treatment (Jadhav *et al*., 2014). Burning the herb repels insects and flies. Marigold pigments are sometimes extracted and used as food colouring for human consumption.

Marigold is gaining commercial importance as a source of carotenioid pigments. The principal pigment present in the flower is xanthophyll – particularly lutein – that accounts for 80 to 90% in the form of esters of plamitic and myristic acid. Ground blossom meal (petal meal) or extract (usually saponified for better absorption) is added to poultry feed (Bosam *et al*., 2003). These products are traded as "Aztec marigold" or marigold extract as "Adoptinal". Marigold

flowers become ready for harvesting in about 2½ months' time from the date of transplanting. The plant continues to bear flowers for another 2-2 ½ months from the date of the first harvest. The flowers are harvested when they have attained their full size. Harvesting the flowers in the evening along with a portion of stalk is ideal. The yield of the African marigold (*Tagetes erecta* L.) is 11-18 t/ha (http://www.keralaagriculture.gov.in/pdf/package_2015.pdf).

Rapid cooling and proper temperature are key requirements for maintaining the vitality of cut and loose flowers. Refrigerated storages provide growers with the capability of extending the storage-life of flowers and, therefore, widen the marketing potential of the product. Temperature is considered the most important factor affecting the quality and longevity of flowers (Cevallos and Reid 2001; Leonard *et al*., 2001; Gul *et al*., 2007; Shashri *et al*, 2009; Shashri and Tahir, 2011). At lower temperatures, flowers have a lower respiration rate and consume stored energy slowly (Van Dorn and De Witte, 1991; Cevallos and Reid 2001; Shashri *et al*., 2009). The storage and packaging systems play a pivotal role in the preservation of produce freshness (Senapti *et al.,* 2016) while lowering transportation costs.

The aim of this study is to evaluate the effect of different storage conditions on the post-harvest quality of the marigold cv. 'Calcutta Gainda'.

Materials and Methods

Healthy Marigold flowers of cv. 'Calcutta Gainda' growing in Supa Village, Ahemad-nagar District, Maharashtra, India were used for this study during August 2016. Fully open and 80% open flowers were harvested at 4:00 PM and transported in 2 hours 30 min in an air-conditioned vehicle to the Agricultural Research Laboratory of Ecofrost Technologies Pvt. Ltd., Pune, where they were immediately prepared for the experiment. At the time of harvesting, environmental temperature was recorded to be 26.8°C. In the laboratory, flowers were selected for their uniformity and lack of defects and were graded into two categories based on 'floret opening percentage' i.e. 80% and 100%. Flowers were kept inside a cold storage unit (Ecofrost) at 4°C and 93% relative humidity as well as in ordinary room conditions, subjecting them to a total of eight treatments *viz.,*T_1 (80% open flowers stored at room temperature (RT) with no humidity control), T_2 (80% open flowers + BPB with 2% ventilation stored at RT), T_3 (fully open flowers stored at room temperature), T_4 (fully open flowers + BPB with 2% ventilation stored at RT), T_5 (80% open flowers stored in Ecofrost), T_6 (80% open flowers + BPB with 2% ventilation stored in Ecofrost), T_7 (fully open flowers stored in Ecofrost), and T_8 (fully open flowers + BPB with 2% ventilation stored in Ecofrost). Each treatment was further replicated thrice. After 8 days of cold storage, the flowers were stored at room conditions. Relevant data for respective parameters such as appearance, shrivelling percentage, weight loss, rot percentage and storage-life (days) was measured at 5:00PM every day. Weight loss was determined by weighing samples of five flowers using a laboratory digital balance before storage and re-weighing every day (Jadhav *et al*., 2018).

Shrivelling and rot percentage (%) were evaluated on a 5-point scale, where 1= 20%, 2= 40%, 3=60%, 4= 80% and 5 = 100%. Colour was evaluated by rating scales of 1 to 4, where 1= 100% (Very good), 2= 75% (Good), 3= 50% (Low) and 4= 25% (Very low).

Observations recorded

Observations regarding post-harvest parameters viz., flower weight (lb), shrivelling percentage, rot percentage, appearance and

colour fading were recorded every day. Flowering parameters were recorded every day after the first day of storage and cumulative data was subjected to statistical analysis.

Statistical analysis

The experiments were replicated three times with completely randomised block design. The recorded data was statistically analyzed (ANOVA analysis) using the software WASP, (developed at ICAR Research Complex for Goa, India) (http://www.ccari.res.in/waspnew.html).

Results and Discussion

This work was conducted to evaluate the storage-life of marigold flower at room and inside cold storage conditions at Ecofrost Technologies Pvt. Ltd., Tathawade, Pune, Maharashtra, India. Parameters like flowers weight (lb), shrivelling (%), rot (%), appearance of flowers, colour of the flowers and the number of days of storage-life of the flowers in room and cold storage conditions were studied.

Weight of five flowers (lb)

The data clearly indicated that the average weight of 5 flowers (Table 1) is statistically high when recorded for T_8, showing the maximum average weight of five flowers on day - 9 and day - 10 at RT, respectively, after post-storage and, then followed by T_7. The lowest weight of an average of five flowers was recorded statistically for T_1.

Shrivelling percentage

T_8 resulted in minimum shrivelling percentage observed on the first 8 days of cold storage and on the day - 9 and day - 10 at RT, followed by T_6 as compared to all other treatments at the end of the experiment (Table 2). The storage and packaging systems were observed to play a pivotal role in the preservation of the freshness of the produce. The use of black polythene bags as packaging inside the Ecofrost was found promising in maintaining the quality of the flower during storage agreeing with Kader (2002). Furthermore, modified atmosphere packaging (MAP) has been widely utilised to retard the wilting of fresh flowers (Bishop *el al.,* 2007).

Rot percentage

The results clearly stated that T_8 had the minimum rot percentage followed by T_6 (Table 3) at the end of the experiment inside the Ecofrost. Similarly, maximum rot percentage was observed for T_4 as 66.67% and T_2 as 60%, respectively at RT. The beneficial effects of MAP included delayed senescence associated with physiological and biochemical changes such as reduction in the rate of respiration, rate of ethylene production, softening, and reduced sensitivity to ethylene. Increased levels of carbon dioxide inhibited the growth of some fungi, agreeing with Kader (2002).

Appearance

A significantly better appearance of flowers was noticed inside cold storage for T_8 and T_6, followed by T_7 and T_5 (Table 4). However, among all other treatments, most degraded appearance was recorded in T_1 on the day-7 of storage. MAP improved product quality and consequently reduced possible biochemical changes (Waringthon and Soni, 2014).

Color

The data showed that T_8 significantly maintained flowering colour in cold storage as compared to any other treatment (Table 5).

Table.1 Weight of Marigold flowers cv. 'Calcutta Gainda'at room and inside cold storage conditions

	At room temperature										
	Flowers weight (lb)										
Treat. No.	**3August 2016 (I)**	**4August 2016**	**5August 2016**	**6August 2016**	**7August 2016**	**8August 2016**	**9August 2016**	**10August 2016**	**11August 2016**	**12August2016**	**13August 2016**
T_1	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.10	0.09	0.09	0.08
T_2	0.12	0.13	0.13	0.12	0.12	0.11	0.11	0.11	0.10	0.10	0.09
T_3	0.12	0.13	0.13	0.13	0.13	0.12	0.13	0.13	0.12	0.11	0.10
T_4	0.12	0.16	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.11	0.11
	In cold storage (4°Cand 93% relative humidity)									**At room conditions**	
T_5	0.12	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.13	0.13	0.12
T_6	0.12	0.13	0.13	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.12
T_7	0.12	0.15	0.16	0.16	0.16	0.16	0.17	0.17	0.16	0.15	0.14
T_8	0.12	0.18	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.16	0.15
CD @ 5%	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
Note	**n=5**	r=3	I- Initial observation								

Table.2 Shrivelling percentage of Marigold flowers cv. 'Calcutta Gainda' at room and inside cold storage conditions

Date	3 August 2016 (I)	4 August 2016	5 August 2016	6 August 2016	7 August 2016	8 August 2016	9 August 2016	10 August 2016	11 August 2016	12 August 2016	13 August 2016
Treat. No.	**At room conditions**										
T_1	0.00	0.00	0.00	13.33	26.67	100	100	100	100	100	100
T_2	0.00	0.00	0.00	0.00	0.00	40.00	53.33	73.33	93.33	100	100
T_3	0.00	0.00	0.00	0.00	33.33	100	100	100	100	100	100
T_4	0.00	0.00	0.00	0.00	0.00	33.33	53.33	66.67	86.67	93.33	100
	In cold storage (4°Cand 93% relative humidity)									**At room conditions (RT)**	
T_5	0.00	0.00	0.00	0.00	0.00	20.00	33.33	33.33	46.67	46.67	46.67
T_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
T_7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	6.67	13.33	20.00
T_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67
C.D. @ 0.05	0.00	0.00	0.00	7.07	15.80	14.13	12.24	14.13	14.13	12.24	12.24
Note	**n=5**	r=3	I- Initial observation								

Table.3 Rot percentage of Marigold flowers cv. 'Calcutta Gainda' at room and inside cold storage conditions

Date	3 August 2016 (I)	4 August 2016	5 August 2016	6 August 2016	7 August 2016	8 August 2016	9 August 2016	10 August 2016	11 August 2016	12 August 2016	13 August 2016
Treat. No.	**At room conditions**										
T_1	0.00	0.00	0.00	0.00	13.33	13.33	13.33	13.33	13.33	13.33	13.33
T_2	0.00	0.00	0.00	0.00	0.00	0.00	6.67	26.67	33.33	53.33	60.00
T_3	0.00	0.00	0.00	0.00	13.33	13.33	13.33	13.33	13.33	13.33	13.33
T_4	0.00	0.00	0.00	0.00	0.00	0.00	6.67	26.67	33.33	40.00	66.67
	In cold storage conditions (4°Cand 93% relative humidity)									**At room conditions**	
T_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	13.33	20.00	26.67
T_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.33	20.00
T_7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	6.67	13.33	26.67
T_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	13.33
CD @ 0.05	0.00	0.00	0.00	0.00	9.99	9.99	14.13	17.31	17.31	24.48	29.98
Note	**n=5**		I- Initial observation								

Table.4 Appearance of Marigold flowers cv. 'Calcutta Gainda' at room conditions and inside cold room of Ecofrost

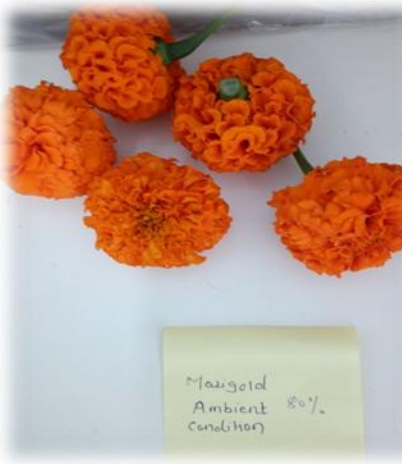
Date	3 August 2016 (I)	4 August 2016	5 August 2016	6 August 2016	7 August 2016	8 August 2016	9 August 2016	10 August 2016	11 August 2016	12 August 2016	13 August 2016
Treat. No.	**At room conditions**										
T_1	VG	VG	VG	G	G	G	G	L	L	VL	VL
T_2	VG	VG	VG	VG	VG	VG	G	G	L	L	VL
T_3	VG	VG	VG	G	G	G	G	G	G	L	L
T_4	VG	VG	VG	VG	VG	VG	G	G	L	L	VL
	In cold storage conditions (4°Cand 93% relative humidity)									**At Room conditions**	
T_5	VG	VG	VG	VG	VG	VG	VG	G	G	G	G
T_6	VG	VG	VG	VG	VG	VG	VG	VG	VG	G	G
T_7	VG	VG	VG	VG	VG	VG	VG	VG	G	G	G
T_8	VG	VG	VG	VG	VG	VG	VG	VG	VG	G	G

Table.5 Color of Marigold Flowers cv. 'Calcutta Gainda' at room conditions and inside cold storage of Ecofrost

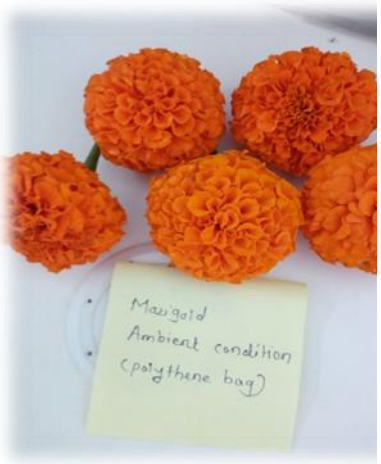
Date	3 August 2016 (I)	4 August 2016	5 August 2016	6 August 2016	7 August 2016	8 August 2016	9 August 2016	10 August 2016	11 August 2016	12 August 2016	13 August 2016
Treat No.	**At room conditions**										
T_1	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.67	3.33	4.00	4.00
T_2	1.00	1.00	1.00	1.33	1.33	1.33	1.67	2.33	2.67	2.67	3.67
T_3	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.33	2.67	3.33
T_4	1.00	1.00	1.00	1.00	1.33*	1.33	1.67	2.00	2.67	2.67	3.67
	In cold storage conditions (4°Cand 93% relative humidity)									**At room conditions**	
T_5	1.00	1.00	1.00	1.33	1.33	1.33	1.33	1.67	2.00	2.33	2.33
T_6	1.00	1.00	1.00	1.00	1.00	1.33	1.00	1.33	1.33	1.33	1.67
T_7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.33	1.33	1.67	2.00
T_8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.33	1.67
C.D. @ 0.05	0.00	0.00	0.00	0.50	0.50	0.71	0.61	0.79	0.87	0.93	0.87
Note	**n=5**	r=3	I- Initial observation								

Figure.1 Fully open marigold flowers packed in BPB and stored at room conditions on 3rd August, 2016

Figure.2 Fully open marigold flowers stored at cold room of Ecofrost on 3rd August, 2016



T_1: 80% Opened flowers stored at room conditions



T_2: 80% Opened flowers packed in BPB and stored at room conditions

T_5: 80 % Opened flowers stored in cold room of Ecofrost (4 °C and 93% RH)

T_6: 80 % Opened flowers packed in BPB and stored inside cold room (4 °C and 93% RH)

Figure.4a On 3rd day of Marigold cv. "Calcutta Gainda"(5th August, 2016)

T_3: Fully open flowers stored at room conditions

T_4: Fully open flowers packed in BPB and stored at room conditions

T_7: Fully open flowers stored inside cold room of Ecofrost (4 °C and 93% RH)

T_8: Fully open flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure.4b On 3rd day of Marigold cv. "Calcutta Gainda" (5th August, 2016)




T_1: 80% Opened flowers stored at room conditions

T_2: 80% Opened flowers packed in BPB and stored at room conditions

T_3: 80% Opened flowers stored inside cold room of Ecofrost (4 °C and 93% RH)

T_5: 80% Opened flowers packed in BPB and stored inside cold room of Ecofrost(4 °C and 93% RH)

Figure 5a:- On 4rd day of Marigold cv. 'Calcutta Gainda' (6th August, 2016)



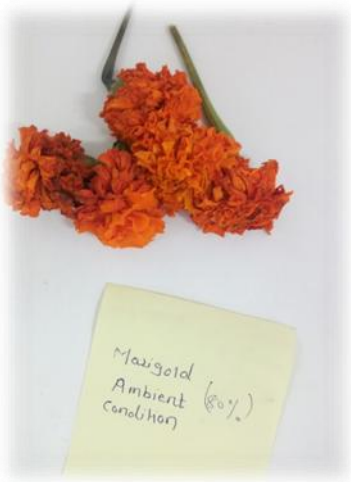

T_3: Fully open flowers stored at room conditions

T_4: Fully open flowers packed in BPB and stored at room conditions

T_7: Fully open flowers stored inside cold room of Ecofrost (4 °C and 93% RH)

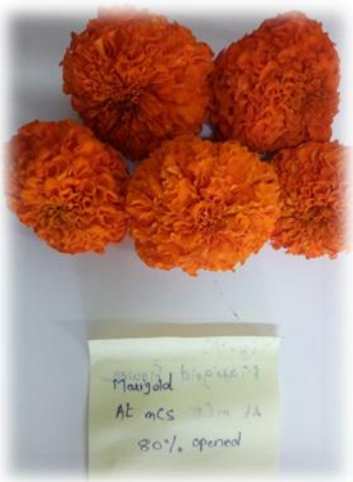
T_8: Fully open flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure 5b:- On 4rd day of storage of Marigold cv. 'Calcutta Gainda' (6th August, 2016)

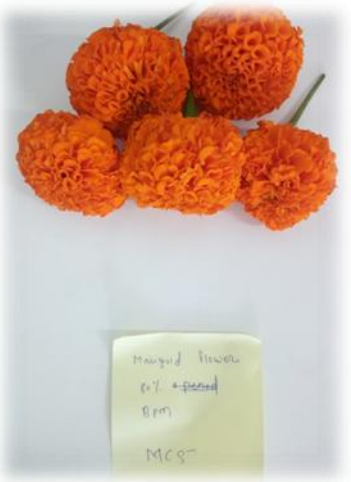


T_1: 80% Opened flowers stored at room conditions

T_2: 80% Opened flowers packed in BPB and stored at room conditions

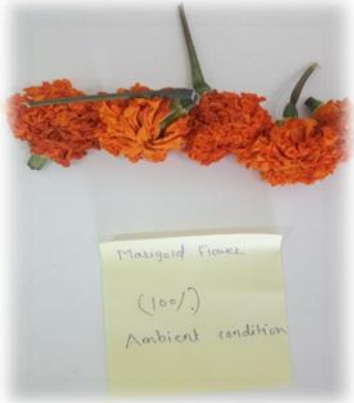


T_5: 80% Opened flowers stored inside cold room of Ecofrost (4 °C and 93% RH)



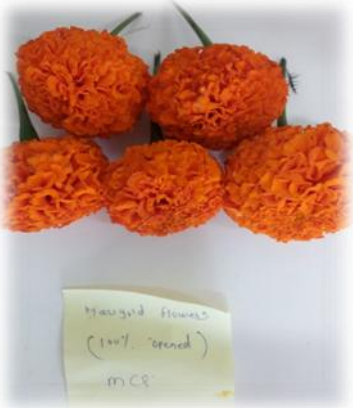
T_6: 80% Opened flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure 6a:- On 10th day of storage of Marigold cv. 'Calcutta Gainda' (12th August, 2016)

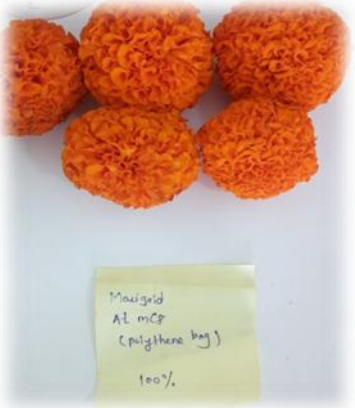


T_3: Fully open flowers stored at room conditions

T_4: Fully open flowers packed in BPB and stored at room conditions



T_7: Fully open flowers stored inside cold room of Ecofrost (4 °C and 93% RH)



T_8: Fully open flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure 6b:- On 10th day of storage of Marigold cv. 'Calcutta Gainda' (12th August, 2016)

T_1: 80 % Opened flowers stored at room conditions

T_2: 80 % Opened flowers packed in BPB and stored at room conditions

T_5: 80 % Opened flowers stored inside cold room of Ecofrost (4 °C and 93% RH)

T_6: 80 % Opened flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure 7a:- On 3rd day after post-storage of Marigold cv. 'Calcutta Gainda' (14th August, 2016)

T_3: Fully open flowers stored at room conditions

T_4: Fully open flowers packed in BPB and stored at room conditions

T_7: Fully open flowers stored inside cold room of Ecofrost (4 °C and 93% RH)

T_8: Fully open flowers packed in BPB and stored inside cold room of Ecofrost (4 °C and 93% RH)

Figure 7b:- On 3rd day after post-storage of Marigold cv. 'Calcutta Gainda' (14th August, 2016)

Table.6 Storage life (days) of Marigold flowers cv. "Calcutta Gainda" at room and inside cold room of Ecofrost (4°C and 93% RH)

	Storage-life of Marigold flowers (Days)
Treat No.	**At room temperature**
T_1	3.50
T_2	5.50
T_3	4.33
T_4	5.83
	Inside cold room of Ecofrost (4°C and 93% RH)
T_5	7.67 (cold storage)
T_6	8.67 (cold storage)
T_7	8 days at cold storage + 2.00 days at room temperature
T_8	8 days at cold storage + 2.00 days at room temperature
C.D. @ 0.05	1.19
Note	n=5, r=3
Flowers were harvested during rainy time.	

The storage and packaging systems played a pivotal role in the preservation of the freshness of the produce (Waringthon and Soni, 2014).

Storage-life

T_8 maintained the longest storage-life of 8 days, whereas the batch of flowers stored at RT lasted the shortest i.e. merely 3.50 days (Table 6). Statistically, the longest storage-life (8 days) was noticed in cold storage for T_8, followed by T_7 and T_6.

Post-storage life

Post-storage life was recorded for 2 days at RT after being flowers taken out of cold room (Table 6). Post-storage life was highest as 2 days under treatment T_8.

Marigold flowers packed in Black Polythene Bag (BPB) with 2% ventilation stored at 4°C exhibited a significantly lower physiological loss in weight, shrivelling percentage, rot percentage (Figures 1 to 7b) and maintained higher relative humidity as witnessed by a well-maintained flower appearance, and colour inside cold storage.

The use of low temperature during storage is important for the conservation of these flowers; in addition to inhibiting bacterial and fungal infections, it reduces degradation of certain enzymes and ethylene production, decreases perspiration, rate of respiration (Van Dorn and De Witte, 1991; Cevallos and Reid 2001; Shashri *et al*., 2009), and delays the different processes of senescence (Ashrae 1994).

In conclusion, harvested fully opened flowers of Marigold cv. 'Calcutta Gainda' packaged in BPB and kept at cold storage (4°C with 93% RH)were seen to keep well and best maintained quality of the flowers.

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