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# Exploring alternative packaging materials for storing marigold strings

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## ABSTRACT

*Traditional packaging materials like gunny bag, bamboo basket etc. can keep marigold strings fresh for only 2-3 days after harvest and those become unacceptable to the consumers very quickly. Considering importance of marigold flower in floriculture scenario of West Bengal, the present experiment was conducted during 2017 and 2018 to find out suitable packaging materials. Flower strings of fresh full-grown marigold variety Bidhan Marigold 2 were kept in three different packaging materials (i) bamboo basket lined with paper, (ii) thermocol box and (iii) CFB box respectively along with placing 100 g ice packs in the centre of packaging materials except for CFB boxes, closed tightly. After storage, marigold strings were hanged in the laboratory for subsequent qualitative evaluation of shelf life for 0,1,2,3 days. Data revealed that thermocol box was the best among the studied packaging materials considering most of the post harvest observations such as maximum shelf life after storage (3.21days), minimum weight loss (7.67%), freshness (94.84%) and acceptability (8.00).*

***Keywords*:** Marigold string, packaging material, storage, carotenoids.

Marigold, scientifically known as *Tagetes erecta,* is the leading loose flower of India with a production share around 29%. In West Bengal, it is the dominant loose flower (75% of total loose flower ) with a production of around 58000 MT (NHB database, 2018-19). The main marigold growing zones in West Bengal are Panskura and Kolaghat in East Midnapore district, Bagnan and Uluberia in Howrah, some areas in the district of Nadia (mostly Ranaghat), 24-Paraganas and Burdwan.

Normally marigold strings are packed in gunny bags and bamboo baskets for transporting throughout India. This traditional packaging allows to keep marigold strings fresh for only few days (maximum 2-3 days after harvest) and those become unacceptable to the consumers very quickly. Though packaging and transporting marigold string in bamboo baskets or gunny bags are traditionally accepted by the farmers, still an alternative packaging material may be explored, especially for online marketing platform, contactless and hygienic delivery. Post-harvest loss being too high for most of the fresh flowers, even maintaining freshness for 3 days after storage can be a huge contribution. Packaged flowers of marigold in all laminates except box designs with single layer coating on the top surface, retained freshness longer than the control (Pal *et al.*, 2016). Also storing marigold flowers inside cold storage could minimise weight loss, shrivelling percentage and rotting along with better appearance and brighter colour (Jadav, 2018). However, after surveying farmers' practice at Mallickghat flower market of West Bengal, from where marigold strings in bamboo baskets lined with paper and having ice packets inside, are transported to different states every day in mammoth quantity, experiment was laid out to identify alternative packaging for marigold. From the survey, we selected three packaging materials viz. i) bamboo baskets, ii) thermocol boxes and iii) corrugated fibre board (CFB) boxes for our present study.

## MATERIALS AND METHODS

The present investigation was undertaken in the laboratories of AICRP on Floriculture, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia during the period of 2017-2019. Average temperature during the experiment was minimum 26$^0$C and maximum 32$^0$C and relative humidity 85%.

### Variety

Flowers of marigold variety Bidhan Marigold 2, which was officially recognised as MG2 or Bidhan Gold in 2018-19, was the released variety of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia for West Bengal. Full-grown flowers of marigold var. Bidhan Marigold-2 were harvested from the experimental field of BCKV and strings of 2 ft. long were used for the present experiment.

### Packaging materials

Marigold strings were placed inside three different packaging materials (i) bamboo basket lined with paper, (ii) thermocol box and (iii) CFB box respectively. Ice packs of 100g each were placed in the centre of all packaging materials except CFB boxes , closed tightly and stored for 0, 1, 2 and 3 days. After storage, marigold strings were hanged in the laboratory for subsequent qualitative evaluation for shelf life.

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**Observations recorded**

Physiological loss in weight (PLW%) and change in fresh weight (%) and fresh flowers (%) was calculated using the formula:

Retention of colour were recorded daily and determined by visual observation using Royal Horticulture Society (RHS) mini colour chart. Acceptability was recorded daily by visual observations. It was based on 1-9 hedonic scale suggested by Ranganna (1997).

**β Carotene content in flower**

Carotene content of dry marigold powder was estimated by spectrophotometric method as advised by Ranganna (2000).

$$\text{PLW (\%)} = \frac{\text{Fresh weight before storage} - \text{Weight after storage}}{\text{Fresh weight before storage}} \times 100$$

$$\text{\% change in fresh weight on } n^{th} \text{ day} = \frac{(\text{weight after storage-final weight on } n^{th} \text{ day of observation})}{\text{Initial weight after storage}} \times 100$$

$$\text{\% of fresh flower on } n^{th} \text{ day} = \frac{\text{Initial number of fresh flowers - final number of fresh flowers on } n^{th} \text{ day}}{\text{Initial number of fresh flowers}} \times 100$$

**Statistical analysis**

The storage study of marigold strings was conducted in two consecutive years (2017-2018). Data were analysed through Two Factor Factorial Completely Randomized Design. Also the pulled were recorded and the results are discussed as per variation of the pulled data.

**RESULTS AND DISCUSSION**

The results obtained from the qualitative evaluation for shelf life of marigold strings after storage are interpreted below:

**Physiological loss in weight (%) after storage**

Data presented in Table 1 revealed that bamboo basket (C1) showed highest percentage of physiological loss in weight (13.53%) followed by CFB box (C3) and thermocol box (C2), which exhibited physiological loss in weight of 10.72% and 7.67% respectively. In addition, percentage of physiological loss in weight increased with enhancement of storage duration in all cases. Highest loss of physiological weight (17.96%) was observed after 3days (S4) of storage and it was minimum (8.20%) after one day (S2). Considering interaction effect of packaging and storage, it was observed that up to 2 days (48 hours) of storage, thermocol boxes (C2) were best option causing least PLW (5.95% and 11.24% respectively). However, for 3days storage (72 hours), CFB box (C3) was better option causing least PLW (12.69%) .

**Shelf life (days)**

Results regarding the shelf life exhibited in Table 1 explained that shelf life significantly varied due to package of marigold flower strings and different storage durations but their interaction effect had no significant effect on shelf life of marigold flower strings. In case of packaging materials, marigold strings kept in thermocol box (C2) exhibited maximum shelf life (3.21days) followed by bamboo basket (C1). Shelf life was considered as days till the garlands had visual acceptability score within 9 to 5 ( as per 1-9 hedonic scale). Minimum shelf life (2.83days) was revealed in marigold strings stored with CFB box (C3). Regarding interaction effects, highest shelf life was observed in marigold strings packed with CFB for 2 days (3.00 days) followed by thermocol box (2.5 days) and bamboo basket respectively stored for 2 days.

**β Carotene content in flower**

Considering packaging materials, marigold flower strings kept in CFB box (C3) had the highest β carotene (1.68 mg $100g^{-1}$) content followed by strings kept in thermocol box (C2) (Table 1). Lowest β carotene (1.61mg 100 $g^{-1}$) was observed in marigold flower strings kept in bamboo basket (C1).

In storage durations, marigold strings at 0 day storage or without storage (S1) had highest β carotene content (1.82mg 100 $g^{-1}$) and lowest (1.55 mg 100 $g^{-1}$) value was observed in strings kept for 3 days storage (S4).

Regarding interaction effects, β carotene content was highest (1.85mg 100 $g^{-1}$) in marigold flower strings stored in CFB box without storage (C3S1) followed by thermocol and bamboo basket. Minimum β carotene content (1.35mg $100g^{-1}$) was found in marigold strings kept in CFB box at 3 days storage (C3S4).

**Change in fresh weight (during shelf life)**

Marigold strings kept in thermocol box (C2) showed the highest per cent of change in fresh weight (53.35%) after 2 days of storage followed by flower strings kept

**Table 1: Physiological loss in weight (%) after storage, shelf life and β carotene content of marigold strings as influenced by different packaging materials and storage durations**

| Treatments | Physiological loss in weight (%) | | | β carotene content (mg 100g$^{-1}$) | | | Shelf life (days) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Factor 1: Container** | **2017** | **2018** | **Pooled** | **2017** | **2018** | **Pooled** | **2017** | **2018** | **Pooled** |
| C1 (bamboo basket) | 13.69 | 13.37 | 13.53 | 1.62 | 1.61 | 1.61 | 2.92 | 2.83 | 2.87 |
| C2 (thermocol) | 7.65 | 7.69 | 7.67 | 1.66 | 1.67 | 1.66 | 3.25 | 3.17 | 3.21 |
| C3 (CFB box) | 10.87 | 10.57 | 10.72 | 1.68 | 1.68 | 1.68 | 2.92 | 2.75 | 2.83 |
| **S.Em(±)** | 1.12 | 1.22 | 0.83 | 0.01 | 0.01 | 0.01 | 0.11 | 0.13 | 0.09 |
| **LSD (0.05)** | 3.28 | 3.57 | 2.35 | NS | NS | NS | NS | NS | NS |
| **Factor 2: Storage duration** | | | | | | | | | |
| S1(0 day) | NA | NA | NA | 1.81 | 1.82 | 1.82 | 4.00 | 3.78 | 3.83 |
| S2(1 day) | 8.51 | 7.89 | 8.20 | 1.63 | 1.63 | 1.63 | 3.22 | 3.00 | 3.11 |
| S3(2 day) | 16.52 | 16.29 | 16.40 | 1.60 | 1.60 | 1.6 | 2.67 | 2.67 | 2.67 |
| S4(3 day) | 17.92 | 17.99 | 17.96 | 1.56 | 1.54 | 1.55 | 2.22 | 2.22 | 2.22 |
| **S.Em(±)** | 1.29 | 1.40 | 0.95 | 0.01 | 0.01 | 0.01 | 0.12 | 0.15 | 0.10 |
| **LSD (0.05)** | 3.79 | 4.12 | 2.71 | NS | NS | NS | 0.37 | 0.43 | 0.28 |
| **Interaction (Factor 1 X Factor 2)** | | | | | | | | | |
| C1S1 | NA | NA | NA | 1.80 | 1.80 | 1.80 | 4.00 | 3.67 | 3.67 |
| C1S2 | 6.91 | 6.64 | 6.77 | 1.70 | 1.70 | 1.70 | 3.33 | 3.00 | 3.17 |
| C1S3 | 19.91 | 19.39 | 19.65 | 1.50 | 1.50 | 1.50 | 2.33 | 2.67 | 2.50 |
| C1S4 | 27.96 | 27.45 | 27.71 | 1.47 | 1.43 | 1.45 | 2.00 | 2.00 | 2.00 |
| C2S1 | NA | NA | NA | 1.80 | 1.80 | 1.80 | 4.00 | 4.00 | 4.00 |
| C2S2 | 6.01 | 5.88 | 5.95 | 1.80 | 1.80 | 1.80 | 3.00 | 2.67 | 2.83 |
| C2S3 | 11.18 | 11.31 | 11.24 | 1.63 | 1.67 | 1.65 | 2.67 | 2.33 | 2.50 |
| C2S4 | 13.40 | 13.55 | 13.48 | 1.40 | 1.40 | 1.40 | 2.00 | 2.00 | 2.00 |
| C3S1 | NA | NA | NA | 1.83 | 1.87 | 1.85 | 4.00 | 3.67 | 3.83 |
| C3S2 | 12.60 | 11.14 | 11.87 | 1.80 | 1.80 | 1.80 | 3.33 | 3.33 | 3.33 |
| C3S3 | 18.46 | 18.17 | 18.32 | 1.70 | 1.70 | 1.70 | 3.00 | 3.00 | 3.00 |
| C3S4 | 12.41 | 12.97 | 12.69 | 1.37 | 1.33 | 1.35 | 2.67 | 2.67 | 2.67 |
| **SEm(±)** | **2.24** | **2.43** | **1.65** | **0.02** | **0.02** | **0.01** | **0.22** | **0.26** | **0.17** |
| **LSD (0.05)** | **6.56** | **7.14** | **4.70** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

in CFB box (51.35%) and bamboo basket (48.99%) respectively (Table-2) . Minimum per cent of change in fresh weight during longevity period was observed in case of bamboo basket storage (27.35%) for 1day only. Regarding storage durations, maximum change in fresh weight of marigold flower strings observed at 2 days storage period (S4) in packaging i.e. 57.43% (2 days after storage) and minimum *i.e*. of 31.52% (1day storage in packaging) at 1 day after storage. Considering interaction effect, maximum change in fresh weight (65.16%) storage was found in marigold strings kept in CFB box for 3 days (C3S4) and minimum (20.38%) at 1 day after storage in marigold strings kept in bamboo basket (C1S2).

**Percent of fresh flowers**

Among packaging materials, maximum fresh flower percentage (98.32% after 1 day of storage) were observed in marigold strings packed with thermocol box (C2) and minimum fresh flower percentage (96.74%) was of marigold strings stored in bamboo basket (Table 3). After 2 days of storage, highest percentage of fresh flower (94.84%) was found in thermocol box (C2) package. Highest percentage of freshness (95.48% after 2days of storage) was recorded in the marigold flower strings without any storage (S1), followed by storage for 1day and 2days.

Regarding interaction effects, marigold flower strings kept in thermocol box without storage (C2S1) showed

**Table 2: Changes in fresh weight during longevity period of marigold strings as influenced by different packaging materials and storage durations**

| Treatments | Changes in fresh weight (%) | | | | | |
|---|---|---|---|---|---|---|
| **Factor 1: Container** | **2017** | | **2018** | | **Pooled** | |
| | **Days after storage** | | **Days after storage** | | **Days after storage** | |
| | **1st day** | **2nd day** | **1st day** | **2nd day** | **1st day** | **2nd day** |
| C1 (bamboo basket) | 27.29 | 49.10 | 27.41 | 48.88 | 27.35 | 48.99 |
| C2 (thermocol) | 32.18 | 53.38 | 32.06 | 53.32 | 32.12 | 53.35 |
| C3 (CFB box) | 28.01 | 51.16 | 27.81 | 50.87 | 27.91 | 51.02 |
| **SEm(±)** | 1.10 | 1.02 | 1.08 | 1.08 | 0.77 | 0.74 |
| **LSD (0.05)** | 3.24 | 3.00 | 3.18 | 3.16 | 2.20 | 2.11 |
| **Factor 2:Storage duration** | | | | | | |
| S1(0 day) | 28.82 | 51.83 | 28.88 | 51.61 | 28.85 | 51.72 |
| S2(1 day) | 27.21 | 45.05 | 27.02 | 45.18 | 27.12 | 45.11 |
| S3(2 day) | 29.01 | 50.48 | 29.02 | 49.93 | 29.02 | 50.21 |
| S4(3 day) | 31.59 | 57.50 | 31.44 | 57.37 | 31.52 | 57.43 |
| **SEm(±)** | **1.27** | **1.18** | **1.25** | **1.24** | **0.89** | **0.86** |
| **LSD (0.05)** | **NS** | **3.47** | **NS** | **3.65** | **2.53** | **2.44** |
| **Interaction (Factor 1 X Factor 2)** | | | | | | |
| C1S1 | 24.73 | 45.17 | 25.13 | 42.28 | 24.93 | 45.18 |
| C1S2 | 20.31 | 41.58 | 20.44 | 39.67 | 20.38 | 41.52 |
| C1S3 | 33.27 | 53.50 | 33.17 | 51.05 | 33.22 | 53.01 |
| C1S4 | 30.83 | 56.14 | 30.89 | 49.29 | 30.86 | 56.25 |
| C2S1 | 30.72 | 60.28 | 30.49 | 55.00 | 30.61 | 60.12 |
| C2S2 | 32.27 | 49.35 | 31.99 | 48.48 | 32.13 | 49.65 |
| C2S3 | 31.06 | 53.03 | 31.37 | 52.48 | 31.22 | 52.73 |
| C2S4 | 34.65 | 50.86 | 34.39 | 49.71 | 34.52 | 50.90 |
| C3S1 | 31.00 | 50.04 | 31.02 | 48.32 | 31.01 | 49.87 |
| C3S2 | 29.05 | 44.22 | 28.64 | 43.64 | 28.85 | 44.17 |
| C3S3 | 22.71 | 44.90 | 22.52 | 46.16 | 22.61 | 44.87 |
| C3S4 | 29.28 | 65.49 | 29.05 | 58.39 | 29.17 | 65.16 |
| **SEm(±)** | **2.21** | **2.05** | **2.16** | **2.16** | **1.55** | **1.49** |
| **LSD (0.05)** | **6.48** | **6.00** | **6.35** | **6.33** | **4.42** | **4.22** |

the maximum percent of fresh flowers (96.01%) followed by the marigold strings kept in bamboo basket (C1S1) and CFB box (C3S1) without storage. Percentage of fresh flower decreased with the enhancement of storage duration.

**Retention of colour**

Colour intensity of the marigold flower strings was recorded by use of Royal Horticulture Society colour chart by assigning different codes for flower colour. Initially (before storage) the colour of marigold flower strings scored 7-24A and after 2days of storage it was scored 7-28B according to mini RHS colour chart.

**Acceptability on visual basis (1-9 hedonic scale)**

Results regarding the acceptability on visual basis (Table 4) exhibited that acceptability of marigold flower strings significantly varied with packaging materials stored for different durations.

Considering packaging materials, the score of acceptability on visual basis (1-9 hedonic scale) was highest (6.21 at 1 day after storage) for the marigold strings packed in thermocol box (C2) followed by bamboo basket (C1). At 2 days after storage, maximum acceptability (5.92) was in case of thermocol box (C2) package. The minimum acceptability (4.13) was observed in bamboo basket (C1).

**Table 3: Effect of different packaging materials and storage durations and their interaction on percent of fresh flower after storage**

| Treatments | Fresh flowers (%) after storage | | | | | |
|---|---|---|---|---|---|---|
| **Factor 1: Container** | **2017** | | **2018** | | **Pooled** | |
| | **Days after storage** | | **Days after storage** | | **Days after storage** | |
| | **1st day** | **2nd day** | **1st day** | **2nd day** | **1st day** | **2nd day** |
| C1 (bamboo basket) | 97.17 | 90.11 | 96.30 | 90.96 | 96.74 | 90.53 |
| C2 (thermocol) | 98.56 | 93.88 | 98.08 | 95.81 | 98.32 | 94.84 |
| C3 (CFB box) | 97.06 | 88.68 | 96.83 | 85.63 | 96.95 | 87.15 |
| **SEm(±)** | **0.47** | **0.85** | **0.51** | **1.10** | **0.35** | **0.69** |
| **LSD (0.05)** | **NS** | **2.50** | **NS** | **3.23** | **0.98** | **1.97** |
| **Factor 2: Storage duration** | | | | | | |
| S1(0 day) | 99.93 | 94.92 | 99.22 | 96.05 | 99.57 | 95.48 |
| S2(1 day) | 98.10 | 91.49 | 97.42 | 90.72 | 97.76 | 91.10 |
| S3(2 day) | 96.52 | 90.38 | 96.18 | 90.24 | 96.35 | 90.31 |
| S4(3 day) | 95.85 | 86.76 | 95.47 | 86.19 | 95.66 | 86.47 |
| **SEm(±)** | **0.54** | **0.98** | **0.58** | **1.27** | **0.40** | **0.80** |
| **LSD (0.05)** | **1.60** | **2.88** | **1.71** | **3.73** | **1.13** | **2.28** |
| **Interaction (Factor 1 X Factor 2)** | | | | | | |
| C1S1 | 99.83 | 94.80 | 98.94 | 97.86 | 99.39 | 95.37 |
| C1S2 | 97.90 | 93.82 | 96.32 | 96.01 | 97.11 | 94.22 |
| C1S3 | 95.90 | 90.06 | 95.10 | 93.68 | 95.50 | 90.37 |
| C1S4 | 95.07 | 81.76 | 94.83 | 90.55 | 94.95 | 82.18 |
| C2S1 | 100.00 | 95.37 | 99.50 | 98.29 | 99.75 | 96.01 |
| C2S2 | 98.93 | 92.89 | 98.41 | 96.74 | 98.67 | 94.40 |
| C2S3 | 98.01 | 94.87 | 97.56 | 96.81 | 97.78 | 95.76 |
| C2S4 | 97.34 | 93.15 | 97.15 | 95.88 | 97.25 | 94.15 |
| C3S1 | 99.96 | 94.59 | 99.21 | 97.92 | 99.58 | 95.07 |
| C3S2 | 97.48 | 87.77 | 97.52 | 94.26 | 97.50 | 84.70 |
| C3S3 | 95.64 | 86.21 | 95.89 | 92.58 | 95.77 | 84.80 |
| C3S4 | 95.13 | 85.35 | 94.42 | 91.63 | 94.77 | 83.10 |
| **SEm(±)** | **0.94** | **1.70** | **1.01** | **2.20** | **0.69** | **1.39** |
| **LSD (0.05)** | **NS** | **4.99** | **NS** | **6.46** | **NS** | **3.95** |

Regarding storage durations, acceptability was decreased with increase in storage durations. Highest acceptability (6.06) was observed in 1day (S2) storage duration and was minimum (2.33) for 3 days of storage (S4).

Regarding interaction effects, highest acceptability (8.00) was found in thermocol box stored for 2 days (C2S2) followed by CFB box (6.00) and bamboo basket (4.17).

**Rotting percentage**

Data pertaining to the rotting percentage (Table 5) significantly varied due to packaging and storage durations.

Highest rotting percentage (14.03% after 2 days of storage) showed in bamboo basket (C1) followed by CFB box (8.26%). Thermocol box resulted lowest (4.76%) rotting observed after 2 days storage durations (S4) followed by 1day after storage duration (bamboo basket: 3.23%, CFB box: 2.84% and thermocol box: 1.28%).

Considering storage durations, rotting of marigold flower strings was increased with the storage durations. Minimum rotting percentage in flowers was 0.14% on without storage and 3.54% on 2nd day. Maximum rotting happened in flowers stored for 3days (4.27% on 1 day and 14.14% on 2nd day in storage.

**Table 4: Effect of different packaging materials and storage durations and their interaction on acceptability of marigold strings**

| Treatments | Acceptability | | | | | |
|---|---|---|---|---|---|---|
| **Factor 1: Container** | **2017** | | **2018** | | **Pooled** | |
| | **Days after storage** | | **Days after storage** | | **Days after storage** | |
| | **1st day** | **2nd day** | **1st day** | **2nd day** | **1st day** | **2nd day** |
| C1 (bamboo basket) | 6.17 | 4.08 | 5.58 | 4.17 | 5.88 | 4.13 |
| C2 (thermocol) | 6.17 | 5.83 | 6.25 | 6.00 | 6.21 | 5.92 |
| C3 (CFB box) | 5.17 | 4.42 | 5.00 | 4.42 | 5.08 | 4.42 |
| **SEm(±)** | **0.17** | **0.08** | **0.05** | **0.08** | **0.09** | **0.06** |
| **LSD (0.05)** | **0.49** | **0.25** | **0.14** | **0.25** | **0.25** | **0.17** |
| **Factor 2: Storage duration** | | | | | | |
| S1(0 day) | 7.89 | 7.00 | 7.78 | 7.11 | 7.83 | 7.06 |
| S2(1 day) | 7.78 | 6.00 | 7.33 | 6.11 | 7.56 | 6.06 |
| S3(2 day) | 4.89 | 3.78 | 4.67 | 3.89 | 4.78 | 3.83 |
| S4(3 day) | 2.78 | 2.33 | 2.67 | 2.33 | 2.72 | 2.33 |
| **SEm(±)** | **0.19** | **0.10** | **0.06** | **0.10** | **0.10** | **0.07** |
| **LSD (0.05)** | **0.57** | **0.28** | **0.16** | **0.28** | **0.28** | **0.19** |
| **Interaction (Factor 1 X Factor 2)** | | | | | | |
| C1S1 | 8.67 | 6.33 | 8.33 | 6.33 | 8.50 | 6.33 |
| C1S2 | 8.00 | 4.00 | 7.00 | 4.33 | 7.50 | 4.17 |
| C1S3 | 5.67 | 4.00 | 5.00 | 4.00 | 5.33 | 4.00 |
| C1S4 | 2.33 | 2.00 | 2.00 | 2.00 | 2.17 | 2.00 |
| C2S1 | 7.00 | 8.00 | 7.00 | 8.00 | 7.00 | 8.00 |
| C2S2 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| C2S3 | 5.67 | 4.33 | 6.00 | 5.00 | 5.83 | 4.67 |
| C2S4 | 4.00 | 3.00 | 4.00 | 3.00 | 4.00 | 3.00 |
| C3S1 | 8.00 | 6.67 | 8.00 | 7.00 | 8.00 | 6.83 |
| C3S2 | 7.33 | 6.00 | 7.00 | 6.00 | 7.17 | 6.00 |
| C3S3 | 3.33 | 3.00 | 3.00 | 2.67 | 3.17 | 2.83 |
| C3S4 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| **SEm(±)** | **0.33** | **0.17** | **0.10** | **0.17** | **0.17** | **0.12** |
| **LSD (0.05)** | **0.98** | **0.49** | **0.28** | **0.49** | **0.49** | **0.33** |

Regarding interaction effects, bamboo basket with 3days storage (C1S4) showed highest (19.31%) rotting percentage. In all the storage durations, bamboo basket exhibited highest rotting per centage followed by CFB box and thermocol box.

From the above results it was revealed that marigold flower strings stored for 2 days (48 hours) in both thermocol box and corrugated fibre board (CFB) boxes had an average shelf of 3.5 days after storage with optimum commercial acceptability. Fresh flower percentage, β-carotene content and shelf life was decreased with increase in storage duration in all the cases of packaging materials.

When stored in CFB boxes, flower strings exhibited minimum change in fresh weight, high colour retention and high carotene content. However, low physiological loss in weight during storage, highest per cent of fresh flowers, maximum visual acceptability, minimum rotting and highest shelf life was exhibited by the marigold strings stored in thermocol boxes.

Regarding storage, as we used ice gel during the storage except in case of CFB box, the results obtained from our present experiment corroborated with the findings of Karuppaiah *et al.* (2006), Chakrabarty *et al*. (2012), Devi (2013) and Halagur *et al.* (2013).

Karuppaiah *et al.* (2006) reported that during storage of jasmine temperature is the prime factor in controlling metabolic activities like ethylene production and action. Again Chakrabarty *et al*. (2012) revealed that tuberose spikes could effectively be stored up to three days in

**Table 5: Rotting percentage during longevity period of marigold strings as influenced by different packaging materials and storage durations**

| Treatments | Rotting (%) during longevity | | | | | |
|---|---|---|---|---|---|---|
| **Factor 1: Container** | **2017** | | **2018** | | **Pooled** | |
| | **Days after storage** | | **Days after storage** | | **Days after storage** | |
| | **1st day** | **2nd day** | **1st day** | **2nd day** | **1st day** | **2nd day** |
| C1 (bamboo basket) | 3.17 | 14.28 | 3.29 | 13.79 | 3.23 | 14.03 |
| C2 (thermocol) | 1.15 | 5.08 | 1.41 | 4.43 | 1.28 | 4.76 |
| C3 (CFB box) | 2.87 | 8.13 | 2.80 | 8.40 | 2.84 | 8.26 |
| **S.Em(±)** | **0.29** | **0.53** | **0.36** | **0.64** | **0.23** | **0.41** |
| **LSD (0.05)** | **0.86** | **1.55** | **1.06** | **1.88** | **0.66** | **1.18** |
| **Factor 2: Storage duration** | | | | | | |
| S1(0 day) | NA | 3.50 | 0.28 | 3.58 | 0.14 | 3.54 |
| S2(1 day) | 2.26 | 8.34 | 2.42 | 7.67 | 2.34 | 8.00 |
| S3(2 day) | 3.04 | 10.53 | 3.06 | 10.24 | 3.05 | 10.38 |
| S4(3 day) | 4.29 | 14.29 | 4.25 | 14.00 | 4.27 | 14.14 |
| **SEm(±)** | **0.34** | **0.61** | **0.42** | **0.74** | **0.27** | **0.48** |
| **LSD (0.05)** | **1.00** | **1.79** | **1.22** | **2.17** | **0.76** | **1.36** |
| **Interaction (Factor 1 X Factor 2)** | | | | | | |
| C1S1 | NA | 3.50 | 0.83 | 3.45 | 0.42 | 3.48 |
| C1S2 | 2.93 | 15.10 | 2.98 | 14.62 | 2.95 | 14.86 |
| C1S3 | 4.07 | 18.97 | 3.49 | 18.01 | 3.78 | 18.49 |
| C1S4 | 5.70 | 19.55 | 5.87 | 19.06 | 5.78 | 19.31 |
| C2S1 | NA | 3.02 | NA | 3.94 | NA | 3.48 |
| C2S2 | 0.86 | 5.10 | 1.50 | 3.65 | 1.18 | 4.37 |
| C2S3 | 1.34 | 4.94 | 1.60 | 4.79 | 1.47 | 4.87 |
| C2S4 | 2.41 | 6.32 | 2.54 | 5.91 | 2.48 | 6.12 |
| C3S1 | NA | 3.98 | NA | 3.36 | NA | 3.67 |
| C3S2 | 2.99 | 4.82 | 2.79 | 4.73 | 2.89 | 4.78 |
| C3S3 | 3.73 | 7.67 | 4.09 | 7.91 | 3.91 | 7.79 |
| C3S4 | 4.75 | 17.00 | 4.33 | 17.02 | 4.54 | 17.01 |
| **SEm(±)** | **0.59** | **1.05** | **0.72** | **1.28** | **0.46** | **0.83** |
| **LSD (0.05)** | **NS** | **3.09** | **NS** | **3.75** | **1.32** | **2.35** |

ambient conditions as well as 3 days at low temperature ($10^0$C) in polyethylene packaging without compromising the vase life and other qualitative parameters. Devi (2013) observed minimum weight loss in loose flowers of Bidhan Marigold 2 variety packed in plastic basket with cover during mid winter (min temp $12^0$C and max temp $25^0$C and min RH 55% and max RH 92%). According to Halagur *et al.* (2013) during storage, the pigment loss was the least in enzyme treated samples stored at 4 °C.

Regarding packaging, our results were also supported by the findings of Madaiah and Reddy (1992), Nagaraja *et al.* (1999), Luo *et al*. (2004), Achour (2005), Shen *et al*. (2006), Gvozdenovic *et al*. (2006), Karuppaiah *et al.* (2006), Grover *et al*. (2006), Sandhya, (2010), Roychowdhury *et al.* (2011), Jawaharlal *et al.* (2012), Shil *et al.* (2017) and Archana *et al.* (2019) who found similar results in storage of different flower crops based on the principle of modified atmosphere packaging (MAP). Inside this package, respiration of flowers could create a modified atmosphere (MA) of reduced oxygen ($O_2$) and elevated carbon dioxide ($CO_2$) levels which became useful to extend the storage period. In addition to packaging, low temperature could also retard the entire metabolism of flower tissues, slow down respiration, transpiration, ethylene production and its action and reduce the multiplication of bacteria and fungi (Rudnicki *et al*., 1991; Madaiah and Reddy, 1992; Patil and Dhaduk

(2010) ; Meir *et al.* (1995); Bell (1996) and Sharma *et al.* (1999). High $CO_2$ (5-10%) in MAP was reported to retard senescence of vegetative tissues by checking ethylene activity and facilitating high amount of polyamines in tissues (Philosoph-Hadas *et al.*, 1995). Thus, the vegetative organs stayed more fresh, served as useful sources for assimilate import to the floret sink during opening after storage (Meir *et al.,* 1995; Zeltzer *et al.,* 2001).

It was concluded from the present experiment that thermocol boxes with ice gel packing was apparently the best packaging material for storing marigold flower strings of variety Bidhan Marigold 2 under ambient condition (6-7$^0$C temperature and 70-75% RH) up to 2 days. Marigold strings stored in thermocol boxes with ice gel packing resulted in a shelf life of 3 days with better post-harvest quality along compared to those kept in bamboo baskets. However, for 3 days of storage, CFB was the best option with 2days of shelf life with acceptable qualitative parameters. These packaging materials may be useful for online marketing platform and hygienic delivery.

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