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# STANDARDIZATION OF DRYING TECHNIQUES IN CUT CHRYSANTHEMUM

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**ABSTRACT**

Cut Chrysanthemum (*Dendranthema grandiflora* Tzeuleu), a member of the Asteraceae family, is a widely admired ornamental flower known as the ‘Queen of East’ or ‘Winter Queen’ due to its Asian origin and winter bloom. Cultivated since 500 BC, it comes in diverse colours and shapes, with a vase life of 10–15 days and extended appeal when dried. A 2024–25 study at the College of Horticulture, Bagalkot, evaluated drying methods for Cut Chrysanthemum. Among Cut Chrysanthemum varieties, ‘Lollipop Pink’ showed superior results. Silica gel emerged as the best drying medium, yielding minimum dry weight (0.56 g/flower), maximum moisture loss (90.03%) and excellent retention of flower quality. It scored highest in colour (8.96), shape (8.97), texture (8.86), appearance (8.57) and overall acceptability (8.84). Compared to ‘Bright Orange’, ‘Lollipop Pink’ retained sensory attributes more effectively.

***Keywords* :** Cut Chrysanthemum, Varieties, Drying Methods, Desiccants

## Introduction

Cut chrysanthemums flourish in polyhouse environments with temperatures between 16–25°C and humidity levels of 70–85 per cent, ensuring optimal physiological balance. $CO_2$ enrichment (600–900 ppm) enhances photosynthetic efficiency and biomass production. A 14-hour photoperiod mimics long-day conditions, triggering floral initiation. These calibrated parameters yield robust stems, vibrant blooms and extended post-harvest longevity. The process of drying flowers involves preserving them by extracting water and moisture. Dehydration is a key step in creating dried flowers. Several methods are used to remove moisture, including air drying, oven drying, embedded drying (with materials such as sand, borax, silica gel, *etc.*), microwave oven drying, freeze drying and press drying. Each technique is designed to ensure the flowers maintain their aesthetic appeal after drying (Nair 2009).

## Material and Methods

The present investigation entitled was done to understand the effect of different drying techniques and desiccants for cut flower that can be used for value addition. The details of the materials used and the procedure adopted in the investigation, which was carried out at Departmental Laboratory, Department of Postharvest Management, College of Horticulture, Bagalkot. Cut Chrysanthemum var. Lollipop pink and Bright orange were collected in the month of March to May as it is the peak time to collect the desired flower. For this research flowers were collected from departmental research field. There are two drying methods (Hot air oven, Shade drying) and three desiccants (Sand, Silica gel and Vermiculite). The experiment was laid out in factorial completely randomized design with three replications. Under this experiment, overall, 12 treatments comprising of different drying techniques with desiccants. Treatment comprised of $T_1$(Lollipop pink+ sand+ Hot air oven), $T_2$(Lollipop pink+ sand+ Shade dry), $T_3$(Lollipop pink+ Silica gel+ Hot air oven), $T_4$(Lollipop pink+ Silica gel+ Shade dry), $T_5$(Lollipop pink+ Vermiculite+ Hot air oven), $T_6$(Lollipop pink+ Vermiculite+ Shade dry), $T_7$(Bright Orange+ Sand+ Hot air oven), $T_8$(Bright Orange+ Sand+ Shade dry), $T_9$(Bright Orange+ Silica gel +Hot air oven), $T_{10}$(Bright Orange+ Silica gel+ Shade dry), $T_{11}$(Bright Orange+ Vermiculite+ Hot air oven), $T_{12}$(Bright Orange+ Vermiculite+ Shade dry). The analysis was done using the formula of Fisher and Yates. The quality score was done using 9-point hedonic scale.

## Results and Discussion

### Time taken for drying (h)

In the current experiment, drying duration of cut chrysanthemum flowers differed significantly (Table 1). The lollipop pink cultivar ($V_1$) and bright orange ($V_2$) took 79 h to reach the target moisture. When silica gel was used as the desiccant ($D_2$), the drying time was the shortest (60 h), followed by river sand (87 h) and vermiculite (90 h), consistent with earlier observations that sand and other embedding media influence drying speed. Among the drying techniques, hot-air-oven drying completed the process in 30 h, quicker than shade drying, which took 128 h, echoing previous reports that shade drying prolongs drying time while hot-air methods accelerate it. The interaction among variety, desiccant and method markedly affected drying time, with the combination Lollipop pink+ silica-gel + hot-air oven ($V_1D_2M_1$) achieving the minimum duration of 24 h, whereas Lollipop pink + river-sand + shade drying ($V_1D_1M_2$) required the maximum of 144 h and Lollipop pink + vermiculite + shade drying ($V_1D_3M_2$) 143 h, illustrating the synergistic effect of these factors as described for chrysanthemum embedded-drying systems.

Drying media play a crucial role in determining the rate at which flowers lose moisture. According to Stern (1994), among the various desiccants tested, silica gel demonstrated the fastest drying capability. Its high moisture absorption capacity enabled rapid dehydration of flowers such as calendula, china aster, dahlia, and candytuft (Roberts, 2000). In the present study, silica gel proved to be the most efficient drying agent, requiring only 24 hours to completely dehydrate cut chrysanthemum var. Lollipop pink. In contrast, shade drying and riverbed sand were the least effective, took 144 hours to achieve optimal dehydration of chrysanthemum blooms. These results are in close agreement with the findings of Sindhuja *et al.* (2015), who also emphasized the superiority of silica gel over other embedding media in accelerating the drying process. Importantly, the shorter drying duration not only enhances flower quality but also reduces processing time and costs, making silica gel a commercially viable option for large-scale dry flower production and export (Chandana *et al.,* 2024).

### Dry weight of flower (g)

The dry-weight data for cut chrysanthemum flowers stored with different desiccants are summarized in Table 2. Across all treatments, dry weight increased progressively with storage time and significant differences were detected among the desiccant groups throughout the storage period. The Lollipop pink cultivar ($V_1$) consistently yielded lower dry weights (0.67, 0.70, 0.73 and 0.75 g per flower at 30, 60 and 90 days, respectively) than the Bright orange cultivar ($V_2$), which recorded 0.73, 0.75, 0.77 and 0.80 g per flower (Table 2). Regarding the embedding media, silica gel ($D_2$) produced the smallest dry weights (0.61, 0.65, 0.67 and 0.69 g per flower), whereas sand ($D_1$) gave intermediate values (0.65, 0.68, 0.71 and 0.74 g per flower) and vermiculite ($D_3$) resulted in the highest dry weights (0.83, 0.84, 0.87 and 0.90 g per flower) at the three storage intervals. Among drying techniques, hot-air-oven drying ($M_1$) generated the lowest dry weights (0.67, 0.70, 0.73 and 0.75 g per flower), followed by shade drying ($M_2$) (0.73, 0.75, 0.77 and 0.80 g per flower). Interaction effects among variety, desiccant and drying method were significant. The minimum dry weight was observed for the Lollipop pink + sand + hot-air-oven combination ($V_1D_1M_1$), which recorded 0.56 g and 0.58 g after 30 days and 0.61 g and 0.65 g after 60 and 90 days, respectively. Conversely, the maximum dry weight occurred in the Bright orange + vermiculite + shade-drying treatment ($V_2D_3M_2$), reaching 0.88, 0.91 and 0.93 g per flower at 30, 60 and 90 days respectively.

The dry weight of the flowers showed significant differences among the treatments. Up to 30 days of storage, the minimum dry weight ($V_1D_1M_1$: 0.56 and 0.58 g/flower) was recorded in flowers dried using the hot air oven method with sand as the embedding medium for 30 h. This may be attributed to the longer exposure of flowers to sand, which enabled better moisture removal, even though sand is considered a weaker dehydrating agent compared to silica gel (Trinklein, 2006).

**Table 1 :** Fresh weight and Time taken for drying of cut chrysanthemum flowers during storage as influenced by various desiccants and drying methods

| Treatments | Fresh weight (g/flowers) | Time taken for drying |
|---|---|---|
| **Variety** | | |
| $V_1$ | 5.10 | 79.00 |
| $V_2$ | 4.39 | 79.00 |
| S.Em ± | **0.02** | **0.01** |
| C.D. at 1 % | **0.09** | **NS** |
| **Desiccant** | | |
| $D_1$ | 4.24 | 87.00 |
| $D_2$ | 5.31 | 60.00 |
| $D_3$ | 4.68 | 90.00 |
| S.Em ± | **0.03** | **0.01** |
| C.D. at 1 % | **0.11** | **0.05** |
| **Method** | | |
| $M_1$ | 5.10 | 30.00 |
| $M_2$ | 4.39 | 128.00 |
| S.Em ± | **0.02** | **0.01** |
| C.D. at 1 % | **0.09** | **0.04** |
| **Interactions** | | |
| $V_1D_1M_1$ | 4.52 | 30.00 |
| $V_1D_1M_2$ | 4.65 | 144.00 |
| $V_1D_2M_1$ | 5.82 | 24.00 |
| $V_1D_2M_2$ | 5.31 | 96.00 |
| $V_1D_3M_1$ | 5.74 | 35.00 |
| $V_1D_3M_2$ | 4.54 | 143.00 |
| $V_2D_1M_1$ | 3.56 | 30.00 |
| $V_2D_1M_2$ | 4.22 | 142.00 |
| $V_2D_2M_1$ | 5.24 | 23.00 |
| $V_2D_2M_2$ | 4.88 | 95.00 |
| $V_2D_3M_1$ | 3.93 | 36.00 |
| $V_2D_3M_2$ | 4.51 | 140.00 |
| Mean | 4.74 | 79.00 |
| S.Em ± | **0.06** | **0.02** |
| C.D. at 1 % | **0.22** | **0.11** |

**$V_1$**= Lollipop Pink  **$D_1$**= Sand  **$M_1$**= Hot air oven drying
**$V_2$**= Bright Orange  **$D_2$**= Silica gel  **$M_2$**= Shade drying
**$D_3$**= Vermiculite

In contrast, after 90 days of storage, the minimum dry weight was observed in cut chrysanthemum var. Lollipop pink (0.61 and 0.65 g/flower), dried by embedding in silica gel for 30 h under shade. This could be due to the strong hygroscopic nature of silica gel, which absorbs residual moisture more effectively than riverbed sand or vermiculite, particularly under elevated temperatures. These findings are consistent with the observations of Deshraj and Gupta (2003), who reported that silica gel (60–120 mesh size) was the most effective absorbent for removing moisture from flowers and foliage, followed by boric acid granules.

On the other hand, flowers dried in vermiculite ($V_2D_3M_2$) consistently recorded the maximum dry weight throughout the storage period, likely due to the inadequate moisture removal capacity of vermiculite. Similar results were reported by Singh *et al.* (2003) in zinnia. Importantly, treatments that ensured lower dry weights particularly silica gel embedding are desirable for commercial dry flower production, as they not only extend storage life but also reduce the risk of microbial growth and quality deterioration during export (Manash *et al.,* 2022).

**Moisture loss (%)**

Moisture loss in dried chrysanthemum flowers, stored under ambient conditions and using various embedding media, exhibited significant differences (Table 2). A trend of decreasing moisture loss was observed as the storage duration progressed. Considering the two varieties, 'Lollipop Pink' ($V_1$)

consistently showed the highest moisture loss, recording 86.27, 85.68 and 85.29% at 30, 60 and 90 days of storage, respectively. In contrast, 'Bright Orange' ($V_2$) displayed the lowest moisture loss, with values of 82.91, 82.46 and 81.77% at the same respective storage intervals. Among the three desiccants, silica gel demonstrated the highest moisture loss (87.75, 87.38, and 87.00% at 30, 60 and 90 days), followed by sand (83.96, 83.25 and 82.54%). Vermiculite resulted in the minimum moisture loss, registering 82.05, 81.41 and 80.76 at 30, 60 and 90 days after storage respectively.

**Table 2 :** Dry weight and moisture loss of dried cut chrysanthemum flowers during storage as influenced by various desiccants and drying methods

| Treatments | Dry weight(g/flowers) | | | | Moisture loss (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | DAS | | | | | | | |
| **Variety** | **Initial** | **30** | **60** | **90** | **Initial** | **30** | **60** | **90** |
| $V_1$ | 0.67 | 0.70 | 0.73 | 0.75 | 87.16 | 86.27 | 85.68 | 85.29 |
| $V_2$ | 0.73 | 0.75 | 0.77 | 0.80 | 83.37 | 82.91 | 82.46 | 81.77 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.22** | **0.20** | **0.18** | **0.17** |
| C.D. at 1 % | **0.02** | **0.03** | **0.02** | **0.02** | **0.88** | **0.80** | **0.70** | **0.67** |
| **Desiccant** | | | | | | | | |
| $D_1$ | 0.65 | 0.68 | 0.71 | 0.74 | 84.66 | 83.96 | 83.25 | 82.54 |
| $D_2$ | 0.61 | 0.65 | 0.67 | 0.69 | 88.51 | 87.75 | 87.38 | 87.00 |
| $D_3$ | 0.83 | 0.84 | 0.87 | 0.90 | 82.26 | 82.05 | 81.41 | 80.76 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.27** | **0.25** | **0.22** | **0.21** |
| C.D. at 1 % | **0.03** | **0.03** | **0.02** | **0.03** | **1.07** | **0.98** | **0.85** | **0.82** |
| **Method** | | | | | | | | |
| $M_1$ | 0.67 | 0.70 | 0.73 | 0.75 | 86.86 | 86.27 | 85.68 | 85.29 |
| $M_2$ | 0.73 | 0.75 | 0.77 | 0.80 | 83.37 | 82.91 | 82.46 | 81.77 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.22** | **0.20** | **0.18** | **0.17** |
| C.D. at 1 % | **0.02** | **0.03** | **0.02** | **0.02** | **0.88** | **0.80** | **0.70** | **0.67** |
| **Interactions** | | | | | | | | |
| $V_1D_1M_1$ | 0.56 | 0.58 | 0.61 | 0.65 | 87.61 | 87.16 | 86.50 | 85.61 |
| $V_1D_1M_2$ | 0.66 | 0.69 | 0.72 | 0.75 | 85.80 | 85.16 | 84.51 | 83.87 |
| $V_1D_2M_1$ | 0.58 | 0.64 | 0.67 | 0.69 | 90.03 | 89.00 | 88.48 | 88.14 |
| $V_1D_2M_2$ | 0.63 | 0.66 | 0.68 | 0.70 | 88.13 | 87.57 | 87.19 | 86.81 |
| $V_1D_3M_1$ | 0.85 | 0.86 | 0.88 | 0.90 | 85.19 | 85.01 | 84.66 | 82.75 |
| $V_1D_3M_2$ | 0.74 | 0.77 | 0.79 | 0.83 | 83.70 | 83.03 | 82.59 | 81.71 |
| $V_2D_1M_1$ | 0.63 | 0.66 | 0.68 | 0.71 | 82.30 | 81.46 | 80.89 | 80.33 |
| $V_2D_1M_2$ | 0.76 | 0.79 | 0.82 | 0.85 | 81.99 | 80.27 | 80.56 | 79.85 |
| $V_2D_2M_1$ | 0.67 | 0.68 | 0.70 | 0.73 | 87.21 | 87.02 | 86.64 | 86.06 |
| $V_2D_2M_2$ | 0.62 | 0.64 | 0.62 | 0.65 | 88.11 | 87.70 | 87.29 | 86.68 |
| $V_2D_3M_1$ | 0.87 | 0.87 | 0.89 | 0.92 | 77.86 | 77.60 | 76.84 | 76.33 |
| $V_2D_3M_2$ | 0.86 | 0.88 | 0.91 | 0.93 | 80.93 | 80.70 | 80.26 | 79.60 |
| Mean | 0.69 | 0.72 | 0.74 | 0.77 | 84.90 | 84.47 | 83.68 | 83.14 |
| S.Em ± | **0.01** | **0.02** | **0.01** | **0.01** | **0.54** | **0.50** | **0.43** | **0.42** |
| C.D. at 1 % | **0.05** | **0.06** | **0.05** | **0.06** | **2.15** | **1.97** | **1.71** | **1.64** |

**DAS:** Days after storage
**$V_1$**= Lollipop Pink **$D_1$**= Sand **$M_1$**= Hot air oven drying
**$V_2$**= Bright Orange **$D_2$**= Silica gel **$M_2$**= Shade drying
**$D_3$**= Vermiculite

Regarding the drying methods, hot air oven drying resulted in the maximum moisture loss (86.27, 85.68 and 85.29% at 30, 60 and 90 days). Conversely, shade drying exhibited the minimum moisture loss, with values of 82.91, 82.46 and 81.77 at 30, 60 and 90 days after storage, respectively. Significant interaction effects were also observed. The highest moisture loss was recorded in the $V_1D_2M_1$ combination (lollipop pink + silica gel + hot air oven), showing 89.00, 88.48 and 88.14% at 30, 60 and 90 days. The minimum moisture loss was evident in the $V_2D_3M_1$ combination (bright orange + vermiculite + hot air oven), with values of 77.60, 76.84 and 76.33% at 30, 60 and 90 days after storage, respectively.

Significant differences were observed in the moisture loss of dried cut chrysanthemum flowers with respect to different desiccants. Flowers embedded in silica gel recorded the highest moisture loss (90.03%), which can be attributed to the strong hygroscopic nature of silica gel that enables it to absorb up to 40 per cent of its weight in moisture. This property makes it particularly effective for flowers with compact petals such as rose (Pertuit, 2002). Similar findings have been reported by Gupta and Prashant (2005) in China aster, Safeena *et al.,* (2006) in marigold, and Singh (2018) in cut chrysanthemum.

In contrast, flowers embedded in vermiculite showed the lowest moisture loss (77.86%). This could be due to the weaker dehydrating ability of vermiculite compared to silica gel and sand, leading to incomplete removal of moisture. These results are consistent with the observations of Singh *et al.* (2003) in zinnia.

**Table 3 :** Reduction of flower diameter and moisture retention of dried cut chrysanthemum flowers during storage as influenced by various desiccants and drying methods

| Treatments | Flower diameter (cm) | | | | Moisture retention (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | DAS | | | | | | | |
| **Variety** | **Initial** | **30** | **60** | **90** | **Initial** | **30** | **60** | **90** |
| $V_1$ | 5.68 | 5.63 | 5.60 | 5.57 | 12.84 | 13.73 | 14.32 | 14.71 |
| $V_2$ | 5.65 | 5.64 | 5.63 | 5.61 | 16.63 | 17.09 | 17.54 | 18.23 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.06** | **0.01** | **0.01** | **0.01** |
| C.D. at 1 % | **0.02** | **0.02** | **0.02** | **0.03** | **0.24** | **0.03** | **0.03** | **0.04** |
| **Desiccant** | | | | | | | | |
| $D_1$ | 5.73 | 5.70 | 5.68 | 5.65 | 15.34 | 16.04 | 16.75 | 17.46 |
| $D_2$ | 5.62 | 5.59 | 5.58 | 5.55 | 11.49 | 12.25 | 12.62 | 13.00 |
| $D_3$ | 5.64 | 5.61 | 5.59 | 5.58 | 17.74 | 17.95 | 18.59 | 19.24 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.07** | **0.01** | **0.01** | **0.01** |
| C.D. at 1 % | **0.03** | **0.03** | **0.03** | **0.03** | **0.29** | **0.04** | **0.03** | **0.05** |
| **Method** | | | | | | | | |
| $M_1$ | 5.68 | 5.63 | 5.60 | 5.57 | 13.14 | 13.73 | 14.32 | 14.71 |
| $M_2$ | 5.65 | 5.64 | 5.63 | 5.61 | 16.63 | 17.09 | 17.54 | 18.23 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.01** | **0.06** | **0.01** | **0.01** | **0.01** |
| C.D. at 1 % | **0.02** | **0.02** | **0.02** | **0.03** | **0.24** | **0.03** | **0.03** | **0.04** |
| **Interactions** | | | | | | | | |
| $V_1D_1M_1$ | 5.97 | 5.92 | 5.90 | 5.84 | 12.39 | 12.84 | 13.50 | 14.39 |
| $V_1D_1M_2$ | 5.70 | 5.65 | 5.61 | 5.57 | 14.50 | 14.84 | 15.49 | 16.13 |
| $V_1D_2M_1$ | 5.77 | 5.71 | 5.69 | 5.65 | 10.97 | 11.00 | 11.52 | 11.86 |
| $V_1D_2M_2$ | 5.35 | 5.32 | 5.30 | 5.27 | 11.87 | 12.43 | 12.81 | 13.19 |
| $V_1D_3M_1$ | 5.50 | 5.48 | 5.41 | 5.40 | 14.81 | 14.99 | 15.34 | 17.25 |
| $V_1D_3M_2$ | 5.79 | 5.72 | 5.71 | 5.70 | 16.30 | 16.97 | 17.71 | 18.29 |
| $V_2D_1M_1$ | 5.41 | 5.40 | 5.38 | 5.37 | 17.70 | 18.54 | 19.11 | 19.67 |
| $V_2D_1M_2$ | 5.85 | 5.83 | 5.82 | 5.81 | 18.01 | 19.73 | 19.44 | 20.15 |
| $V_2D_2M_1$ | 5.62 | 5.61 | 5.58 | 5.56 | 12.79 | 12.98 | 13.36 | 13.94 |
| $V_2D_2M_2$ | 5.74 | 5.73 | 5.72 | 5.71 | 11.89 | 12.30 | 12.71 | 13.32 |
| $V_2D_3M_1$ | 5.93 | 5.92 | 5.91 | 5.89 | 12.14 | 12.40 | 12.16 | 12.67 |
| $V_2D_3M_2$ | 5.34 | 5.33 | 5.32 | 5.31 | 19.07 | 19.30 | 19.74 | 20.40 |
| Mean | 5.66 | 5.63 | 5.61 | 5.59 | 15.20 | 15.69 | 16.15 | 16.77 |
| S.Em ± | **0.01** | **0.01** | **0.01** | **0.02** | **0.15** | **0.02** | **0.02** | **0.03** |
| C.D. at 1 % | **0.06** | **0.05** | **0.05** | **0.07** | **0.58** | **0.08** | **0.06** | **0.10** |

**DAS:** Days after storage

**$V_1$**= Lollipop Pink  **$D_1$**= Sand  **$M_1$**= Hot air oven drying
**$V_2$**= Bright Orange  **$D_2$**= Silica gel  **$M_2$**= Shade drying
**$D_3$**= Vermiculite

## Flower diameter

Flowers dried with different embedding media and stored under ambient conditions showed significant reductions in flower diameter (Table 3). As storage time increased, diameter decreased for all treatments. Among the two varieties, the Lollipop pink variety ($V_1$) exhibited the minimum reduction (5.63, 5.60 and 5.57 cm at 30, 60 and 90 days, respectively) compared with Bright orange ($V_2$), which showed reductions of 5.64, 5.63 and 5.61 cm at the same intervals. Among the three desiccants, silica gel ($D_2$) produced the least diameter loss (5.59, 5.58 and 5.55 cm), followed closely by vermiculite (5.61, 5.59 and 5.58 cm), whereas sand ($D_1$) resulted in the greatest loss (5.70, 5.68 and 5.65 cm). For drying methods, hot-air-oven drying ($M_1$) yielded the smallest reduction (5.63, 5.60 and 5.57 cm), while shade drying ($M_2$) produced the largest (5.64, 5.63 and 5.61 cm). Interaction effects were also significant: the Lollipop pink + silica-gel + hot-air-oven combination ($V_1D_2M_2$) showed the minimum overall reduction (5.32, 5.30 and 5.27 cm), whereas the Bright orange+ sand + hot-air-oven treatment ($V_2D_3M_1$) exhibited the maximum reduction (5.92, 5.91 and 5.89 cm) across the 30, 60 and 90 days storage periods respectively.

Different desiccants were found to have a significant influence on the reduction in flower diameter of dried cut chrysanthemum flowers. Flowers embedded with silica gel and shade-dried exhibited the minimum reduction in flower diameter (5.35%) among all treatments. The maximum flower diameter was observed in the $V_2D_3M_1$ treatment, measuring 5.92, 5.91 and 5.89 cm at 30, 60 and 90 days of storage, respectively Dalal and Mishra. (2025)

**Moisture retention**

Different drying methods and desiccants significantly affected the final moisture retention of dried cut chrysanthemum flowers during storage (Table 3). Moisture retention increased with longer storage periods.

The Lollipop-Pink cultivar ($V_1$) showed the lowest moisture retention 13.73, 14.32 and 4.71% at 30, 60 and 90 days, respectively, whereas the Bright-orange cultivar ($V_2$) recorded the highest values (17.09, 17.54 and 18.23 % at the same intervals).

Silica gel ($D_2$) yielded the minimum moisture retention (12.25, 12.62 and 13.00 % at 30, 60, and 90 days), followed by sand ($D_1$) (16.04, 16.75 and 17.46 %). Vermiculite ($D_3$) produced the greatest retention (17.95, 8.59 and 19.24 % during 30,60 and 90 days, respectively).

Hot-air oven drying ($M_1$) resulted in the lowest moisture levels (13.73, 14.32, and 14.71 %), while shade drying ($M_2$) gave the highest retention (17.09, 17.54 and 18.23 %) during 30,60 and 90 days of storage respectively.

The combination Lollipop pink+ silica-gel + hot-air-oven ($V_1D_2M_1$) produced the minimum moisture retention across all storage times (11.00, 11.52 and 11.86 %). Conversely, the Bright orange+ vermiculite + shade-drying treatment ($V_2D_3M_2$) exhibited the maximum retention (19.30, 19.74 and 20.40 %) during 30, 60 and 90 days after storage respectively.

It was found that different desiccants had a significant influence on the final moisture retention of dried cut chrysanthemum flowers. Flowers embedded in silica gel exhibited the minimum final moisture content (10.97%) among all treatments. These results are consistent with Moona (2004), who reported that the strong hygroscopic nature of silica gel leads to rapid moisture removal from cut chrysanthemum flowers. In contrast, flowers embedded in vermiculite ($V_2D_3M_2$) showed the maximum final moisture content, measuring 19.30, 19.74 and 20.40 per cent at 30, 60, and 90 days after storage (DAS), respectively. This may be attributed to the lower moisture-absorbing capacity of vermiculite, allowing moisture to be reabsorbed by the flowers (Sha *et al.,* 2023 : Sindhuja *et al.,* 2015).

**Quality parameters of flowers as influenced by various desiccants and drying methods**

**Flower colour**

The colour of dried cut chrysanthemum flowers was significantly affected by the type of desiccant used during storage (Table 4). Across the two varieties, the Lollipop pink ($V_1$) variety consistently received higher colour scores (7.62, 7.60 and 7.59 at 30, 60 and 90 days, respectively) than Bright orange (6.92, 6.91 and 6.90). Regarding desiccants, silica gel ($D_2$) produced the highest colour ratings (7.97, 7.95 and 7.94), followed by vermiculite ($D_3$: 7.29, 7.27 and 7.26), whereas sand ($D_1$) yielded the lowest scores (6.57, 6.55 and 6.53). The drying method also influenced colour quality hot-air-oven drying achieved superior scores (7.62, 7.60 and 7.59) compared with shade drying (6.92, 6.91 and 6.90). Interaction effects highlighted that the combination of Lollipop-pink, silica-gel and hot-air-oven ($V_1D_2M_1$) attained the highest overall colour rating (8.96, 8.92 and 8.91), whereas the Lollipop pink, sand and hot-air-oven combination ($V_1D_1M_1$) recorded the lowest (6.95, 6.92 and 6.91) across the three storage intervals.

**Table 4 :** Quality parameter of dried cut chrysanthemum flowers during storage as influenced by various desiccants and drying methods

| Treatments | Colour | | | | Shape | | | |
|---|---|---|---|---|---|---|---|---|
| | DAS | | | | | | | |
| **Variety** | **Initial** | **30** | **60** | **90** | **Initial** | **30** | **60** | **90** |
| $V_1$ | 7.65 | 7.62 | 7.60 | 7.59 | 7.58 | 7.57 | 7.55 | 7.54 |
| $V_2$ | 6.95 | 6.92 | 6.91 | 6.90 | 6.82 | 6.81 | 6.79 | 6.78 |
| S.Em ± | **0.05** | **0.05** | **0.05** | **0.04** | **0.05** | **0.05** | **0.04** | **0.04** |
| C.D. at 1 % | **0.19** | **0.20** | **0.19** | **0.18** | **0.19** | **0.20** | **0.17** | **0.17** |
| **Desiccant** | | | | | | | | |
| $D_1$ | 6.59 | 6.57 | 6.55 | 6.53 | 6.42 | 6.40 | 6.38 | 6.37 |
| $D_2$ | 8.00 | 7.97 | 7.95 | 7.94 | 7.93 | 7.92 | 7.91 | 7.90 |
| $D_3$ | 7.31 | 7.29 | 7.27 | 7.26 | 7.26 | 7.25 | 7.23 | 7.22 |
| S.Em ± | **0.06** | **0.06** | **0.06** | **0.05** | **0.06** | **0.06** | **0.05** | **0.05** |
| C.D. at 1 % | **0.23** | **0.25** | **0.23** | **0.22** | **0.23** | **0.25** | **0.20** | **0.21** |
| **Method** | | | | | | | | |
| $M_1$ | 7.65 | 7.62 | 7.60 | 7.59 | 7.58 | 7.57 | 7.55 | 7.54 |
| $M_2$ | 6.95 | 6.92 | 6.91 | 6.90 | 6.82 | 6.81 | 6.79 | 6.78 |
| S.Em ± | **0.05** | **0.05** | **0.05** | **0.04** | **0.05** | **0.05** | **0.04** | **0.04** |
| C.D. at 1 % | **0.19** | **0.20** | **0.19** | **0.18** | **0.19** | **0.20** | **0.17** | **0.17** |
| **Interactions** | | | | | | | | |
| $V_1D_1M_1$ | 6.97 | 6.95 | 6.92 | 6.91 | 6.88 | 6.86 | 6.83 | 6.82 |
| $V_1D_1M_2$ | 6.87 | 6.83 | 6.81 | 6.80 | 6.56 | 6.54 | 6.52 | 6.52 |
| $V_1D_2M_1$ | 8.97 | 8.96 | 8.92 | 8.91 | 8.96 | 8.97 | 8.95 | 8.93 |
| $V_1D_2M_2$ | 7.46 | 7.42 | 7.41 | 7.40 | 7.55 | 7.54 | 7.53 | 7.52 |
| $V_1D_3M_1$ | 7.97 | 7.96 | 7.94 | 7.92 | 7.97 | 7.96 | 7.95 | 7.93 |
| $V_1D_3M_2$ | 7.64 | 7.62 | 7.61 | 7.60 | 7.54 | 7.54 | 7.53 | 7.52 |
| $V_2D_1M_1$ | 5.97 | 5.96 | 5.94 | 5.92 | 5.68 | 5.66 | 5.64 | 5.62 |
| $V_2D_1M_2$ | 6.54 | 6.52 | 6.51 | 6.50 | 6.54 | 6.53 | 6.52 | 6.51 |
| $V_2D_2M_1$ | 7.57 | 7.56 | 7.54 | 7.52 | 7.67 | 7.64 | 7.63 | 7.62 |
| $V_2D_2M_2$ | 7.98 | 7.94 | 7.93 | 7.92 | 7.54 | 7.53 | 7.52 | 7.51 |
| $V_2D_3M_1$ | 6.97 | 6.94 | 6.93 | 6.92 | 6.97 | 6.95 | 6.93 | 6.92 |
| $V_2D_3M_2$ | 6.64 | 6.62 | 6.61 | 6.60 | 6.54 | 6.53 | 6.52 | 6.51 |
| Mean | 7.29 | 7.27 | 7.25 | 7.24 | 7.2 | 7.18 | 7.17 | 7.16 |
| S.Em ± | **0.12** | **0.12** | **0.12** | **0.11** | **0.12** | **0.12** | **0.10** | **0.10** |
| C.D. at 1 % | **0.46** | **0.49** | **0.47** | **0.43** | **0.46** | **0.49** | **0.41** | **0.41** |

**DAS:** Days after storage
**$V_1$**= Lollipop Pink **$D_1$**= Sand **$M_1$**= Hot air oven drying
**$V_2$**= Bright Orange **$D_2$**= Silica gel **$M_2$**= Shade drying
**$D_3$**= Vermiculite

## Flower shape

The shape of cut chrysanthemum flowers was significantly influenced by different desiccants during storage (Table 4). Among the two varieties, higher scores were consistently recorded in Lollipop Pink (7.57, 7.55 and 7.54) compared to Bright orange (6.81, 6.79 and 6.78) at 30, 60, and 90 days after storage (DAS), respectively. With respect to desiccants, flowers embedded in silica gel ($D_2$) achieved the highest shape scores (7.92, 7.91 and 7.90), followed by vermiculite (7.25, 7.23 and 7.22). The lowest scores were observed with sand (6.40, 6.38 and 6.37) across the three storage periods. Considering drying methods, hot-air oven drying ($M_1$) produced higher shape scores (7.57, 7.55 and 7.54), whereas shade drying ($M_2$) recorded comparatively lower values (6.81, 6.79 and 6.78). A significant interaction effect was also evident. The maximum shape score was obtained in $V_1D_2M_1$ (8.97, 8.95 and 8.93), while the minimum was observed in $V_2D_3M_2$ (6.53, 6.52 and 6.51) at 30, 60, and 90 DAS, respectively.

## Flower texture

Significant variation in texture of dried cut chrysanthemum flowers was observed due to varieties, desiccants, and drying methods during storage. Among the varieties, var. Lollipop pink ($V_1$) consistently recorded higher texture scores (7.63, 7.61, and 7.58 at 30, 60, and 90 DAS, respectively) compared to Bright orange ($V_2$: 6.86, 6.85, and 6.83). Among desiccants, silica gel ($D_2$) showed the maximum scores (8.04, 8.03, and 8.00), followed by vermiculite ($D_3$: 7.27, 7.25, and

7.24), while sand ($D_1$) recorded the lowest (6.42, 6.41, and 6.38). Hot-air oven drying ($M_1$) maintained superior texture (7.63, 7.61 and 7.58) compared to shade drying ($M_2$: 6.86, 6.85 and 6.83). Regarding interaction effects, the highest texture scores were achieved in Lollipop pink +silica gel +hot-air oven $V_1D_2M_1$ (8.84, 8.82, and 8.79), whereas the lowest were in Bright orange+ sand+ hot-air oven $V_2D_1M_1$ (5.54, 5.53 and 5.52) during 30,60 and 90 days after storage respectively.

**Table 5 :** Quality parameters of dried cut flowers during storage as influenced by various desiccants and drying methods

| Treatments | Texture | | | | Appearance | | | |
|---|---|---|---|---|---|---|---|---|
| | DAS | | | | | | | |
| **Variety** | **Initial** | **30** | **60** | **90** | **Initial** | **30** | **60** | **90** |
| $V_1$ | 7.65 | 7.63 | 7.61 | 7.58 | 7.58 | 7.56 | 7.55 | 7.53 |
| $V_2$ | 6.88 | 6.86 | 6.85 | 6.83 | 6.85 | 6.84 | 6.82 | 6.82 |
| S.Em ± | **0.05** | **0.04** | **0.04** | **0.05** | **0.05** | **0.04** | **0.04** | **0.05** |
| C.D. at 1 % | **0.18** | **0.16** | **0.15** | **0.18** | **0.19** | **0.17** | **0.18** | **0.18** |
| **Desiccant** | | | | | | | | |
| $D_1$ | 6.44 | 6.42 | 6.41 | 6.38 | 6.61 | 6.59 | 6.58 | 6.56 |
| $D_2$ | 8.06 | 8.04 | 8.03 | 8.00 | 7.91 | 7.89 | 7.88 | 7.86 |
| $D_3$ | 7.29 | 7.27 | 7.25 | 7.24 | 7.13 | 7.12 | 7.10 | 7.09 |
| S.Em ± | **0.06** | **0.05** | **0.05** | **0.06** | **0.06** | **0.05** | **0.05** | **0.06** |
| C.D. at 1 % | **0.22** | **0.20** | **0.19** | **0.23** | **0.23** | **0.20** | **0.22** | **0.22** |
| **Method** | | | | | | | | |
| $M_1$ | 7.65 | 7.63 | 7.61 | 7.58 | 7.58 | 7.56 | 7.55 | 7.53 |
| $M_2$ | 6.88 | 6.86 | 6.85 | 6.83 | 6.85 | 6.84 | 6.82 | 6.81 |
| S.Em ± | **0.05** | **0.04** | **0.04** | **0.05** | **0.05** | **0.04** | **0.04** | **0.05** |
| C.D. at 1 % | **0.18** | **0.16** | **0.15** | **0.18** | **0.19** | **0.17** | **0.18** | **0.18** |
| **Interactions** | | | | | | | | |
| $V_1D_1M_1$ | 6.97 | 6.95 | 6.93 | 6.89 | 6.95 | 6.93 | 6.92 | 6.91 |
| $V_1D_1M_2$ | 6.58 | 6.56 | 6.54 | 6.50 | 6.96 | 6.94 | 6.93 | 6.91 |
| $V_1D_2M_1$ | 8.86 | 8.84 | 8.82 | 8.79 | 8.57 | 8.55 | 8.53 | 8.51 |
| $V_1D_2M_2$ | 7.96 | 7.94 | 7.93 | 7.91 | 7.45 | 7.44 | 7.43 | 7.41 |
| $V_1D_3M_1$ | 7.95 | 7.93 | 7.92 | 7.90 | 7.57 | 7.55 | 7.53 | 7.51 |
| $V_1D_3M_2$ | 7.55 | 7.53 | 7.52 | 7.51 | 7.96 | 7.94 | 7.93 | 7.92 |
| $V_2D_1M_1$ | 5.56 | 5.54 | 5.53 | 5.52 | 5.66 | 5.65 | 5.63 | 5.62 |
| $V_2D_1M_2$ | 6.66 | 6.64 | 6.63 | 6.61 | 6.86 | 6.84 | 6.82 | 6.81 |
| $V_2D_2M_1$ | 7.96 | 7.94 | 7.93 | 7.92 | 7.96 | 7.94 | 7.92 | 7.91 |
| $V_2D_2M_2$ | 7.46 | 7.44 | 7.43 | 7.40 | 7.64 | 7.63 | 7.62 | 7.62 |
| $V_2D_3M_1$ | 6.88 | 6.86 | 6.84 | 6.82 | 6.55 | 6.54 | 6.53 | 6.52 |
| $V_2D_3M_2$ | 6.76 | 6.74 | 6.73 | 6.72 | 6.45 | 6.44 | 6.42 | 6.41 |
| Mean | 7.26 | 7.24 | 7.22 | 7.20 | 7.21 | 7.19 | 7.18 | 7.17 |
| S.Em ± | **0.11** | **0.10** | **0.09** | **0.11** | **0.12** | **0.10** | **0.11** | **0.11** |
| C.D. at 1 % | **0.44** | **0.40** | **0.37** | **0.45** | **0.46** | **0.41** | **0.43** | **0.45** |

**DAS:** Days after storage

**$V_1$**= Lollipop Pink **$D_1$**= Sand **$M_1$**= Hot air oven drying

**$V_2$**= Bright Orange **$D_2$**= Silica gel **$M_2$**= Shade drying

**$D_3$**= Vermiculite

## Flower Appearance

Significant differences in the appearance of dried cut chrysanthemum flowers were observed due to varieties, desiccants and drying methods during storage (Table 5). Between the two varieties, Lollipop pink consistently scored higher (7.56, 7.55 and 7.53 at 30, 60, and 90 DAS, respectively) compared to Bright orange (6.84, 6.82 and 6.82). Among desiccants, silica gel yielded the highest appearance scores (7.89, 7.88 and 7.86), followed by vermiculite (7.12, 7.10 and 7.09), while sand recorded the lowest (6.59, 6.58 and 6.56). With respect to drying methods, hot-air oven drying maintained superior appearance (7.56, 7.55 and 7.53) compared to shade drying (6.84, 6.82 and 6.81). The interaction effect revealed that the maximum scores were recorded in Lollipop pink+ silica gel+ hot-air oven $V_1D_2M_1$ (8.55, 8.53 and 8.51), while the lowest were observed in Bright orange+ vermiculite+ shade dry $V_2D_3M_2$ (6.44, 6.42 and 6.41) during 30,60 and 90 days after storage respectively.

### Overall acceptability

The effect of different desiccants on the overall acceptability of dried cut chrysanthemum flowers is presented in Table 6. Significant variation was observed among varieties, desiccants and drying methods during storage. Between the two varieties, Lollipop pink consistently received higher scores (7.59, 7.57 and 7.56 at 30, 60 and 90 DAS, respectively) compared to Bright orange (6.85, 6.84 and 6.83). With respect to desiccants, silica gel recorded the highest scores (7.95, 7.94 and 7.92), followed by vermiculite (7.23, 7.21 and 7.20), while sand consistently showed the lowest scores (6.49, 6.48 and 6.46). Among drying methods, hot-air oven drying produced superior acceptability (7.59, 7.57 and 7.56) compared to shade drying (6.85, 6.84 and 6.83). The interaction effect showed that $V_1D_2M_1$ (Lollipop pink + silica gel + hot-air oven) achieved the highest acceptability (8.83, 8.80 and 8.78), whereas $V_2D_1M_1$ (Bright orange + sand + hot-air oven) recorded the lowest scores (5.70, 5.68 and 5.67) across the storage period.

**Table 6 :** Quality parameters of dried cut chrysanthemum flowers during storage as influenced by various desiccants and drying methods

| Treatments | Overall acceptability | | | |
|---|---|---|---|---|
| | DAS | | | |
| **Variety** | **Initial** | **30** | **60** | **90** |
| $V_1$ | 7.61 | 7.59 | 7.57 | 7.56 |
| $V_2$ | 6.87 | 6.85 | 6.84 | 6.83 |
| S.Em ± | **0.04** | **0.05** | **0.05** | **0.05** |
| C.D. at 1 % | **0.18** | **0.18** | **0.18** | **0.18** |
| **Desiccant** | | | | |
| $D_1$ | 6.51 | 6.49 | 6.48 | 6.46 |
| $D_2$ | 7.97 | 7.95 | 7.94 | 7.92 |
| $D_3$ | 7.24 | 7.23 | 7.21 | 7.20 |
| S.Em ± | **0.05** | **0.06** | **0.06** | **0.06** |
| C.D. at 1 % | **0.22** | **0.22** | **0.22** | **0.22** |
| **Method** | | | | |
| $M_1$ | 7.61 | 7.59 | 7.57 | 7.56 |
| $M_2$ | 6.87 | 6.85 | 6.84 | 6.83 |
| S.Em ± | **0.04** | **0.05** | **0.05** | **0.05** |
| C.D. at 1 % | **0.18** | **0.18** | **0.18** | **0.18** |
| **Interactions** | | | | |
| $V_1D_1M_1$ | 6.94 | 6.92 | 6.90 | 6.88 |
| $V_1D_1M_2$ | 6.74 | 6.71 | 6.70 | 6.68 |
| $V_1D_2M_1$ | 8.84 | 8.83 | 8.80 | 8.78 |
| $V_1D_2M_2$ | 7.60 | 7.58 | 7.57 | 7.56 |
| $V_1D_3M_1$ | 7.86 | 7.85 | 7.83 | 7.81 |
| $V_1D_3M_2$ | 7.67 | 7.65 | 7.64 | 7.63 |
| $V_2D_1M_1$ | 5.71 | 5.70 | 5.68 | 5.67 |
| $V_2D_1M_2$ | 6.65 | 6.63 | 6.62 | 6.60 |
| $V_2D_2M_1$ | 7.79 | 7.77 | 7.75 | 7.74 |
| $V_2D_2M_2$ | 7.65 | 7.63 | 7.62 | 7.61 |
| $V_2D_3M_1$ | 6.84 | 6.82 | 6.80 | 6.79 |
| $V_2D_3M_2$ | 6.59 | 6.58 | 6.57 | 6.56 |
| Mean | 7.24 | 7.22 | 7.20 | 7.19 |
| S.Em ± | **0.11** | **0.11** | **0.11** | **0.11** |
| C.D. at 1 % | **0.43** | **0.45** | **0.44** | **0.45** |

**DAS:** Days after storage

**$V_1$**= Lollipop Pink **$D_1$**= Sand **$M_1$**= Hot air oven drying
**$V_2$**= Bright Orange **$D_2$**= Silica gel **$M_2$**= Shade drying
**$D_3$**= Vermiculite

Effect of Desiccants on Quality Parameters: Quality parameters such as colour, shape, texture, appearance and overall acceptability were significantly affected by both desiccants and drying methods. Chrysanthemum var. Lollipop Pink embedded in silica gel and dried in a hot air oven achieved the highest scores for colour (8.97), shape (8.96), texture (8.86), appearance (8.57) and overall acceptability (8.84). This can be attributed to the smooth texture of silica gel and its rapid dehydrating action, which preserves the flower's original quality. Similar observations have been reported in rose (Safeena *et al.,* 2006; Dhatt *et al.,* 2007), acroclinum (Katoch. 2010), and chrysanthemum (Nair *et al.,* 2011).

Silica gel's efficient moisture absorption helps retain flower shape (Nirmala *et al.,* 2008) and ensures proper colour preservation in flowers such as helichrysum and Statice (Safeena and patil, 2013). Dhatta *et al.* (2007) also reported that rose cultivars embedded in silica gel exhibited superior shape retention. Conversely, river bed sand caused punctures on petals due to its angular edges, resulting in poor acceptability. Stern (1994) suggested that sand used for drying should have uniform, fine, and preferably round granules. For Chrysanthemum var. Bright, flowers dried in a hot air oven using sand scored the lowest for colour (5.97), shape (5.68), texture (5.56), appearance (5.66) and overall acceptability (5.71), likely due to the inability of sand to maintain the flowers' original shape and appearance (Lalhruaitluangi, 2017).

## Conclusion

The various desiccants and drying methods were used to maintained the quality of dried cut chrysanthemum var. lollipop pink and bright orange and lisianthus var Rosita clear pink and Rosita bright blue. The salient findings are listed below.

**Desiccant Efficiency:** Silica gel was identified as the most effective desiccant for preserving the quality of dried cut chrysanthemum flowers.

1. **Optimal Drying Method**: Embedding flowers in silica gel and drying them in a hot air oven at 50°C yielded superior results in terms of structural integrity, colour retention and overall aesthetic quality for cut chrysanthemum.
2. **Varietal Performance-** Among the tested cut chrysanthemum cultivars, 'Lollipop Pink' demonstrated better retention of sensory attributes such as colour, petal texture and shape compared to 'Bright Orange'.

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