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Assessment of suitable embedding media for drying of rose and marigold flowers

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Abstract
The present investigation entitled "Evaluation of Embedding Media on Drying of Rose (*Rosa hybrida*) and Marigold (*Tagetes erecta*) Flowers" was conducted during the academic session 2024–25 at the Department of Floriculture and Landscaping, College of Horticulture and Research Station, Mahatma Gandhi University of horticulture and forestry, Durg (Chhattisgarh) to assess the effect of different embedding media on drying efficiency and quality of dried flowers. The experiment was laid out in a Completely Randomized Design (CRD) with two factors, namely flowers and embedding media, comprising 14 treatment combinations and three replications. Rose and marigold flowers were dried using embedding media such as sand, silica gel, borax, sand + silica gel, sand + borax, and silica gel + borax, along with a control without embedding. Observations were recorded on flower size, reduction in flower diameter (cm and %), fresh and dry flower weight, moisture loss percentage, time taken for drying, and qualitative parameters including colour, shape, texture, shattering of petals, and overall acceptability evaluated using a 9-point Hedonic scale. The results revealed that flower type significantly influenced initial flower size and weight, with rose (F_1) recording larger flowers (5.25 cm) and higher initial weight (6.93 g) than marigold (F_2) (2.62 cm and 5.57 g, respectively). Final flower size was also higher in rose (2.89 cm) compared to marigold (1.30 cm). Among embedding media, silica gel (M_2) and silica gel + borax (M_6) showed superior size retention (2.64 cm and 2.55 cm, respectively). Minimum reduction in flower size was observed in M_2 (rose: 0.73 cm, 15.60%; marigold: 0.55 cm, 12.22%), while maximum shrinkage occurred in the control without embedding (≈ 50%). Rose retained a higher final dry weight (1.71 g) than marigold (1.22 g). Moisture loss was highest in M_2 (81.98%), followed by M_6 (79.40%), indicating rapid and uniform dehydration, whereas the control recorded the lowest moisture loss (70.67%). Qualitative assessment showed that rose consistently outperformed marigold for colour (7.05), appearance (6.35), texture (6.35), shattering resistance (7.01), and overall acceptability (7.88). Among embedding media, M_2 recorded the highest scores for colour (7.63), appearance (7.74), texture (7.74), shattering resistance (7.59), and overall acceptability (8.52), followed by M_6. Significant interaction effects were observed for most qualitative traits, with $F_1 \times M_2$ (Rose + Silica Gel) producing the best overall acceptability score (8.87), while $F_2 \times M_5$ recorded the lowest (6.44).

Keywords: Dry flowers, Embedding Media, Rose, Marigold, Silica gel

Introduction
Despite their beauty, flowers and foliage are highly perishable and delicate. Their freshness can be extended only up to about 40% with the use of preservatives or chemicals (Ranjan & Misra, 2002) [1]. Moreover, flowers are not available year-round in all regions, leading to supply shortages (Sindhuja *et al.*, 2017) [2]. To overcome these limitations, the concept of dry flower technology has gained importance. Dry flowers offer novelty, durability, aesthetic appeal, adaptability and year-round availability, making them a valuable product in floriculture (Dilta *et al.*, 2011) [3]. What began as a traditional art form has now evolved into an interdisciplinary science and a global economic activity (Verma *et al.*, 2012) [4].
The practice of desiccating flowers is ancient, originating in Egypt, where herbs and flowers were dehydrated for mummy preservation and in medieval times when monks suspended therapeutic herbs in inverted bundles for drying. Botanists later used dried specimens for herbarium collections and plant identification. In modern times, advanced drying methods

such as hot-air ovens and microwave drying are used to enhance quality and reduce drying time (Acharya *et al.*, 2013) [5]. Consumer demand for dried flowers has been increasing in both national and international markets. Compared to fresh flowers, dried flowers are biodegradable, ecofriendly, long-lasting and retain their decorative appeal for years when properly protected from humidity, dust and wind (Ranjan & Misra, 2002) [1]. Among commercially important flowers, rose (*Rosa hybrida*) occupies the leading position in international cut flower trade due to its attractive form, wide colour range, growth habit and fragrance. In addition to cut flower use, roses are important for garlands, bouquets, floral arrangements, hair adornments and value-added products such as gulkand, attar and rose water (Arora, 1990) [6]. Moisture content plays a critical role in determining the quality and durability of dried flowers. Ideally, flowers should be dried to a moisture level of 8–11.5% to maintain their structural and biochemical integrity (Acharya *et al.*, 2013) [5]. Various drying methods are employed, ranging from traditional sun and air drying to modern techniques such as microwave and freeze drying. While sun and air drying are inexpensive, they often lead to discoloration and shrinkage (Dilta *et al.*, 2011) [3]. Press drying is suitable for making art works but not for whole blooms.

Material and Method

Experimental Site

The laboratory experiment was carried out in the Department of Floriculture and Landscaping, College of Horticulture and Research Station, Mahatma Gandhi Udyaniki Evam Vanik Vishwavidyalaya, Durg (Chhattisgarh).

Experimental details and methodology

Detailed Programme of research:

The present experiment was conducted on two flower crops, Rosa hybrida (Rose) and Tagetes erecta (Marigold) to study the effect of different embedding media on flower drying. The drying of flowers was carried out using the embedding method with different materials such as silica gel, borax, and sand. In this experiment, two factors were considered. Factor A consisted of the type of flower, where F1 represented Rose and F2 represented Marigold. Factor B consisted of the embedding media used for drying. The embedding media included M0 – Without embedding, M1 – Sand, M2 – Silica gel, M3 – Borax, M4 – Sand + Silica gel, M5 – Sand + Borax, and M6 – Silica gel + Borax.

A total of 14 treatment combinations were formed by combining the two flowers with the different embedding media. These treatments included: T1 (F1M0) – Rose without embedding, T2 (F1M1) – Rose with sand, T3 (F1M2) – Rose with silica gel, T4 (F1M3) – Rose with borax, T5 (F1M4) – Rose with sand and silica gel, T6 (F1M5) – Rose with sand and borax, and T7 (F1M6) – Rose with silica gel and borax. Similarly, T8 (F2M0) – Marigold without embedding, T9 (F2M1) – Marigold with sand, T10 (F2M2) – Marigold with silica gel, T11 (F2M3) – Marigold with borax, T12 (F2M4) – Marigold with sand and silica gel, T13 (F2M5) – Marigold with sand and borax, and T14 (F2M6) – Marigold with silica gel and borax.

Experimental Procedure

Embedding of flowers in desiccants

By drying the flower using various embedding medium, such as Sand, Silica Gel, Borax, Sand + Silica Gel, and Silica Gel + Borax (1:1) mixture, the problem of petal shrinking and floral shape destruction can be resolved. This procedure involved inserting 5 cm flower stems into the desiccant after pouring a layer of the embedding material, about 1 to 1.5 cm thick, into the bottom of the container. Pour the embedding media slowly and continuously around and above the flower up to to cm to cover all the spaces between the petals without changing the shape of the flowers. These containers were used to store the flowers in the appropriate drying procedure after they had been placed in desiccant.

Removal of flower from the container

After the completion of drying process and setting time, the containers were gently inclined over to remove the dried flower from embedding material without making any mechanical damage. The dried flowers were lifted up by hand; clean the embedding material which is adsorbed on the flower by inverting them and tapping the stems with fingers slowly. Remaining desiccants were finally cleaned by using fine brush.

Results and Discussion

Quantitative Parameter

Initial flower size

The data pertaining to the effect of flower types and embedding media on the initial flower size have been presented in Fig.1 The results indicated that flower types significantly influenced the initial flower size. Between the two flower types, F_1 (Rose) recorded the highest mean initial flower size (5.25 cm), whereas F_2 (Marigold) showed a comparatively smaller mean size (2.62 cm). This clearly shows that rose flowers inherently possessed a larger bloom size at the initial stage than marigold.

The effect of embedding media and their interaction with flower type (F × M) on initial flower size was non-significant. Flower type alone had a significant influence, with roses showing larger initial size than marigold. Although some media combinations showed numerical improvement, the differences were statistically non-significant, indicating that initial flower size is mainly determined by flower type rather than embedding media.

Final flower size (cm)

The data pertaining to the effect of flower types and embedding media on the final flower size have been presented in Fig.2. The results indicated that flower types exerted a significant influence on the final flower size. Between the two flower types, F_1 recorded a higher mean final flower size (2.89 cm), whereas F_2 showed a comparatively smaller mean final flower size (1.30 cm). This clearly indicates that F_1 flowers retained a larger bloom size at the final stage of drying than F_2.

The effect of embedding media on the final flower size was also found to be significant at the 5% level, indicating that different embedding media influenced the extent of size retention in flowers. Among the embedding media, M2 (Silica Gel; 2.64 cm) recorded the highest overall mean final flower size, followed by M6 (Silica Gel + Borax; 2.55 cm), whereas M5 (Sand, 1.44 cm) recorded the smallest mean final size.

However, the interaction effect between flower types and embedding media (F × M) was nonsignificant, indicating that their combined influence did not cause statistically significant variation in final flower size. Both flower type and embedding media individually affected flower size significantly, but their interaction did not. F_1 retained a larger flower size after drying than F_2, while embedding media such as M_2 and M_6 showed better size retention. This suggests that final flower size is mainly governed by the inherent characteristics of the flower type and the independent effect of embedding media.

Reduction in flower size (cm)

The data pertaining to the effect of flower types and embedding media on the reduction in flower size after drying have been presented in Fig.3. The results revealed that flower types significantly influenced the extent of flower size reduction. Rose flower (F_1) recorded a higher mean reduction (2.36 cm), whereas Marigold flower (F_2) exhibited a comparatively lower mean reduction (1.26 cm).

This indicates that F_1 flowers experienced greater shrinkage during drying compared to F_2. The effect of embedding media was also found to be significant, indicating that different media influenced the degree of shrinkage during the drying process. Among the embedding media, M2 (1.11 cm) recorded the lowest reduction in flower size, followed by M3 (1.69 cm) and M6 (1.55 cm). The highest reduction was observed in M0 (2.34 cm) and M1 (2.23 cm), suggesting that untreated or coarse media allowed more shrinkage. The interaction effect between flower types and embedding media (F × M) was found to be nonsignificant, indicating that the combined effect of flower type and embedding media did not produce statistically meaningful differences in size reduction. Overall, the results showed that flower type and embedding media independently affected flowersize reduction after drying, while their interaction was non-significant. F_2 retained its size better than F_1, and media such as M_2 (Silica Gel) and M_6 (Silica Gel + Borax) performed best in minimizing shrinkage. The greater reduction in F_1 may be attributed to its higher moisture content and softer petals, whereas rapid moisture removal by Silica Gel– based media helped preserve structure. This indicates that shrinkage is primarily governed by flower characteristics and the individual efficiency

1.4 Reduction in Flower Size %

The data pertaining to the effect of flower types and embedding media on the percentage reduction in flower size have been presented in Fig. 4. The results indicated that flower types significantly differed in the extent of percentage reduction during drying. Between the two flower types, F_2 recorded a higher mean percentage reduction (50.51%), whereas F_1 exhibited a comparatively lower mean percentage reduction (44.65%). This shows that F_2 flowers shrank relatively more than F_1 during the drying process.

The embedding media also showed clear differences in the percentage reduction. Among the seven media tested, M2 (30.87%) exhibited the lowest percentage reduction, followed by M6 (37.61%) and M3 (40.84%), indicating better shape and size retention. The highest reduction was observed under M5 (52.97%) and M4 (50.78%), while M0 (61.94%) and M1 (58.07%) also showed comparatively higher shrinkage.

Flower type and embedding media significantly influenced the percentage reduction in flower size, with F_1 retaining its size more effectively than F_2. Media such as M_2 and M_6 provided the best size preservation, whereas coarse or slow-drying media led to greater shrinkage. The smaller reduction in F_1 is likely due to its thicker, firmer petals, which resist deformation during drying. Silica gel–based media like M_2 and M_6 promote quick, uniform moisture removal, thereby minimizing shrinkage, while slower-acting media such as M_4 and M_5 retain moisture longer, resulting in higher shrinkage. These factors explain the variation observed across treatments.

Initial flower weight (g)

The data related to the effect of flower types and embedding media on the initial flower weight are presented in Fig.5. The results revealed that flower types had a significant influence on the initial flower weight at the 5% level of significance. Between the two flower types, F_1 recorded a higher mean initial flower weight (6.93 g), whereas F_2 showed a lower mean weight (5.57 g). This clearly indicates that F_1 flowers possessed greater fresh weight at the beginning of drying as compared to F_2

The effect of embedding media on the initial flower weight was found to be nonsignificant, indicating that the variation among different media did not statistically affect the initial weight of flowers. Similarly, the interaction effect between flower type and embedding media (F×M) was also found to be non-significant, suggesting that the combined effect of flower type and media did not produce any meaningful variation in initial flower weight.

The results indicate that flower type alone had a significant effect on the initial flower weight, whereas embedding media and their interaction with flower type showed no significant influence. F_1 flowers started with a higher initial weight than F_2, primarily due to their inherently larger and more succulent floral tissues, which naturally contribute to greater fresh weight. Since initial weight is determined by the physiological characteristics of the flowers at harvest, embedding media could not alter this parameter. The nonsignificant interaction (F × M) further confirms that the initial fresh weight is independent of the media used.

1.6 Final flower weight (g)

The data presented in Fig.6. show that both flower types and embedding media significantly influenced the final flower weight. Between the flower types, F_1 recorded a higher mean final flower weight (1.71 g) compared to F_2 (1.22g), indicating that F_1 flowers retained more dry matter after the drying process.

Embedding media also showed a significant effect, with the highest overall mean final weight observed in M_0 (1.84 g). In contrast, the lowest weight retention occurred in M_2 (1.11 g) and M_6 (1.26g). This variation reveals that some media supported better weight retention than others during drying. However, the interaction between flower types and embedding media (F×M) was found to be non-significant, indicating that both flower types responded similarly across all media.

These findings lies in the inherent structural differences between the flower types: F_1 flowers possess denser and more compact tissues, enabling higher mass retention after drying than F_2. Likewise, the significant effect of media is due to their differences in moisture absorption and drying behavior, where media such as M_0, M_1, and M_5 slowed moisture loss and supported the flower structure, resulting in greater retained weight, while highly absorbent or faster-drying media like M_2 and M_6 led to greater shrinkage and lower final weight.

Moisture loss (%)

The data in Fig.7 indicate that flower type had a non-significant effect on moisture loss during drying. Although marigold (F_2) recorded slightly higher moisture loss (77.56%) than rose (F_1) (74.69%), the difference was not statistically significant. This means that both roses and marigolds lost moisture at nearly the same rate under the given drying conditions. On the other hand, embedding media showed a significant effect on moisture loss, meaning the drying material strongly influenced how much water the flowers lost. The highest moisture loss was observed in M_2 (81.98%), followed by M_6 (79.40 %) and M_3 (78.11%), all of which involved silica gel or its combinations, indicating faster moisture withdrawal. Lower moisture loss occurred in M_0 (70.67%), where drying was comparatively slower. The interaction between flower type and media (F × M) was nonsignificant, showing that roses and marigolds responded similarly across all embedding media.

Moisture loss between roses and marigolds was non-significant because, despite species differences, both have similar initial petal water content, and their tissues release moisture at comparable rates during drying. Rose petals are softer with higher surface moisture, while marigold petals are firmer, but these traits balance out, resulting in similar moisture loss. Embedding media, however, showed significant effects—materials like silica gel absorb moisture rapidly, causing higher loss, whereas sand and less absorbent media dry flowers more slowly. Since both flowers responded similarly to each media type, the interaction remained non-significant.

Quantitative Parameters

Initial flower size and weight

- Flower type significantly influenced both initial flower size and weight.
- Rose (F) recorded larger size (5.25 cm) and higher initial weight (6.93 g) than Marigold (F) (2.62 cm;1 2 5.57 g).
- Embedding media and F × M interaction showed non-significant effects, indicating that initial size and weight are inherent flower traits.

Final flower size

- Both flower type and embedding media had significant effects.
- Rose (F_1) retained a larger final size (2.89 cm) compared to Marigold (F) (1.30 cm). 2
- Among media, M_2 (Silica Gel) (2.64 cm) and M_6 (Silica Gel + Borax) (2.55 cm) recorded the highest size retention.
- Interaction effect (F × M) was non-significant.

Reduction in flower size (cm and %)

- Reduction in size (cm) and percentage shrinkage differed significantly among flower types and embedding media.
- Rose (F_1) showed a higher absolute reduction (2.36 cm), whereas Marigold (F_2) recorded a higher percentage reduction (50.51%), indicating greater relative shrinkage in marigold petals.
- Among the embedding media, minimum shrinkage was observed in M_2 (Silica Gel, F_1: 0.73 cm, 15.60%; F_2: 0.55 cm, 12.22%), while maximum shrinkage occurred in M_0 (Without embedding, F_1: 2.36 cm, 50.43 % ; F_2 ; 2.28cm, 50.67 %)

Final flower weight

- Both flower type and embedding media showed significant differences.
- Rose (F_1) retained a higher dry weight (1.71 g) than Marigold (F_2) (1.22 g).
- The highest weight retention occurred in M_0 and M_1, while M_2 and M_6 recorded the lowest due to faster dehydration.
- Interaction was non-significant.

Moisture loss (%)

- Flower type showed non-significant differences, indicating similar moisture-release patterns in both flowers.
- Embedding media differed significantly, with M_2 (81.98%), M_6 (79.40%), and M_3 (78.11%) showing maximum moisture loss.
- M_0 (70.67 %) showed the lowest loss due to slower drying.
- Interaction effect was non-significant.

Table 1: Combined Effect of Flower Types and Embedding Media on Quantitative Parameters of Dried Flowers

Parameter	Flower Type	M0	M1	M2	M3	M4	M5	M6	Mean
Initial Flower Size (cm)	F1	5.17	5.28	4.93	5.20	5.30	5.23	5.62	5.25
Initial Flower Size (cm)	F2	2.38	2.44	2.58	2.55	3.26	2.58	2.57	2.62
Final Flower Size (cm)	F1	1.97	2.24	3.64	3.26	2.90	2.65	3.57	2.89
Final Flower Size (cm)	F2	0.91	1.01	1.65	1.43	1.42	1.12	1.53	1.30
Reduction in Flower Size (cm)	F1	3.20	3.03	1.29	1.94	2.40	2.58	2.05	2.36
Reduction in Flower Size (cm)	F2	1.47	1.43	0.93	1.43	1.42	1.12	1.04	1.26
Reduction in Flower Size (%)	F1	61.94	57.48	26.18	37.29	45.13	49.28	35.26	44.65
Reduction in Flower Size (%)	F2	61.93	58.65	35.56	44.39	56.42	56.65	39.95	50.51
Initial Flower Weight (g)	F1	7.08	7.21	6.92	6.74	6.80	6.92	6.87	6.93
Initial Flower Weight (g)	F2	5.64	5.52	5.50	5.49	5.71	5.56	5.59	5.57
Final Flower Weight (g)	F1	2.11	1.97	1.43	1.55	1.63	1.87	1.45	1.71
Final Flower Weight (g)	F2	1.56	1.47						

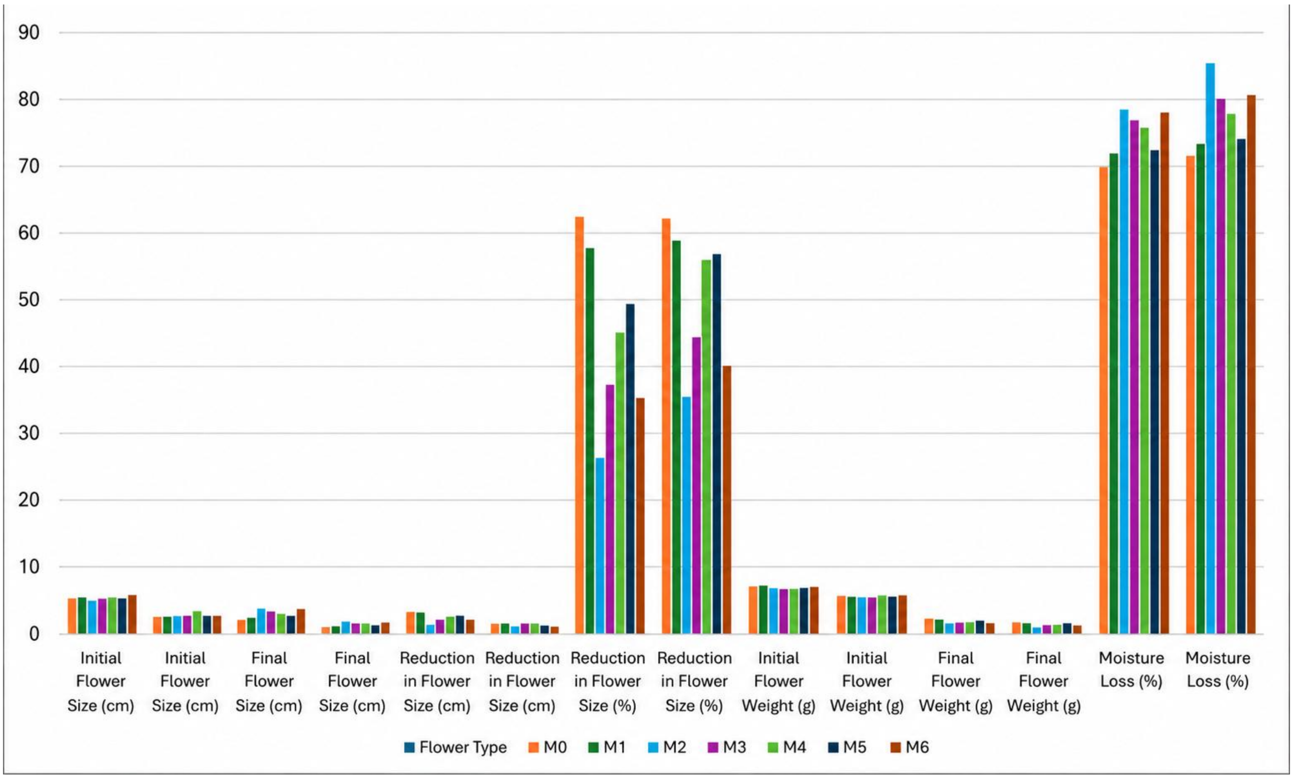

Fig 1: Combined Effect of Flower Types and Embedding Media on Quantitative Parameters of Dried Flowers

Conclusions

1. Embedding media significantly affected drying quality.

A) Silica Gel (M_2) was the most effective medium for rapid and uniform dehydration.

B) Silica Gel + Borax (M_6) also performed exceptionally well across parameters.

C) Control (M_0) and Sand (M_1) resulted in poor colour, lower texture, more shrinkage, and inferior appearance.

2. Interaction effects (F×M) were significant for most qualitative parameters, showing that the choice of medium is crucial for each flower type.

3. Best treatment combination:
$F_1 \times M_2$ (Rose + Silica Gel)
This combination consistently gave superior results in colour, appearance, texture, shattering resistance, and overall acceptability.

4. Silica gel–based media enhanced colour retention, minimized shrinkage, and produced aesthetically superior dried flowers due to fast and uniform moisture withdrawal.

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