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Influence of Various Chemical Pre- Treatments And Drying Methods On Value Addition Of Marigold (*Tagetes erecta* L.)

Amita Gurjar[1], Nomita Laishram*[1], Arvinder Singh[1], R.K.Pandey[2], B.K.Sinha[2]

[1]Division of Plant Physiology, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu, Chatha-18000, India
[2]Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu, Chatha-180009, India

ABSTRACT

The current study was carried out with the objective of determining the most effective pre-drying preservative treatments and the best drying method for marigold flowers. The flowers of marigold cv. Pusa Narangi Gainda were subjected to four different chemical pre-drying treatments, comprising of P0 (control), P1 (2% citric acid), P2 (10% MgCl2), P3(1:3 glycerol: water), and five different drying techniques, viz., D0 (air drying), D1 (silica gel + hot air oven), D2 (silica gel + microwave oven), D3 (Borax + hot air oven) and D4 (Borax + microwave oven). Results revealed that the maximum dry flower weight (1.55 g), minimum percent moisture loss (78.89 %), maximum dry flower diameter (4.64 cm), lowest diameter reduction (1.38 cm), minimum drying time (77.66 h), maximum score for color (2.82), texture (2.64), shape (3.60), non-shattering of petals (3.84) and overall acceptability (3.62) were achieved after pre-drying treatment with 1: 3 glycerol: water. Silica gel embedded flowers dried in a hot air oven resulted in less reduction in diameter (1.14 cm) and the maximum score for color (4.00), texture (4.10), shape (4.23), non-shattering of petals (4.18) and overall acceptability (4.55). Among the interaction effect, pre-treatment of glycerol: water (1: 3) and drying method (silica gel + hot air oven) showed the least amount of diameter reduction (0.97cm) and maximum scores for color (4.30), texture (4.50), shape (4.50), non-shattering of petals (4.50) and overall acceptability (4.80). Flowers dried in a microwave oven with either of the desiccant used took the least time to dry recording 0.16h. Air-dried flowers without embedding recorded the least dry flower weight (0.74g), maximum percent moisture loss (90.14%), minimum dry flower diameter (3.10cm), and largest diameter reduction (2.94cm). However, air drying took the longest drying time (352.33 h) and also yielded unacceptable dried flowers with minimum scores for color (1.20), texture (1.28), shape (1.93), and overall acceptability (2.30).

Keywords: *Desiccant, drying technique, marigold, preservative treatment, texture.*

INTRODUCTION

Although exceedingly beautiful, fresh flowers are quite expensive, short-lived, and only available during a specific season. On the other hand, products made from dried flowers last longer and maintain their aesthetic appeal throughout the year [1]. As an alternative to fresh flowers and foliage for vase decoration and other artistic and commercial uses, dried flowers and plant materials have shown to have enormous potential in exteriors and interiors. Dehydrated flowers are much appreciated because of their bio-friendly aesthetic beauty, long-lasting quality as they can be used all year round regardless of season and climate [2].
The top three countries in the world for dried flower consumption are the US, Germany, and the UK. The main exporters in the market are India, Netherlands, Mexico, Israel, and more recently, Australia. India has become a global leader in the export of products made from dried flowers, doing business in dried flowers worth Rs 150 crores each year, 25% of the world's dried flower business comes from this. The sector exports dried plant components in 500 distinct types to 20 different nations [3].
Flowers and leaves can be dehydrated in a variety of ways. The techniques entail lowering the flower's moisture content to a level where biochemical changes are reduced to a minimum but cell structure, pigment level, and floral shape are preserved. The process of drying is equally crucial to the type of flower, stage of harvest, and other harvesting criteria. The simplest way, air drying, causes tissue to shrink as a result of cell water loss. The "embedding approach" is usually preferred to prevent this [2].
During drying, petal color changes (browning or darkening) are prevalent, because of the continued use of heat which eventually damages the tissue. Pre-treatment using chemicals such as sodium bisulfate, magnesium chloride, and magnesium sulfate has also been shown to have a substantial effect on the color and quality retention of vegetables and flowers during the dehydration process [4].
Marigold (Tagetes erecta L.) belongs to the Asteraceae family. Mexico is the birthplace of marigolds throughout Central and

**Corresponding Author: : Nomita Laishram*
Email Address: nomitalaishram@gmail.com

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South America. Marigold is commercially grown in several nations for industrial, medical, and decorative uses. The African marigold is among the most crucial flowers for business. The African marigold (Tagetes erecta L.) produces huge, reduplicated yellow to orange blooms from mid-summer until frost [5]. Due to their lovely color and shape, marigold, an annual flower, have several uses in the landscaping sector as well as the potential to be used as dried flowers [6].

More research is needed to support and advance the dry flower sector, which will help the industry grow. The primary processing steps in the creation of dried flowers are drying and pre-treatments, which have a significant impact on the quality of the finished product. Therefore, a study was conducted to standardize dried-flower production processes and pre-treatments.

Material and Methods

The investigation was conducted in the Division of Vegetable Science and Floriculture, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Jammu & Kashmir during the month of November 2021 to March 2022. In this study, flowers of marigold cv. Pusa Narangi Gainda were subjected to four different chemical pre-drying treatments, comprising of P0 (control), P1 (2% citric acid), P2 (10% $MgCl_2$), P3(1:3 glycerol: water) and five different drying techniques, viz., D0 (Air drying), D1 (Silica gel + hot air oven at 55±1ºC), D2 (Silica gel + microwave oven), D3 (Borax + hot air oven 55±1ºC) and D4 (Borax + microwave oven), replicated thrice and analyzed using factorial Completely Randomized Design (CRD). Healthy, disease-free, uniform flower stems of marigolds were collected from the field at full bloom stage in the morning hours between 9.00 and 10.00 am. Each flower's stem length was kept consistent at 6 cm. Flowers were immersed in chemical solutions based on the treatments. The flowers were then removed from the solution, the water was drained out by placing the flowers on a fine cloth, and the water was allowed to evaporate. Flowers were dried using various drying techniques mentioned in the treatments after being subjected to the pre-treatment. Air drying in room temperature was performed by tying the flowers by a thread and hanging them in the inverted position. At the time of drying maximum room temperature was 23.3°C and the minimum room temperature was 15.6°C. RH (relative humidity) inside the lab was within the range of 48.7 % to 85.4%. Pre-treated flowers were embedded in appropriate media (either silica gel or borax) in microwavable plastic containers. Depending on the treatment, the embedded flowers were dried in an electrically operated hot air oven or a microwave oven. After the flowers had dried, the containers were removed and left at room temperature for approximately 3 hours (setting time). The flowers were removed from the embedding media by inverting the containers after dehydration to remove the desiccants from the flowers. The dried flowers were then hand-picked and cleaned by inverting them and gently tapping the stems with fingertips. The last remnants of desiccant were eventually removed with the help of a fine brush. At the end of the drying process, the petals of the flowers were pressed with fingertips to check for wetness. If moisture remained, the flowers were dried further to ensure complete moisture removal. Flower fresh weight, dry weight, fresh flower diameter, dry flower diameter, reduction in diameter, percent moisture loss, and drying time were all recorded. A panel of five judges scored the quality parameters of color, shape, texture, overall acceptability, and non-shattering of petals on a five-point scale i.e. excellent, very good, good, bad, and below average, with weights of 4.1-5.0, 3.1-4.0, 2.1-3.0, 1.1-2.0, and 0.0-1.0, respectively. The data was examined using factorial CRD [7].

The amount of moisture lost as a result of drying was calculated using the formula below and expressed in percentage.

$$\text{Per cent moisture loss (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

Results and Discussion

Effect on physical parameters

Since the flowers used in the experiment were uniform, there was no variation in fresh weight or fresh flower diameter due to drying methods or pre-treatments. The flowers pre-treated with glycerol and water (1:3) for 24 hours had a maximum dry flower weight of (1.55g) and a minimum moisture loss of (78.89%), while the flowers pre-treated with water had a minimum dry weight of (1.12g) and a maximum moisture loss of (84.96%). This could be because glycerol (plasticizer) replaces native water content in plant material after osmosis, and these plasticizers typically improve gas, liquid, and water vapor permeability[8]. These findings are consistent with those of Ravichandra and Pedapathi[9] in Carnation, Mathapati et al.[10] in gerbera, Patil et al.[11] in carnation, and Malakar et al.[12] in various ornamental foliages. Flowers embedded in borax and microwaved for 10 minutes yielded the highest dry flower weight (1.47g) with the lowest moisture loss (80.08%), which could be attributed to borax's inability to extract moisture from the surrounding environment as efficiently as silica gel. Furthermore, silica gel is more hygroscopic than borax as an embedding medium, and borax absorbs moisture less quickly and solidifies into lumps, reducing the possibility of floral moisture evaporation[13]. Similar findings have been reported by Nirmala et al.[14] in carnation, Nair et al.[15] in yellow button chrysanthemum. Air drying without embedding resulted in the lowest dry weight (0.74g) and highest moisture loss (90.14%), which could be attributed to the flowers being directly exposed to microclimate for a longer period of time[16]. These findings are in line with those of Dilta et al.[1] in rose buds. In contrast, Wilson et al.[17] discovered that embedded drying resulted in the greatest moisture loss when compared to air drying while working on chrysanthemums. The interactive effect of pre-drying treatments and drying methods on dry weight and moisture loss was also discovered to be significant. Maximum dry weight (1.80g) was recorded with flowers that were pre-treated with glycerol: water (1:3) for 24 h and embedded in borax dried in a hot air oven, while minimum moisture loss (75.78%) was recorded with flowers that were pre-treated with glycerol: water (1:3) for 24 h and embedded in borax dried in a microwave oven, and minimum dry weight (0.67g) coupled with maximum moisture loss (91.65%) was observed in flowers pre-treated with 10% $MgCl_2$ and air dried at room temperature in shade without embedding(Table 1).

The pre-drying treatments had a significant impact on dry flower diameter and relative shrinkage; flowers pre-treated with glycerol and water (1:3) for 24 h had the largest dry flower diameter (4.64cm) with the least shrinkage (1.38cm), while flowers pre-treated with 10% $MgCl_2$ had the smallest diameter (4.28cm) with the most shrinkage (1.75cm). With different drying techniques, dry flower diameter and relative shrinkage changed significantly. When flowers were dried in a hot air oven while embedded in silica gel, the largest dry flower diameter (4.89cm) and least amount of shrinkage (1.14 cm) were measured, whereas the smallest dry flower diameter (3.10cm) and the most amount of shrinkage (2.94 cm) were recorded when flowers were dried at room temperature in the shade without being embedded. These findings are in agreement with those of Dhatt et al.[18], Wilson et al.[17] in the chrysanthemum, Verma et al.[19] and Akram et al.[20] in the cleretum bellidiforme and Calendula officinalis. but another study by Acharyya et al.[2] showed that rose buds dried in a microwave oven have a tendency to shrink less than those dried in a room or a hot air oven. Pretreatments and drying techniques worked together to significantly reduce the floral diameter. The maximum dry flower diameter(5.06cm) and minimum diameter reduction(0.97cm) were observed in flowers pre-treated with glycerol: water (1:3) for 24 h and dried in a hot air oven, embedded in silica gel, while the diameter of the dry flower was smallest(2.94cm) and shrinkage was greatest(3.10cm) when flowers air dried at room temperature without embedding and pre-treated with 2% citric acid(Table 1).

Among all pre-drying treatments, water pre-treatment required the most time (83.14h) to dry the flowers, while glycerol: water (1:3) pre-treatment required the shortest drying time (77.66 h) for flowers. The dehydrating ability of glycerol, which replaces the native water molecules in the flower through osmosis and causes the bloom to dry out sooner than expected, maybe the likely cause[10]. The results are in line with those of Adiga et al.[8] in gerbera and Ravichandra and Pedapathi[9] in carnation. Different drying techniques had a significant impact on the drying time of flowers. Flowers embedded with silica gel and borax as embedding media and dried in the microwave oven took the shortest drying time (0.16h), while air drying in the shade at room temperature took the longest drying time (352.73 h). This could be due to the rapid release of the greatest amount of moisture caused by the agitation of water molecules by electronically generated microwaves; additionally, the potent hygroscopic properties of borax and silica gel contribute to the above-mentioned results[16]. The findings are in line with Singh et al.[21] in zinnia flowers and Safeena et al.[22] in roses. It was discovered that the interaction effects of pretreatments and drying techniques on drying time were significant. Flowers that were pre-treated with any of the chemicals, embedded in borax or silica gel and microwaved, dried in less time (0.16h), whereas flowers that were air dried without embedding and pre-treated with water (control) dried in the longest time (363.20 h)(Table 1).

Effect on dry flower quality parameters

Flowers pre-treated with 1:3 glycerol: water for 24 hours received the highest scores for color (2.82), texture(2.64), shape retention(3.60), non-shattering of petals(3.84) , and overall acceptability(3.62), while flowers pre-treated with water (control) received the lowest scores for color(2.12), texture(2.16), shape retention(3.13), non-shattering of petals(3.24) and overall acceptability(3.16). Humectants, such as glycerol, are hygroscopic compounds that maintain the flexibility of plant material by drawing water vapor from the atmosphere, making preserved plant material less brittle and more lifelike [8]. The findings are consistent with those of Ravichandra and Pedapathi[9] in Carnation, Mathapati et al.[10]] in gerbera and Patil et al.[11] incarnation. When flowers were air-dried without embedding, they received the lowest scores for color (1.20), texture(1.28), shape retention(3.13), and overall acceptability(2.30). Flowers embedded in borax and dried in a microwave oven also received a minimum grade of (1.28) for texture and (2.30) for non-shattering of petals. This could be due to fluctuations in the relative humidity of the microclimate, which would cause uneven drying and cracking, affecting the shape, color, and other quality parameters[16]. Flowers dried in a hot air oven with silica gel embedded produced more acceptable flowers in terms of color (4.00), texture (4.10), shape (4.23), non-shattering of petals (4.18), and overall acceptability (4.55). When dried in a hot air oven, flowers embedded in silica gel received the highest scores for better appearance as reported by Nair and Singh (2011). These results are in line with Sindhuja et al.[16] in carnation, Nair et al.[15] in chrysanthemum, Safeena and Patil[23] in rose, Akram et al.[20] confirmed that silica gel-embedded flowers of Cleretum bellidiforme and Calendula officinalis dried in a hot air oven were the best in terms of texture and appearance, Lalhruaitluangi[24] also reported that rose flowers embedded in silica gel and dried in hot air oven received the highest rating in sensory evaluations for flower color, flower shape, flower texture, and overall acceptance. In another experiment, Acaryya et al.[2] reported that silica gel was the best embedding media in terms of retaining the color, texture, and shape of rose buds when dried in a microwave oven. The interaction of pre-drying treatments and drying techniques significantly influenced the dry flower quality parameters, with maximum scores for color (4.3), texture (4.5), shape (4.5), non-shattering of petals (4.5), and overall acceptability (4.8) achieved with flower pre-treatment in glycerol: water (1: 3) and drying in hot air oven embedded in silica gel. Water pre-drying and microwave drying embedded in borax produced the lowest color (1.1), texture (1.1) , and non-petal shattering scores (2.0), Furthermore, pre-treatment with 10% $MgCl2$ and drying in a microwave oven embedded with borax resulted in the lowest color rating (1.1). Pre-treatment of water (control) and air drying yielded the lowest scores for shape retention and overall acceptability (1.75 and 2.0, respectively)(Table 2).

Conclusion

The conclusions are summarised here based on the present investigation's findings. The best pre-drying chemical treatment for creating high-quality dry marigold flowers was soaking flowers in glycerol: water (1:3) ratio for 24 hours. The highest-quality marigold dry flowers were generated by hot air oven drying at 55±1°C, embedded in silica gel, when compared to all other drying processes. The quickest drying method, out of all the ones tested, was microwave oven drying. Silica gel fared better than the other desiccant.

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Conflict of interest

No conflicts of interest are disclosed by the authors.

TABLE 1 : The effect of pretreatments and drying methods on physical parameters

Pretreatments	**Parameters**						
	Fresh weight	**Dry weight**	**Moisture loss**	**Fresh flower diameter**	**Dry flower diameter**	**Reduction in diameter**	**Time taken to dry**
P_0	7.34	1.12	84.96	6.03	4.43	1.59	83.16
P_1	7.33	1.19	83.56	6.02	4.40	1.62	81.33
P_2	7.41	1.22	83.45	6.03	4.28	1.75	81.68
P_3	7.41	1.55	78.89	6.02	4.64	1.38	77.66
$CD_{0.1}$	NS	0.02	0.33	NS	0.03	0.05	3.44
SEM±	0.05	0.01	0.12	0.05	0.01	0.01	1.20
Drying methods	**Fresh weight**	**Dry weight**	**Moisture loss**	**Fresh flower diameter**	**Dry flower diameter**	**Reduction in diameter**	**Time taken to dry**
D_0	7.43	0.74	90.14	6.04	3.10	2.94	352.73
D_1	7.40	1.35	81.79	6.03	4.89	1.14	25.78
D_2	7.32	1.39	80.79	6.03	4.80	1.22	0.16
D_3	7.31	1.41	80.77	6.04	4.74	1.30	25.95
D_4	7.43	1.47	80.08	6.00	4.67	1.33	0.16
$CD_{0.1}$	NS	0.03	0.37	NS	0.03	0.04	3.84
SEM±	0.04	0.01	0.13	0.06	0.01	0.01	1.34
Interaction P X D	**Fresh weight**	**Dry weight**	**Moisture loss**	**Fresh flower diameter**	**Dry flower diameter**	**Reduction in diameter**	**Time taken to dry**
P_0D_0	7.42	0.69	91.00	6.05	2.99	3.05	363.20
P_0D_1	7.40	1.15	84.79	6.01	4.83	1.18	26.40
P_0D_2	7.35	1.25	82.80	6.05	4.62	1.43	0.16
P_0D_3	7.35	1.26	83.44	6.03	5.03	1.00	25.87
P_0D_4	7.20	1.23	82.75	5.97	4.69	1.28	0.16
P_1D_0	7.40	0.69	90.44	6.04	2.94	3.10	353.33
P_1D_1	7.30	1.28	82.23	6.05	4.83	1.22	26.47
P_1D_2	7.29	1.33	81.67	6.01	4.70	1.31	0.16
P_1D_3	7.20	1.24	82.71	6.04	4.81	1.23	26.53
P_1D_4	7.48	1.43	80.75	6.00	4.73	1.27	0.16
P_2D_0	7.45	0.67	91.65	6.05	2.96	3.09	355.20
P_2D_1	7.54	1.34	82.33	6.04	4.85	1.19	25.80
P_2D_2	7.30	1.33	81.17	6.05	4.91	1.14	0.16
P_2D_3	7.23	1.35	81.06	6.02	4.20	1.82	27.07
P_2D_4	7.52	1.43	81.04	6.01	4.50	1.51	0.16
P_3D_0	7.45	0.90	87.45	6.00	3.50	2.50	339.20
P_3D_1	7.35	1.63	77.79	6.03	5.06	0.97	24.47
P_3D_2	7.33	1.66	77.52	5.99	4.99	1.00	0.16
P_3D_3	7.45	1.80	75.88	6.05	4.91	1.14	24.33

Note: Pre- treatments, P0 (control), P1 (2% citric acid), P2 (10% MgCl2), P3(1:3 glycerol: water) ; Drying techniques, viz., D0 (air drying), D1 (silica gel + hot air oven), D2 (silica gel + microwave oven), D3 (Borax + hot air oven) and D4 (Borax + microwave oven

TABLE 2 : The effect of pretreatments and drying methods on quality parameters

Pretreatments	**Parameters**				
	Colour	**Texture**	**Shape**	**Non shattering of petals**	**Overall acceptability**
P_0	2.12	2.16	3.13	3.24	3.16
P_1	2.68	2.40	3.34	3.30	3.30
P_2	2.62	2.32	3.17	3.40	3.34
P_3	2.82	2.64	3.60	3.84	3.62
Drying methods	**Fresh weight**	**Dry weight**	**Moisture loss**	**Fresh flower diameter**	**Dry flower diameter**
D_0	1.20	1.28	1.93	4.03	2.30
D_1	4.00	4.10	4.23	4.18	4.55
D_2	3.78	3.93	4.08	4.08	4.43
D_3	2.43	1.33	3.25	2.65	2.90
D_4	1.40	1.28	3.08	2.30	2.60
Interaction P X D	**Fresh weight**	**Dry weight**	**Moisture loss**	**Fresh flower diameter**	**Dry flower diameter**
P_0D_0	1.10	1.20	1.75	3.80	2.00
P_0D_1	3.60	3.80	3.90	4.00	4.30
P_0D_2	3.20	3.50	3.80	3.90	4.20
P_0D_3	1.50	1.20	3.20	2.50	2.70
P_0D_4	1.20	1.10	3.00	2.00	2.60
P_1D_0	1.20	1.30	1.90	3.90	2.20
P_1D_1	4.00	4.10	4.20	4.10	4.50
P_1D_2	3.80	3.90	4.20	4.00	4.30
P_1D_3	3.00	1.40	3.30	2.40	3.00
P_1D_4	1.40	1.30	3.10	2.10	2.50
P_2D_0	1.10	1.10	1.45	4.00	2.30
P_2D_1	4.10	4.00	4.30	4.10	4.60
P_2D_2	4.00	4.00	4.00	4.10	4.50
P_2D_3	2.50	1.20	3.10	2.60	2.90
P_2D_4	1.40	1.30	3.00	2.20	2.40
P_3D_0	1.40	1.50	2.60	4.40	2.70
P_3D_1	4.30	4.50	4.50	4.50	4.80
P_3D_2	4.10	4.30	4.30	4.30	4.70
P_3D_3	2.70	1.50	3.40	3.10	3.00
P_3D_4	1.60	1.40	3.20	2.90	2.90

NOTE : The scores were given on a scale of 1-5 (0-1 : below average, 1.1-2 : bad, 2.1-3 : good, 3.1-4 : very good, 4.1-5 :excellent)

Pre- treatments, P0 (control), P1 (2% citric acid), P2 (10% MgCl2), P3(1:3 glycerol: water) ; Drying techniques, viz., D0 (air drying), D1 (silica gel + hot air oven), D2 (silica gel + microwave oven), D3 (Borax + hot air oven) and D4 (Borax + microwave oven)

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