Original Research Article

Standardization of drying techniques of Dahlia, Larkspur and China Aster

ABSTRACT

Aims: i) To standardize drying methods of Dahlia, Larkspur and China Aster
ii) To evaluate storage methods of dried flowers of Dahlia, Larkspur and China Aster.
Study design: Completely Randomized Design.
Place and Duration of Study: Sample: Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, (UP), between October 2021 and May 2022.
Methodology: Flowers of Dahlia, Larkspur and China Aster were subjected to seven different drying treatments like shade drying (T_1), shade drying with sand as embedding medium (T_2), shade drying with silica gel as embedding medium (T_3), microwave oven drying with sand as embedding medium (T_4), microwave oven drying with silica gel as embedding medium (T_5), hot air oven drying with sand as embedding medium (T_6) and hot air oven drying with silica gel as embedding medium (T_7). Observations such as reduction in weight, percent moisture loss, time taken to dry, percent reduction in perimeter, percent retention of perimeter, color, texture, appearance and shattering of petals were recorded. The well dried flowers were packed in cardboard boxes and plastic boxes and stored at ambient temperature for three months and observations were recorded on i) extent of color fading on storage ii) damage of flower due to incidence of pests and diseases *etc.*
Results: In Dahlia, maximum reduction in total weight (3.41 g) and maximum moisture loss (88.25), maximum final perimeter (28.08 cm), minimum reduction in perimeter (1.40 cm), minimum percent reduction of perimeter (4.72 %) and maximum percent retention of perimeter (95.28%) was observed in hot air oven drying with silica gel as embedding medium (T_7). In Larkspur, maximum reduction in total weight (1.16 g) and maximum moisture loss (73.43 %) was observed in shade drying method (T_1). Maximum final perimeter (9.92 cm), minimum reduction in perimeter (1.13 cm), minimum percent reduction of perimeter (10.38 %) and maximum percent retention of perimeter (89.62 %) was observed in microwave oven drying with sand as embedding medium (T_4). In China Aster, maximum reduction in total weight (4.22 g) and maximum moisture loss (89.10 %) was observed in microwave oven drying with silica gel as embedding medium (T_5). Maximum final perimeter (17.02 cm), minimum reduction in perimeter (0.84 cm), minimum percent reduction of perimeter (4.71 %) and maximum percent retention of perimeter (95.29%) was observed in hot air oven drying with sand as embedding medium (T_6). Time taken for drying was found significantly minimum in silica embedded drying in microwave oven in Dahlia (0.001389days), Larkspur (0.001388 days) and China Aster (0.002779days) while, shade drying treatment (T_1) took maximum time for drying in Dahlia (14.0 days), Larkspur (12.0 days) and in China Aster (15.0 days).
Maximum quality score on visual basis of color,appearance, texture and shattering of petals in dried flowers of Dahlia (15.73) was observed in T_7, in T_4 for Larkspur (15.63) and China Aster (15.51).
In studies about storage methods of dried Dahlia, Larkspur and China Aster, Highest

sensory score in color fading in Dahlia (3.51) (3.21) was reported in treatment combination with (M_7S_2) viz., hot air oven with silica gel embedding + plastic boxes after 60 after 90 days respectively. In Larkspur flowers, highest score (3.32) was reported in treatment combination with (M_4S_2) viz., microwave oven drying with silica gel embedding + plastic boxes after 60 days (2.93) after 90 days respectively. In China Aster, highest score (3.57) (3.41) (3.15) was reported in treatment combination with (M_6S_2) viz., hot air oven with sand embedding + plastic boxes after 30, 60 and 90 days respectively. There were no incidence of pests and diseases in both storage conditions.

Conclusion: For Dahlia (T_7) i.e., hot air oven drying with silica gel as embedding medium gives the best quality dried flowers which was on par with (T_5) i.e., microwave oven drying with silica gel as embedding medium. For Larkspur, (T_4) i.e., microwave oven drying with sand as embedding medium gives best results which was on par with (T_6) i.e., hot air oven with sand as embedding medium. For China aster, (T_6) i.e., hot air oven at with sand as embedding medium provide the best results which was on par with (T_4) i.e., microwave drying with sand as embedding medium.
Storage of flowers in plastic boxes was found to be better than cardboard boxes in terms of color fading on up to three months storage.
There was no incidence of pest and diseases that occur during storage in Dahlia, Larkspur and China Aster flowers as influenced by drying methods, storage methods and their interactions.

Keywords: Drying methods, embedding medium, storage methods, sensory evaluation

1. INTRODUCTION

Flowers have always remained an innate part of human life. They are an integral part of mankind and almost every occasion, from welcoming to funeral, wedding and various ceremonies have involvement of flowers Fresh flowers though exquisite in their beauty, can be quite expensive and are perishable in nature and most flowers are available only for particular seasons. These reasons have led to the popularity of dry flowers among the masses where people want to enjoy blooms all year long as dried flowers are enduring, adds on aesthetics and are available all year round, irrespective of the season [1]. The dehydrated or dried ornamental plant parts are generally inexpensive and are sought for their everlasting and attractive appearance [2]. The art of flower drying is a very age-old practice. Earlier dried flowers were used in the form of herbarium by botanists for the purpose of identification of various species [3]. Though drying of flowers is well known even in the past but for the first time the flowers were dried commercially in Germany [4].

The dry flower industry has become the most promising area in floriculture since the past four decades after it was being initially introduced by British in Calcutta due to its proximity to north east and eastern regions where exotic and various plants were easily accessible [5]. This industry includes not only use of flower but every part of plant that can be dehydrated foliage, seeds, flower, stem etc. The dry Government of India has identified floriculture as a sunrise industry and accorded it 100 % export-oriented status. The country has exported 15,695.31 MT of floriculture products to the world for the worth of Rs. 575.98 Crores/77.84 USD Millions in 2020-2021. The export market of flowers in India is composed of 71% of dry flowers exported mainly to U.S.A, Japan, Australia, Europe and Russia [6]. Demand of dry flower increase at impressive rate of 8 – 10%. This industry shows a growth rate of 15% annually. India is the fifth largest exporter of

dry flowers in the world. Though dried flowers are earning better exchange than fresh cut flowers, a number of flowers and ornamentals have not been exploited to produce dry horticultural products. There is the need to identify, explore and evaluate native plant species and various ornamentals having potential as dry flowers.

- To standardize drying methods of Dahlia, Larkspur and China Aster.
- To evaluate storage methods of dried flowers of Dahlia, Larkspur and China Aster.

2. MATERIAL AND METHODS

Flowers used in the experiment were grown in the experimental field and the present investigation was carried out in the laboratory of the Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, (UP), between October 2021 and May 2022. The experiment was laid out in CRD design with three replications. Flowers were harvested when the petals had just completely opened and were subjected to seven different drying treatments like shade drying (T_1), shade drying with sand as embedding medium (T_2), shade drying with silica gel as embedding medium (T_3), microwave oven drying with sand as embedding medium (T_4), microwave oven drying with silica gel as embedding medium (T_5), hot air oven drying with sand as embedding medium (T_6) and hot air oven drying with silica gel as embedding medium (T_7). Observations such as reduction in weight, percent moisture loss, time taken to dry, percent reduction in perimeter, percent retention of perimeter were recorded. Quality parameters such as colour, appearance, texture and shattering of petals were assessed by means of sensory evaluation. Panel of judges assessed the quality parameters viz., colour, appearance, and texture by scoring on a five-point scale i.e. excellent, very good, good, bad and very bad with the weightage of 3.5-4.0, 2.5-3.4, 1.5-2.4, 0.5-1.4 and 0.0-0.4 respectively.

In shade drying method, freshly harvested flowers were tied in bunches and hanged vertically in upside down position in shade in the laboratory. For embedded drying in shade, the plastic trays were filled evenly with the desiccants up to two inches of height and flowers were inserted. After inserting the flowers in upside down position, it was covered with the desiccants again by spreading the media evenly so that the petals are completely covered and there is equal pressure on all sides of the flower. Same method was followed for embedded drying in microwave oven and hot air oven except the plastic trays were replaced to aluminium trays. After the flowers were dried completely, the trays were tilted to remove the desiccants over and around the flowers. The dried flowers were then picked up by hand, cleaned by inverting them and tapping the stems with the fingers slowly and gently. Any remaining desiccants were then removed with the help of fine and soft brush The flowers were checked at regular intervals to record the weight loss up to standstill, indicating the completion of the drying process. At the end of the drying process, the petals of the flowers were pressed with fingers to check the presence of moisture. If the moisture was still present, then the flowers were further exposed for drying for complete elimination of moisture.

For storage studies, the well dried flowers were packed in cardboard boxes and plastic boxes and stored at ambient temperature for three months and observations were recorded on i) extent of color fading on storage ii) damage of flower due to incidence of pests and diseases *etc.* Panel of judges assessed the parameters viz., colour fading and damage to flower by scoring on a five-point scale i.e. very low, low, medium, high and very high with the weightage of 3.5-4.0, 2.5-3.4, 1.5-2.4, 0.5-1.4 and 0.0-0.4 respectively by means of sensory evaluation.

3. RESULTS AND DISCUSSION

3.1 Experiment I

3.1.1 To standardize drying methods for Dahlia, Larkspur and China aster.

Results revealed that, minimum final weight of Dahlia (0.44 g), maximum reduction in total weight (3.41 g) and maximum moisture loss (88.25 %), maximum final perimeter (28.08 cm), minimum reduction in perimeter (1.40 cm), minimum percent reduction of perimeter (4.72 %) and maximum percent retention of perimeter (95.28%) was observed in hot air oven drying with silica gel as embedding medium (T_7).
Minimum final weight of Larkspur (0.33 g), maximum reduction in total weight (1.16 g) and maximum moisture loss (73.43 %) was observed in shade drying method (T_1). Maximum final perimeter (9.92 cm), minimum reduction in perimeter (1.13 cm), minimum percent reduction of perimeter (10.38 %) and maximum percent retention of perimeter (89.62 %) was observed in microwave oven drying with sand as embedding medium (T_4).
Minimum final weight of China Aster (0.50 g), maximum reduction in total weight (4.22 g) and maximum moisture loss (89.10 %) was observed in microwave oven drying with silica gel as embedding medium (T_5). Maximum final perimeter (17.02 cm), minimum reduction in perimeter (0.84 cm), minimum percent reduction of perimeter (4.71 %) and maximum percent retention of perimeter (95.29%) was observed in hot air oven drying with sand as embedding medium (T_7). Time taken for drying was found significantly minimum in silica embedded drying in microwave oven in Dahlia (0.001389 days), Larkspur (0.001388 days) and China Aster (0.002779 days) while, shade drying treatment (T_1) took maximum time for drying in Dahlia (14.0 days), Larkspur (12.0 days) and in China Aster (15.0 days).

Maximum quality score on visual basis of color, texture, appearance and shattering of petals in dried flowers of Dahlia (15.73) was observed in T_7, in T_4 for Larkspur (15.63) and China Aster (15.51).

Dried flowers varied in their appearance and in their quality attributes, when different methods of drying were employed. The effects of different methods of drying on quality of Dahlia, Larkspur and China aster flowers are discussed below.

Shade drying under room temperature is one of the oldest and least expensive methods commonly followed by florists and common people almost everywhere as it is the easiest method to dry flowers. Under this method, Dahlia, Larkspur and China Aster flowers took maximum time to dry (14, 12 and 15 days respectively) and yield a medium quality of produce. Since shade drying depends greatly on relative humidity and room temperature, the low ambient room temperature and relative humidity were inadequate to dry the flowers quickly. There was maximum shrinking of petals and reduction in perimeter of flowers for all the three flowers in shade drying method. This was because there was no embedding medium to support and hold the petals in place as moisture gets removed from the surface of the flowers combined with low room temperature which takes longer time for drying. Shrivelling of flowers and withering of petals are most commonly observed in this method. Similarly slow rate of drying and shrinking of petals under shade was reported by Aravinda [7] and Hemant *et al*., [8]. Minimum moisture loss was observed in shade drying with sand as embedding medium for Dahlia (75.72%), Larkspur (62.32%) and China Aster (81.33%) flowers. This might be due to the large particle size and heavy weight of sand that absorbed less moisture and retained moisture for a short duration which ultimately led to fractional reabsorption by the partly dried tissues. Maximum moisture loss (73.43%) was observed in shade drying in Larkspur. Similar results were observed in Carnation Cv. Master by Nirmala *et al*.**,** [9].

Table 1. Changes in weight of flowers and duration of drying of Dahlia, Larkspur and China Aster

	Dahlia				Larkspur				China Aster			
Treatment	**Final weight of the flowers (g)**	**Reduction in total weight of flowers (g)**	**Duration required for drying of flowers (days)**	**Loss of moisture content (%)**	**Final weight of the flowers (g)**	**Reduction in total weight of flowers (g)**	**Duration required for drying of flowers (days)**	**Loss of moisture content (%)**	**Final weight of the flowers (g)**	**Reduction in total weight of flowers (g)**	**Duration required for drying of flowers (days)**	**Loss of moisture content (%)**
T_1	0.5	3.38	14	86.26	0.33	1.16	12	73.43	0.63	3.11	15	82.39
T_2	0.76	2.42	12	75.72	0.61	1.01	9	62.32	0.66	2.94	11	81.33
T_3	0.51	2.43	6.5	82.42	0.58	1.13	5.3	64.36	0.58	3.49	5	85.18
T_4	0.74	2.73	0.002778	77.52	0.35	0.72	0.002083	67.83	0.62	3.3	0.003473	83.96
T_5	0.68	2.66	0.001389	79.11	0.36	0.74	0.001388	65.56	0.5	4.22	0.002779	89.1
T_6	0.62	2.83	3	81.75	0.39	0.81	2.4	66.66	0.53	3.56	4	86.4
T_7	0.44	3.41	2.5	88.25	0.36	0.82	1.4	65.69	0.51	3.92	3	88.15
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.101	0.145	0.13	0.057	0.045	0.097	0.092	0.011	0.046	0.349	0.087	0.015
CV	20.448	6.256	2.935	3.922	12.547	13.059	2.457	1.999	9.781	12.198	2.006	2.224
C.D. @ 5%	0.22	0.314	0.282	0.057	0.096	0.211	0.2	0.024	0.1	0.756	0.188	0.034

Table 2. Changes in perimeter of flowers of Dahlia, Larkspur and China Aster

	Dahlia				Larkspur				China Aster			
Treatment	**Final perimeter of flowers (cm)**	**Reduction in perimeter of flowers (cm)**	**Percent reduction of perimeter %**	**Percent retention of perimeter %**	**Final perimeter of flowers (cm)**	**Reduction in perimeter of flowers (cm)**	**Percent reduction of perimeter %**	**Percent retention of perimeter %**	**Final perimeter of flowers (cm)**	**Reduction in perimeter of flowers (cm)**	**Percent reduction of perimeter %**	**Percent retention of perimeter %**
T_1	18.8	9.19	32.53	67.47	6.34	3.6	35.07	64.93	12.75	2.4	16.33	83.67
T_2	25.59	3.75	12.47	87.53	9.39	2.25	18.92	81.08	15.3	1.66	9.72	90.28
T_3	25.06	2.65	9.36	90.64	9.51	1.63	14.56	85.44	13.36	2.34	14.73	85.27
T_4	27.45	2.21	7.47	92.53	9.92	1.13	10.38	89.62	16.03	1.25	7.16	92.84
T_5	27.69	2.13	6.96	93.04	8.79	1.44	13.83	86.17	14.83	1.59	9.89	90.11
T_6	27.06	3.79	12.57	87.43	9.42	1.42	13.01	86.99	17.02	0.84	4.71	95.29
T_7	28.08	1.4	4.72	95.28	8.81	1.55	14.48	85.52	14.61	2.33	13.63	86.37
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	1.123	0.995	0.035	0.035	0.408	0.497	0.042	0.042	0.871	0.416	0.025	0.025
CV	5.359	33.945	34.624	4.85	5.568	34.37	31.207	6.13	7.191	28.762	28.677	3.501
C.D. @ 5%	2.433	2.155	0.075	0.075	0.883	1.076	0.091	0.091	1.887	0.901	0.055	0.055

Table 3: Effect of different drying methods on qualitative characteristics of Dahlia, Larkspur and China Aster flowers

	Dahlia				Larkspur				China Aster			
Treatment	Colour	Appearance	Texture	Shattering of petals	Colour	Appearance	Texture	Shattering of petals	Colour	Appearance	Texture	Shattering of petals
T_1	1.62	0.24	0.24	1.48	1.17	0.39	0.22	0.2	1.41	0.23	0.18	0.7
T_2	2.57	2	2.01	2.51	3.61	3.79	3.69	3.69	3.31	2.39	3.05	3.13
T_3	3.11	3.83	3.9	3.32	3.74	3.33	3.67	3.37	3.27	3.23	2.45	2.9
T_4	3.2	3.1	3.51	3.68	3.9	3.96	3.88	3.89	3.93	3.75	3.57	3.71
T_5	3.78	3.91	3.82	3.83	3.52	3.79	3.55	3.75	3.81	3.72	3.54	3.43
T_6	3.36	3.3	3.41	3.51	3.83	3.93	3.85	3.8	4	3.9	3.79	3.82
T_7	3.89	4.01	3.91	3.92	3.6	3.4	3.69	3.71	3.33	3.51	3.16	3.1
F-test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.115	0.066	0.087	0.086	0.07	0.087	0.102	0.14	0.063	0.067	0.121	0.134
CV	4.527	2.784	3.527	3.305	2.561	3.311	3.863	5.357	2.251	2.768	5.253	5.511
C.D. @ 5%	0.246	0.143	0.189	0.186	0.151	0.189	0.22	0.303	0.137	0.145	0.262	0.289

Table 4: Effect of drying methods, storage methods and their interactions on extent of colour fading during storage of Dahlia, Larkspur and China Aster flowers.

Treatments	Dahlia			Larkspur			China Aster		
Drying methods (M)	**30 Days**	**60 Days**	**90 Days**	**30 Days**	**60 Days**	**90 Days**	**30 Days**	**60 Days**	**90 Days**
M_1	2.57	2.24	2.02	3.22	2.12	2.08	2.53	2.37	2.07
M_2	3.19	2.46	2.18	3.56	2.33	2.51	2.97	2.81	2.5
M_3	3.5	2.85	2.55	3.62	2.48	2.29	2.76	2.59	2.24
M_4	3.13	2.88	2.36	3.8	3.22	2.79	3.37	3.12	2.93
M_5	3.5	3.01	2.87	3.44	2.34	2.25	2.97	2.77	2.45
M_6	3.32	2.98	2.68	3.65	3.02	2.61	3.55	3.37	3.04
M_7	3.62	3.35	3.11	3.55	2.43	2.46	2.97	2.93	2.66
SE(d) ±	0.224	0.059	0.046	0.187	0.042	0.093	0.052	0.061	0.058
CD	0.46	0.122	0.094	NS	0.087	0.191	0.107	0.126	0.118
Storage methods (S)									
S_1	3.18	2.65	2.45	3.46	2.4	2.25	2.89	2.74	2.4
S_2	3.35	3	2.63	3.64	2.72	2.61	3.15	2.96	2.72
SE(d) ±	0.12	0.032	0.024	0.1	0.023	0.05	0.028	0.033	0.031
CD	NS	0.065	0.05	NS	0.047	0.102	0.057	0.067	0.063
Interaction (M x S)									
M_1S_1	2.53	2.14	2	3.1	2.1	2.05	2.48	2.33	2.01
M_1S_2	2.6	2.33	2.03	3.34	2.13	2.11	2.58	2.4	2.13
M_2S_1	3.1	2.45	2.15	3.44	2.23	2.14	2.78	2.61	2.2
M_2S_2	3.28	2.47	2.22	3.68	2.43	2.87	3.16	3.01	2.81
M_3S_1	3.4	2.62	2.32	3.56	2.18	2.04	2.58	2.42	2.03
M_3S_2	3.6	3.08	2.78	3.68	2.78	2.55	2.94	2.76	2.45
M_4S_1	3	2.61	2.31	3.75	3.12	2.65	3.31	3.1	2.86
M_4S_2	3.27	3.15	2.42	3.85	3.32	2.93	3.43	3.13	3
M_5S_1	3.43	2.72	2.85	3.32	2.1	2.07	2.87	2.67	2.32
M_5S_2	3.57	3.3	2.89	3.56	2.57	2.43	3.07	2.87	2.57
M_6S_1	3.23	2.82	2.52	3.61	2.8	2.42	3.53	3.33	2.93
M_6S_2	3.4	3.14	2.84	3.7	3.23	2.8	3.57	3.41	3.15
M_7S_1	3.53	3.19	3	3.43	2.31	2.35	2.67	2.72	2.42
M_7S_2	3.7	3.51	3.21	3.67	2.56	2.57	3.27	3.13	2.9
SE(d) ±	0.317	0.084	0.065	0.265	0.064	0.129	0.074	0.086	0.081
CD	NS	0.173	0.133	NS	0.131	0.266	0.152	0.178	0.167

Microwave oven drying method with silica gel as embedding medium took the least time to dry among the seven different drying methods for all the three flowers Dahlia, Larkspur and China Aster. This might be due strong hygroscopic nature of silica gel which is manufactured from sodium silicate. Silica gel is composed of a vast network of interconnecting microscopic pores, which attract and hold moisture by a phenomenon known as physical adsorption and capillary condensation and thus act as a dehydrating agent as also explained by Sindhuja *et al*.**,** [10]. The principle behind the microwave oven drying is liberating moisture by agitating water molecules in the organic substances with the help of electronically produced microwaves. Maximum amount of water reduction in China Aster (89.10%) was also noticed with this technique with silica gel as embedding medium. The reduction in flower perimeter was found minimum for Larkspur (10.38%) through microwave oven drying with sand as embedding medium. Sand never reacts with water and allow the water vapour generated during drying to escape freely to the environment thereby maintaining the minimum loss in dimension for suitable flowers and can produce as equally good results as flowers embedded in silica gel. Use of sand as embedding material for drying of Chrysanthemum was also reported by Wilson *et al*., [11]. Sand and silica gel were both found to be equally effective embedding materials for drying of Dahlia, Larkspur and China Aster in microwave oven with regard to moisture removal. Hemant *et al*.,[8] also noticed the efficacy of microwave oven as a tool for drying of ornamentals.

In the present experiment, embedded drying in sand in hot air oven at 45^0C and embedded drying in silica gel in hot air oven at 45^0C were adopted in drying of Dahlia, Larkspur and China Aster. The maximum moisture loss (88.25%) and maximum percent retention of perimeter (95.28%) in Dahlia was observed in hot air oven drying method with silica gel as embedding medium (T_7). It might be owing to exposure of flowers in a higher temperature for maximum duration which has caused the maximum loss of moisture while the constant temperature maintained throughout the drying period caused minimum reduction in the dimension of the flowers. Safeena *et al*.,[12] reported that silica gel as embedding material prevents the shrinkage of flower petals. Dilta et al., [13] had also reported maximum moisture loss at 45^0C when flowers were embedded in silica gel. The efficacy of silica gel as embedding material in hot air oven was also reported by Lalhruaitluangi and Khawlhring [14] in Rose and Sudeep *et al*., [15] in Orchid. For China Aster, sand embedded drying in hot air oven showed minimum percent reduction (4.71%) and maximum percent retention (95.29%) in the dimension of the flowers. This may be due to the fact that sand does not react with water vapour released during the process of drying. It allows the water vapour to escape in to the air freely thereby causing minimum loss in size of flowers as explained by Sindhuja *et al.*, [10].

With respect to colour, texture, appearance and shattering of petals, significant differences were obtained in different methods of drying for Dahlia, Larkspur and China Aster. Drying techniques except shade drying showed highly acceptable flower qualities. In Dahlia, highest quality score for colour (3.89), texture (3.91), appearance (4.01) and no shattering of petals was observed when flowers were embedded in silica gel in hot air oven. In China Aster, maximum score for colour (4.0), texture (3.79), appearance (3.90) and no shattering of petals was observed when flowers were embedded in sand in hot air oven. This may be due to the uniform temperature maintained inside the hot air oven and which facilitated rapid and uniform removal of moisture which cause gradual loss of moisture from the flowers. Hence it avoids severe dehydration and shrivelling of flowers. This helps in obtaining better quality dry flowers. Highest score for colour (3.90), texture (3.88), appearance (3.96) and no shattering of petals for Larkspur flowers was observed when flowers were dried in microwave oven with sand as embedding medium. Meman *et al*.,[16] observed brighter coloured flowers when embedded in sand as a medium. Singh [17] had also reported that colour retention and texture of many flowers was better maintained in sand and silica gel. In the present study also, sand has been found to be the best medium for embedding in Larkspur and China Aster. Further, fine sand was the cheapest embedding medium, easy to handle, heavy and does not react with water vapour, when compared to the other embedding medium. Similarly, Prasad *et al.*, [3] found that Rose flowers appeared almost fresh when dried in silica gel, although the colour darkened. Colours that came out close to the original when dried in silica gel are white, yellow, and lavender. Darker colours such as red, deep pink and orange tend to turn even darker.

3.2 Experiment II

3.2.1 To evaluate storage methods of dried Dahlia, Larkspur and China Aster flowers.

3.2.1.1 Extent of colour fading on storage

One of the main reasons besides many other useful qualities for the production of dried flowers is to fill the glut in the market when seasonal fresh flowers are unavailable. Flowers are dried during production season so they could be stored to meet a glut in the market hence these dried flowers have to be maintained and protected from various conditions that could destroy their qualities. Dried flowers tend to reabsorb moisture and lose their quality during storage if proper steps and measures are not taken to prevent these problems. Therefore, selection of suitable

packaging and storage methods are very important to enhance the shelf life of dried flowers. In the present study, the effect of storage methods on the quality of dried Dahlia, Larkspur and China Aster have been evaluated.
Data on the extent of colour fading and damage caused due to incidence of pests or diseases in dried Dahlia, Larkspur and China Aster during storage were recorded at 30, 60 and 90 days and are discussed below.
The effect of drying methods on colour fading was found to be significant after 30, 60 and 90 days of storage respectively. With respect to drying methods, highest sensory score (3.11) in hot air oven with silica gel as embedding medium i.e. (M_7) after 90 days, because hot air oven drying method causes uniform moisture loss in the flower and the uniform drying temperature maintained in the oven provided best quality flowers even in storage. The hygroscopic nature of silica gel absorbed the maximum moisture during drying and hence there was no absorbance of moisture during storage. Therefore, it was proved to be the best method of drying for Dahlia flowers in storage. Similar results in the efficacy of silica gel embedding in storage was also reported in Carnation by Warakar *et al*., [18]. In Larkspur, maximum score (2.79) after 90 days was obtained for microwave drying with sand as embedding medium. In China Aster, hot air oven drying with sand as embedding medium gave best results (3.04) in colour fading on 90 days of storage. These methods gave the best colour after storage because there was maximum moisture loss and sand helped in the retention of colour for Larkspur and China Aster flowers. Minimum score in Dahlia (2.02), Larkspur (2.08) and China Aster (2.07) was observed through shade drying method (M_1) after 90 days of storage, this is due to exposure of flowers to various micro climatic conditions and maximum time taken to dry by all three flowers.
The effect of storage methods on colour fading on storage was found significant after 60 and 90 days respectively. For Dahlia, maximum score (3.35) was observed in plastic boxes i.e., (S_2) after 30 days, (3.00) after 60 days and (2.63) after 90 days. While, it was reported minimum in cardboard boxes i.e., (S_1) (3.18), (2.65) and (2.45) after 30, 60 and 90 days of storage respectively. For Larkspur, maximum score (3.64) was observed in plastic boxes i.e., (S_2) after 30 days, (2.72) after 60 days and (2.61) after 90 days. While, it was reported minimum in cardboard boxes i.e., (S_1) (3.46), (2.40) and (2.25) after 30, 60 and 90 days of storage respectively and in China Aster, maximum score (3.15) was observed in plastic boxes i.e., (S_2) after 30 days, (2.96) after 60 days and (2.72) after 90 days. While, it was reported minimum in cardboard boxes i.e., (S_1) (2.89), (2.74) and (2.40) after 30, 60 and 90 days of storage respectively. Dry flowers are fragile and they require careful handling. Among the two conditions of storage, both storage methods were fairly good for storing flowers. However, sensory score for colour fading was found slightly higher in flowers stored in plastic boxes as compared to cardboard boxes for Dahlia, Larkspur and China Aster. This may be due to the reabsorption of moisture from atmosphere when flowers were stored in cardboard boxes and also the colour fading that occurs due to exposure to some light. Dried materials should be stored in a dark, dry airtight container to prevent them from absorbing water during humid periods and also to prevent dust from sticking and discolouration of the petals Gouin [19]. The efficacy of plastic boxes as storage for dried flowers were also reported in Dendrobium orchid by Salma *et al*., [20].
Interaction effect of drying methods and storage conditions had a significant effect on colour fading of dried flower colour. Highest score (3.21) was reported in treatment combination with (M_7S_2) viz., hot air oven with silica gel embedding + plastic boxes after 90 days for Dahlia. In Larkspur, highest score (2.93) after 90 days was observed in microwave oven drying with sand embedding + plastic boxes. In China Aster, highest score (3.15) was observed in hot air oven drying with sand embedding + plastic boxes. Minimum score was observed in shade drying + cardboard boxes for Dahlia, Larkspur and China Aster. Bhalla *et al*.,[21] also reported a better keeping quality for rose buds, dried in the hot air, microwave oven and stored covered.

3.2.1.2 Damage to flower due to incidence of pests and diseases etc.
There was no incidence of pest and diseases that occurred during storage as influenced by varieties, drying methods and their interactions. This may be due to proper removal of moisture from the flowers as well as favourable climatic and storage conditions that inhibits the growth of microbes and prevent insect attack.

4. CONCLUSION

- For dahlia (T_7) i.e., hot air oven drying with silica gel as embedding medium gives the best quality dried flowers which was on par with (T_5) i.e., microwave oven drying with silica gel as embedding medium.
- For larkspur, (T_4) i.e., microwave oven drying with sand as embedding medium gives best results which was on par with (T_6) i.e., hot air oven with sand as embedding medium.
- For China aster, (T_6) i.e., hot air oven at with sand as embedding medium provide the best results which was on par with (T_4) i.e., microwave drying with sand as embedding medium.
- Storage of flowers in plastic boxes was found to be better than cardboard boxes in terms of color fading on up to three months storage.
- There was no incidence of pest and diseases that occur during storage as influenced by drying methods, storage methods and their interactions.

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