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EFFECT OF DEHYDRATION METHODS ON QUALITY OF ORNAMENTAL FOLIAGE

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ABSTRACT

The present investigation was undertaken with six foliage species such as Boston Fern, Oak Leaf Croton, Sloppy Painter Croton, Cordyline, Monstera and Ornamental Rubber for assessing the quality of dried foliage for decoration. Four dehydration methods were adopted with silica gel and boric acid as desiccant in Tray drying, Sun drying and Microwave Oven drying whereas two concentrations (1:1 & 1:2) was taken for glycerin dip method. The overall acceptability of the dried foliage was found to be superior in glycerin dip method and microwave oven drying with silica gel in terms of shape retention and brittleness and colour retention with shortest time of drying. Silica gel showed highest moisture loss and total chlorophyll retention for all the six ornamental foliage. The maximum moisture reduction was observed in tray drying for all the foliage except for Boston fern, which was better in microwave oven drying.

Keywords **:** Dehydration techniques, Embedding media, Ornamental foliage, Silica gel

Introduction

India is endowed with a rich diversity of floristic ornamental plant species, many of which have the ability to be commercially exploited in a variety of ways due to varying agro-climatic conditions and regional geography. Rural and hilly regions are covered in a variety of vibrant flowers and foliages throughout the year, however these are all lost due to natural processes. Using the dehydration approach, all of the seasonal, colourful plants can be turned into value added goods (Patel *et al.*, 2018). The dried or dehydrated flowers or plant parts are sustainable, reasonably priced and have lasting value that is available year around (Safeena *et al.*, 2006). The idea behind foliage preservation by dehydration is to rapidly reduce moisture content to a point where microbe development can be stopped and biochemical changes can be reduced or ceased while preserving cell structure, pigment level and flower form (Singh *et al.*, 2003). The ideal drying method is the embedding method since it maximizes the colour and shape retention of flowers and foliages (Gill *et al.*, 2003). The most frequently used desiccants include borax, sand and silica gel. Flowers and foliages are embedded in various media, kept in an open sun or room or placed in an oven or microwave (at a specific temperature) until the foliage are properly dried and can be used to create decorative floral art and craft products like cards, wall hangings, landscapes, calendars, wreaths, and potpourri for a variety of purposes (Bhutani 1990; Bhalla and Sharma 2002). Glycerinization refers to the process of preserving plant material using glycol. This method preserves the texture, shape, and colour of plant pieces by replacing their internal moisture with solvents like glycol by adding a "novelty" of colour for aesthetic appeal (White *et al.*, 2007).

Considering the expanding potential of the flower and foliage drying industry, its usefulness and the research need in this area, the current research work

has been carried out with the following objectives:

1. Assessment of suitable method for drying of ornamental foliage
2. Assessment of quality of dried ornamental foliage

Materials and Methods

The experiment was carried out with four dehydration techniques viz., tray drying (50°C) (D1), sun drying (D2), microwave oven drying (D3) and glycerin drying(D4) in six different foliages such as Boston Fern (*Nephrolepis exaltata),* Cordyline (*Cordyline fruticose)*, Duck foot 'Croton' (*Codiaeum variegatum* 'Duck foot'), Monstera (*Monstera deliciosa),* Ornamental Rubber (*Ficus elastic)* and Sloppy Painter 'Croton' (*Codiaeum variegatum* 'Sloppy Painter'). Foliages were embedded with silica gel, boric acid and diluted glycerin. In tray drying, sun drying and microwave oven drying the foliages were embedded in two different desiccants viz., silica gel and boric acid and in glycerin drying with two concentrations of glycerin (1:1 and 1:2) followed by tray drying for 1 hour. Design of the experiment is completely randomized design (factorial) with three replications.

Treatment notation:

Notation	Treatments
D1T1	Hot air oven drying with silica gel as an embedding media
D1T2	Hot air oven drying with boric acid as an embedding media
D2T1	Sun drying with silica gel as an embedding media
D2T2	Sun drying with boric acid as an embedding media
D3T1	Microwave oven drying with silica gel as an embedding media
D3T2	Microwave oven drying with boric acid as an embedding media
D4T1	Glycerin drying in 1:1 solution
D4T2	Glycerin drying in 1:2 solution

Results and Discussion

Time taken to dry ornamental foliage

Among the desiccants used, silica gel took the least time to dehydrate for all the six ornamental foliage followed by boric acid (Table 1). This could be as a result of silica gel's high hygroscopic properties as well as its hydrosorbant properties as it is made from sodium silicate. The drying ability of silica gel results from its vast network of tiny pores, which draw and hold moisture by a process called physical adsorption and capillary condensation. The findings of the present study corresponded with the study conducted by Sindhuja *et al. (*2015) in carnation flowers. Microwave oven drying took the shortest time to dehydrate all the six ornamental foliage among the dehydration techniques, glycerin drying recorded the maximum time to dehydrate all the six ornamental foliage. The results are consistent with those acquired by Jawaharlal *et al*. (2013) in silver oak leaves.

Moisture loss (%)

T_1 (silica gel and 1:1 ratio for glycerin) recorded the highest moisture loss for all the six ornamental foliage as compared to T_2 (boric acid and 1:2 ratio for glycerin) (Table 2). The quality of the dry ornamental foliage was acceptable when dehydrated using silica gel due to its excellent ability to absorb moisture. For absorbing moisture from the flower and foliage, silica gel (60-120 mesh) has been proven to be the best absorbent among all desiccants (Desh Raj, 2006; Nazki *et al.*, 2012 and Desh Raj and Gupta, 2005).

Moisture loss of the dry ornamental foliage was found maximum in tray drying for Cordyline (73.08%), Monstera (74.37%), Duck foot 'Croton' (75.43%), Ornamental rubber (78.66%) and Sloppy painter 'Croton' (75.97%) whereas for Boston fern it was found in microwave oven drying (74.12%).

Table 1 : Effect of dehydration techniques with embedding media on timetaken to dry ornamental foliage

Dehydration Techniques	Cordyline		Boston Fern		Monstera		Duck Foot 'Croton'		Ornamental Rubber		Sloppy painter 'Croton'	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
D1	4hrs	4hrs 30mins	3hrs	3hrs 15 mins	4hrs	4hrs 20mins	5hrs	5hrs 30mins	10hrs	10hrs 30mins	5hrs	5hrs 30mins
D2	96hrs	144hrs	96hrs	120 hrs	144 hrs	192hrs	120hrs	144hrs	336hrs	384hrs	120hrs	144hrs
D3	1min	2mins	40sec	50sec	1min 30sec	2mins	1min	1min 30sec	4mins	6mins	1min 30sec	2mins
D4	168hrs	144hrs	144hrs	96hrs	168hrs	120hrs	192hrs	168hrs	432hrs	384hrs	240hrs	216hrs

Similar findings were also obtained by Jawaharlal *et al.* (2013) in camellia leaves with a maximum moisture loss per cent of 61.18.

The interaction effect between dehydration technique and embedding media also showed significant difference. Maximum loss of moisture was recorded in tray drying with silica gel (D_1T_1) for Cordyline (73.75%), Monstera (77.10%), Duck foot 'Croton' (76.09%) and Sloppy painter 'Croton' (76.03%). These results are in conformity with Dilta *et*

al. (2014) who reported maximum moisture loss at highest temperature *i.e.* for 45°C for 72 hours when flowers were embedded in silica gel. Similar results were also observed by Roy and Gantait (2015) in Croton spp. In case of microwave oven drying along with silica gel (D3T1) combination it was found maximum moisture loss for Boston fern (76.10%) and Ornamental rubber (80.55%) which may be due to the hygroscopic properties of silica gel (Datta,1999) and the rapid release of the maximum amount of moisture caused by agitating water molecules with the aid of electronically produced microwaves (Bhutani, 1990), that resulted in maximum moisture loss.

Table 2 : Effect of dehydration techniques with embedding media on moistureloss (%) of dry ornamental foliage

Dehydration Techniques	Cordyline			Boston Fern			Monstera			Duck Foot 'Croton'			Ornamental Rubber			Sloppy Painter 'Croton'		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
D1	73.75	72.42	73.08	75.79	69.16	72.48	77.10	71.64	74.37	76.09	74.77	75.43	79.44	77.88	78.66	76.03	75.91	75.97
D2	72.76	63.56	68.16	67.11	60.68	63.90	68.89	66.87	67.88	73.15	63.59	68.37	75.15	62.55	68.85	74.17	70.93	72.55
D3	71.96	69.87	70.92	76.10	72.14	74.12	74.12	67.29	70.71	75.16	72.49	73.82	80.55	64.41	72.48	71.23	68.23	69.73
D4	36.37	37.16	36.76	32.03	34.57	33.30	32.80	36.95	34.88	39.93	43.30	41.62	31.58	34.88	33.23	37.89	39.32	38.60
Mean	63.71	60.75		62.76	59.14		63.23	60.69		66.08	63.54		66.68	59.93		64.83	63.59	
CD (P=0.05)	D = 0.82 T = 0.58 D x T = 1.17			D = 0.80 T = 0.56 D x T = 1.13			D = 0.66 T = 0.46 D x T = 0.93			D = 0.60 T = 0.42 D x T = 0.85			D = 0.57 T = 0.40 D x T = 0.81			D = 0.73 T = 0.52 D x T = 1.03		

Total chlorophyll content

T1 (silica gel and 1:1 ratio for glycerin) recorded the highest total chlorophyll content for Cordyline (0.74mg/g), Boston fern (0.77mg/g), Monstera (0.75mg/g), Duck foot 'Croton' (0.74mg/g), Ornamental rubber (0.41mg/g) and Sloppy painter 'Croton' (0.75mg/g) as compared to T2 (boric acid and 1:2 ratio for glycerin) (Table 3). The results were in accordance with Malakar *et al.* (2016) where they found maximum chlorophyll content in *Araucaria cunninghamii* (0.26mg/g) and *Juniperus chinensis* (0.44mg/g) when silica gel was used as an embedding media.

A significant difference was noticed among the dehydration techniques in respect of the total chlorophyll content of dry ornamental foliage. Highest total chlorophyll content was noticed in microwave oven drying (D3) for Cordyline (0.89mg/g), Monstera (0.92mg/g) and Duck foot 'Croton' (0.85mg/g). In case of Boston fern highest total chlorophyll content (0.82mg/g) was recorded in tray drying (D1) and under sun drying (D2) it was observed in Ornamental rubber (0.46mg/g) and Sloppy painter 'Croton' (0.99mg/g). It may be the result of constant moisture removal without impacting the leaves' structural integrity and texture, which produced the leaves' maximum total chlorophyll content (Kulkarni *et al.*, 2004).

Different foliage dried under glycerin drying (D4) method showed minimum total chlorophyll content for all the six ornamental foliage. Depending on the age of the leaf, the chlorophyll content can change. The addition of glycerol increasesthe rate of degradation of chlorophyll (Lajolo and Marquez, 1982) in leaves. The decreased chlorophyll content in leaves treated with glycerin may be related to greater dehydration of the foliage because chlorophyll is an oily pigment and its concentration changes relatively slowly with less water loss. The results were in accordance with Yadav *et al.* (2018) in *Buxus sempervirens* when dried in 40% glycerin solution.

Among the treatment combination microwave oven drying with silica gel(D3T1) showed highest total chlorophyll content for Cordyline (0.96mg/g), Monstera (1.01mg/g) and Duck foot 'Croton' (0.93mg/g). In case of Boston fern it was observed highest in tray drying along with silica gel (D1T1) (0.98mg/g) whereas sun drying with silica gel (D2T1) showed maximum total chlorophyll content for Ornamental rubber (0.55mg/g) and Sloppy painter 'Croton' (1.05mg/g). This is because of the hygroscopic nature of silica gel along with gradual and constant-temperature elimination of moisture from the leaf tissue which resulted in the total chlorophyll retention.

Table 3 : Effect of dehydration techniques with embedding media on total chlorophyll content (mg/g) of dry ornamental foliage

Dehydration Techniques	Cordyline			Boston Fern			Monstera			Duck Foot 'Croton'			Ornamental Rubber			Sloppy Painter 'Croton'		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
D1	0.87	0.80	**0.84**	0.98	0.66	**0.82**	0.75	0.69	**0.72**	0.76	0.61	**0.69**	0.36	0.34	**0.35**	0.68	0.54	**0.61**
D2	0.69	0.62	**0.65**	0.83	0.63	**0.73**	0.89	0.79	**0.84**	0.87	0.66	**0.76**	0.55	0.37	**0.46**	1.05	0.92	**0.99**
D3	0.96	0.81	**0.89**	0.88	0.72	**0.80**	1.01	0.84	**0.92**	0.93	0.76	**0.85**	0.47	0.35	**0.41**	0.83	0.77	**0.80**
D4	0.43	0.54	**0.48**	0.38	0.59	**0.48**	0.35	0.49	**0.42**	0.40	0.53	**0.46**	0.27	0.30	**0.28**	0.43	0.53	**0.48**
Mean	**0.74**	**0.69**		**0.77**	**0.65**		**0.75**	**0.70**		**0.74**	**0.64**		**0.41**	**0.34**		**0.75**	**0.69**	
CD (P=0.05)	D = 0.05 T = 0.04 D x T = 0.08			D = 0.05 T = 0.03 D x T = 0.07			D = 0.06 T = 0.04 D x T = 0.09			D = 0.05 T = 0.03 D x T = 0.07			D = 0.06 T = 0.04 D x T = 0.08			D = 0.07 T = 0.05 D x T = 0.10		

Colour retention

Table 4 showed significant difference on the effect of embedding media on colour retention (ΔE*) of dry ornamental foliage except for Cordyline. Among the embedding media, T2 (boric acid and 1:2 ratio for glycerin) showed maximum colour retention for Duck foot 'Croton' (14.62) and Sloppy painter 'Croton' (11.79). But in case of Boston fern (9.85), Monstera (19.04) and Ornamental rubber (13.27) maximum colour retention was observed in T1 (silica gel and 1:1 ratio for glycerin). Fine Silica gel was better because of the light weight of silica gel particles which do not adhere to the leaves and also as it prevents the direct removal of moisture from foliage and acts as an intermediate and consequently prevents degradation of colouring pigments that could take place when foliage tissues are exposed to higher temperatures without embedding material (Safeena and Patil, 2013). However, in case of Cordyline it was found to be Non-Significant.

Tray drying (D1) showed maximum colour retention for Cordyline (9.37), Boston fern (9.49) and Sloppy painter 'Croton' (6.88) because the moisture inside is removed at a steady and uniform rate without affecting the structural integrity of the foliage (Sharma *et al.*, 2016). For foliage like Monstera (15.88), Duck foot 'Croton' (12.13), Ornamental rubber (7.75) it was found maximum in microwave oven drying (D3) due to its quick drying property in short duration and due to the variation in the characteristics of the crop. Similar finding was also reported by Kumari *et al.* (2017) in Gomphrena with highest colour retention in microwave oven drying.

The combination of tray dry with silica gel (D1T1) showed best colour retention in Cordyline (8.32), Boston fern (6.33) and Sloppy painter 'Croton' (6.45) which might be due to faster removal of moisture at higher temperature by the tray drier and in addition silica gel being the best embedding media for quality dried product without causing bleaching effect. Similar findings were observed by Roy and Gantait (2015) in Croton. For Duck foot 'Croton' (9.77) it was recorded highest in D3T2 combination (microwave oven drying with silica gel) which might be due to quick drying results in microwave oven and boric acid even after having bleaching property, itdoes not change the yellow colour even at high temperature but for foliage like Monstera (14.60) and Ornamental rubber (7.23) it was found excellent in microwave oven drying along with silica gel (D3T1). As silica gel does not possess any bleaching effect resulting in better colour retention in a short period of time. The results were consistent with Katoch *et al*. (2010) in Acroclinum flowers.

Table 4 : Effect of dehydration techniques with embedding media on colour retention (ΔE*) of dry ornamental foliage

Dehydration Techniques	Cordyline			Boston Fern			Monstera			Duck Foot 'Croton'			Ornamental Rubber			Sloppy Painter 'Croton'		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
D1	8.32	10.42	9.37	6.33	12.66	9.49	23.37	26.83	25.10	15.50	13.69	14.59	20.71	22.45	21.58	6.45	7.31	6.88
D2	13.47	14.21	13.84	6.95	12.43	9.69	20.17	22.62	21.39	15.70	15.84	15.77	13.23	15.40	14.31	12.27	10.09	11.18
D3	12.42	9.74	11.08	10.50	13.61	12.05	14.60	17.16	15.88	14.49	9.77	12.13	7.23	8.27	7.75	7.72	9.20	8.46
D4	16.10	15.09	15.59	15.64	14.28	14.96	18.02	17.26	17.64	20.24	19.20	19.72	11.93	8.96	10.44	22.05	20.58	21.32
Mean	12.58	12.36		9.85	13.24		19.04	20.97		16.48	14.62		13.27	13.77		12.12	11.79	
CD (P=0.05)	D = 0.53 T = NS D x T = 0.75			D = 0.45 T = 0.32 D x T = 0.64			D = 0.56 T = 0.40 D x T = 0.80			D = 0.83 T = 0.59 D x T = 1.18			D = 0.51 T = 0.36 D x T = 0.72			D = 0.46 T = 0.32 D x T = 0.65		

Size reduction

The minimum reduction in size of the dried ornamental foliage were recorded in T2 (boric acid and 1:2 ratio for glycerin) for Cordyline (25.74%), Monstera (13.39%), Duck foot 'Croton' (24.32%), Ornamental rubber (7.11%) and Sloppy painter 'Croton' (30.54%). Minimum of 28.02 per cent size reduction was observed in T1 (silica gel and 1:1 ratio for glycerin) for Boston fern (Table 5).

According, to the result obtained, minimum size reduction was obtained in glycerin drying (D4) for all the six ornamental foliages *viz.*, Cordyline (11.47%), Boston fern (16.17%), Monstera (8.19%), Duck foot 'Croton' (12.78%), Ornamental rubber (5.71%) and Sloppy painter 'Croton' (15.25%) since glycerin was employed to replace water loss in tissues and with lesser change in the treated leaf area. Yadav *et al*. (2018) in *Buxus sempervirens* acquired similar results. The study also revealed that microwave oven drying (D3) showed maximum reduction in size for all the foliages. This may be related to high temperature, moisture loss rates or moisture liberation from tissues, due to high heat transfer through conduction and convection. The results are in confirmation with the findings of Bhalla *et al.* (2006) and Kumari *et al*. (2017) in *Gomphrena globosa.*

Among the dehydration techniques and embedding media, glycerin drying technique in 1:1 ratio (D4T1) replaces the internal moisture of leaves and slows down the drying process, causing less moisture loss and minimal change in leaf size for Cordyline (11.14%), Boston fern (15.04%), Duck foot 'Croton' (11.11%) and Sloppy painter 'Croton' (12.73%). Glycerin drying at 1:2 ratio (D4T2) showed minimum reduction in Monstera (7.72%) and Ornamental rubber (5.53%) which might be due to the texture and density of the foliage. Maximum reduction in size was observed in microwave oven drying with boric acid (D3T2) for Cordyline. For Boston fern, Monstera, Duck foot 'Croton', Ornamental rubber and Sloppy painter 'Croton' it was recorded in microwave oven drying along with silica gel (D3T1).

Table 5 : Effect of dehydration techniques with embedding media on size reduction (%) of dry ornamental foliage

Dehydration Techniques	Cordyline			Boston Fern			Monstera			Duck Foot 'Croton'			Ornamental Rubber			Sloppy Painter 'Croton'		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
D1	30.68	21.65	**26.16**	24.87	29.60	**27.23**	17.92	13.73	**15.83**	34.97	29.98	**32.47**	26.37	23.45	**24.91**	38.53	36.01	**37.27**
D2	32.13	29.08	**30.61**	23.65	21.00	**22.32**	11.95	10.55	**11.25**	21.95	16.49	**19.22**	16.49	15.54	**16.01**	28.95	18.60	**23.77**
D3	38.90	40.45	**39.67**	48.53	47.16	**47.85**	26.61	21.57	**24.09**	41.45	36.38	**38.91**	27.11	23.92	**25.51**	62.94	49.81	**56.37**
D4	11.14	11.80	**11.47**	15.04	17.30	**16.17**	8.65	7.72	**8.19**	11.11	14.45	**12.78**	5.89	5.53	**5.71**	12.73	17.76	**15.25**
Mean	**28.21**	**25.74**		**28.02**	**28.76**		**16.28**	**13.39**		**27.37**	**24.32**		**18.96**	**7.11**		**35.79**	**30.54**	
CD (P=0.05)	D = 0.30 T = 0.21 D x T = 0.43			D = 0.24 T = 0.17 D x T = 0.35			D = 0.31 T = 0.22 D x T = 0.44			D = 0.34 T = 0.24 D x T = 0.48			D = 0.40 T = 0.28 D x T = 0.56			D = 0.47 T = 0.33 D x T = 0.66		

The result of the study revealed that even though different dehydration techniques can be used for drying but specific methods are suitable only for some particular type of foliage. Amongthe dehydration techniques used, drying in microwave oven along with silica gel showed quickest drying and also showed best color retention for Monstera, Duck foot 'Croton' and Ornamental rubber. Whereas, Cordyline, Boston fern and Sloppy painter 'Croton' retained better colour in Tray drying. Depending upon the uses to get superior quality dried ornamental foliage and cost effective results, the foliages may be dried either in glycerin drying (dip method) in 1:1 ratio or microwave oven drying with silica gel.

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