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Improving the shelf life of cut foliage through glycerinization

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ABSTRACT

Dried floral products constitute an important part of commercial floricultural industry worldwide. Different methods are used to dry different floral products but there is a need to standardize a particular method for particular floral part. In present investigation, three types of foliages {*Asparagus setaceus* (Asparagus), *Nephrolepis exaltata* (Ferns) and *Grevilla robusta* (Silver Oak)} were subjected to different drying techniques viz. air drying, water drying, embedding drying in sand and silica in hot air oven at 50°C and dehydration in glycerine and the results revealed glycerinization as the best method for drying foliages. Based on this finding, further studies were conducted to standardize the method and concentration (10, 20 and 40%) of glycerine for dehydrating foliage of high acceptability. All the three foliages could be dehydrated best by dipping them in 20% glycerine solution in well ventilated dark room for 7-8 days and could be used for more than six months with high acceptability score. The ease in accessibility to this drying technique will not only strengthen the utility of dehydrated foliages in floral arrangements and as gift items but will also ensure employment to youths, housewives and rural women with low inputs and high outputs.

Key words: Drying techniques, dehydration, value addition.

INTRODUCTION

Floriculture is emerging as a profitable industry worldwide and within this industry, dried flowers are the most promising products. The dried flowers constitute 71% of the total floricultural export from India (De *et al*., 7). The dried or dehydrated flowers or plant parts are natural, comparatively inexpensive and have everlasting value with year around availability (Safeena *et al*., 12). After drying, the charm of ornamental flowers could be enjoyed for several years without disturbing their colour and form (Ranjan and Misra, 11). The flower drying techniques involve reducing moisture content of flowers to a point at which biochemical changes are minimized while maintaining cell structure, pigment level and flower shape (Singh *et al*., 13). Different drying techniques like air, desiccant, oven, freeze, water, humectant etc are used to dry different flowers, foliages, seeds, fruits or pods but each floral product could be dried with best retention of colour, shape and texture using a specific technique (Singh and Suman, 14).

Cut foliage represents an important part of the floricultural industry and dried foliage has versatile utility. Drying of most of the foliages results in brittle and distorted leaves (Vishnupriya and Jawaharlal, 16). The key solution to this problem is use of hygroscopic chemicals or humectants like glycerol, glycols, sorbitol, sucrose etc having good water holding capacity to retain suppleness of plant material. Glycerinization is the technique in which fresh plant material is treated with humectant i.e. glycerin having very good hygroscopic properties. It helps to maintain the suppleness of dried foliage by replacing the natural moisture with mixture of water and glycerin. Glycerinization is found to be the best method to preserve foliage as the foliage preserved by this method retains flexibility, shape and texture (Cintu, 5). The glycerin dried leaves do not retain green color instead they become brownish green or coppery but still acceptable. The dehydrated foliage can be wiped or cleaned or painted or used naturally in arrangements.

Keeping in view the increasing demand of cut foliages in floricultural industry and different drying techniques for different floral products, the study was undertaken to evaluate different methods for different foliages and standardize the best method for higher acceptability and shelf life of dried product.

MATERIALS AND METHOD

The present investigation was conducted to standardize the dehydration technique for the foliage of three ornamentals viz. *Asparagus setaceus* (Asparagus), *Nephrolepis exaltata* (Ferns) and *Grevilla robusta* (Silver Oak) and study their shelf life after dehydration. The foliage of Asparagus and Ferns was harvested from the plants growing in green houses and silver oak from trees in Botanical Garden, in the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana.

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Stage and time of harvest of foliage

The leaves at an appropriate stage (neither too young nor too old) and time (neither early morning nor late evening) were harvested for drying/dehydration. The disease free leaves were selected and cut with a sharp knife or pruning shears.

Techniques used for drying

The foliage after harvesting was subjected to different techniques of drying such as air drying, water drying, embedding drying in sand and silica in hot air oven at 50°C and dehydration in glycerine. Observations were recorded for weight loss, brittleness, colour, shape and texture retention after dehydration. Based on these parameters overall acceptability was computed and the best technique was selected for further detailed standardization.

Dehydration of foliage by glycerinisation

Test for possibility of glycerinization under ambient conditions

Glycerin will be taken by foliage under particular set of temperature and pressure. The water vapour pressure at different temperature and humidity is given in Annexure 1. The vapour pressure deficit (VPD) is calculated by subtracting water vapour pressure under atmospheric relative humidity (RH) from water vapour pressure under 100% RH at ambient temperature. For glycerin to enter the foliage, VPD must be positive and should be greater than 10 millibars for dehydration under the ambient conditions of temperature and humidity.

The present study was conducted in the months of September and October 2016 and 2017. The data of temperature and relative humidity was collected from "School of Climate Change and Agrometeorology" Punjab Agricultural University, Ludhiana (Annexure 2) and calculation for possibility of glycerinization was done as mentioned above. The VPD was found to be positive and about 13 millibars for both months in both years. Based on positive result, the experiment was carried out during these two months in both years.

Methodology

The present experiment was done in months of September and October 2016 and 2017. The foliage of three ornamentals was dehydrated using glycerine at three concentrations viz. 10, 20 and 40% and following two methods of application viz. uptake and dipping.

The leaves were glycerinated by uptake or dip method.

Uptake method: In this method, the leaves were tied in bunches, basal stem was immersed in glycerin solution and glycerin moved up the stem as moisture evaporated from the leaves.

Dip method: In this method, the leaves were completely immersed in container having glycerin solution. The time taken for drying depends upon the type and condition of leaves.

The dehydration process was complete when the whole leaf becomes soft and flexible. The dehydrated

Annexure 2. Meteorological data (Source: School of Climate Change and Agrometeorology, Punjab Agricultural University, Ludhiana).

Month	Average Temperature (°C)		Relative Humidity (%)	
	2016	2017	2016	2017
September	29.8	28.8	70.5	72.0
October	25.9	25.9	63.5	63.0

Annexure 1. Chart for determination of water vapour pressure (millibars).

Temperature (°C) \ Relative humidity (%)	10	20	30	40	50	60	70	80	90	100
10	1	2	3	5	6	8	9	10	11	12
15	2	3	5	7	9	10	12	13	16	17
20	2	4	7	8	11	13	16	19	21	23
25	3	7	10	13	16	19	22	26	29	32
30	4	8	12	17	21	25	29	34	38	42
35	5	11	17	22	28	34	39	45	50	56
40	8	15	22	30	37	44	52	59	67	74
45	10	19	29	38	48	57	67	77	86	96
50	12	25	37	49	62	74	86	99	111	123
55	16	32	47	63	79	95	110	126	142	158

(Source: https://www.agric.wa.gov.au › Crops › Horticulture › Nursery & cutflowers)

leaves were then hung upside down for 3-4 days in a well ventilated dark room for removal of glycerin solution from their surface.

Preparation of glycerin solution: The dehydration of different types of foliage was done by using 10, 20 and 40% glycerin solution. To prepare X% glycerin solution, X ml of glycerin (commercially used) was thoroughly mixed with (100-X) ml of warm water.

Observations

1. Moisture Loss (%)

The weight of leaves was recorded before and after treatment and per cent loss in moisture was calculated as by Gupta (8).

$$\text{Per cent moisture loss} = \frac{\text{Weight of sample before drying - Weight of sample after drying}}{\text{Weight of sample before drying}} \surd 100$$

2. Time taken for drying (days)

The number of days was recorded for complete drying of leaves starting from day of treatment till drying in inverted position.

3. Parameters by Sensory Evaluation

The sensory evaluation for colour {using RHS (Royal Horticultural Society) chart, C}, shape (S) and texture (T) retention was done on the score from 1-10 (where each one unit corresponds to 10%). The brittleness (B) after dehydration was recorded after pressing the sample between thumb and finger and giving score from 1-10. Based on all above parameters, overall acceptability of a treatment was calculated using formula {C+S+T+(10-B)}/4. All these observations were recorded after dehydration and at monthly interval for 6 months. The acceptability was calculated after every month on the basis of colour, shape, texture and brittleness using the same formula {C+S+T+(10-B)}/4.

RESULTS AND DISCUSSION

The foliage of Asparagus, Ferns and Silver Oak was dried with different techniques viz. air, water, sand +oven (50°C), silica gel + oven (50°C) and glycerine and their acceptability based on brittleness, shape and colour retention after drying/ dehydration treatment was calculated (Table 1). The air dried foliage of all the three species was not acceptable whereas dehydrated foliage (glycerine drying) showed significantly high acceptability (10 scores) in comparison to other methods of drying. The water, sand +oven (50°C), silica gel + oven (50°C) drying showed less than 5 scores of acceptability which indicated that these methods could not be used for drying foliage. Thus, from the results of this experiment glycerine treatment was selected for three foliages.

The effect of method (Uptake and Dip) and different concentrations of glycerine (10, 20 and 40%) was recorded on different parameters viz. change in weight, time taken for dehydration, quality parameters (colour, shape and texture retention; brittleness) and overall acceptability of dried foliage of Asparagus, Fern and Silver Oak.

The foliages of all the three plants showed significant change in the weight after glycerinization (Table 2). The air dried foliage serving as control showed 79 to 83% reduction in weight that declined to 5.55% when foliage of asparagus was dehydrated in 20% glycerine by uptake method. Glycerinization of foliage of ferns @ 10% by uptake method resulted in 38% reduction in weight in comparison to 11% when glycerinized @20% by dip method. The foliage of silver oak showed reduction in weight after glycerinization by uptake method but there was increase in weight after glycerinization by dip method. The silver oak foliage dehydrated @20% glycerine retained its weight after drying whereas increase of 15.68 and 17.61 % respectively was recorded for 40 and 10% glycerinization.

The variation in change in weight after dehydration could be accounted for the structural differences in the leaves of different plants (Paul and Joyce, 10). There was higher reduction in weight in air drying as it resulted in loss of moisture but in glycerinization this loss is reduced due to replacement of water with glycerine. The glycerine molecule with 3 hydroxyl groups is highly hygroscopic in nature and serves as a good humectant with good water holding capacity (Visalakshi, 15). The type of foliage determines the amount of glycerine entering into the tissues so higher the amount of glycerine entering into the tissue lesser will be weight loss. This is in concomitant with

Table 1. Acceptability of dried foliage based on brittleness, shape and colour retention after drying/dehydration treatment.

Foliage of Plant	Air	Water	Sand+ Oven (50°C)	Silica gel + oven (50°C)	Glycerine	CD (0.05)
Asparagus setaceus	NA	0.33	1.67	3.67	10.00	0.89
Nephrolepis exaltata	NA	1.27	2.67	4.67	10.00	0.84
Grevillea robusta	NA	1.00	2.00	4.00	10.00	0.32

Table 2. Effect of dehydration treatments on weight loss and time taken for drying of foliage of Asparagus, Fern and Silver Oak.

Dehydration Treatment		Loss in weight (%)			Time taken for drying (days)		
		Asparagus	Fern	Silver Oak	Asparagus	Fern	Silver Oak
Dip in Glycerin (%)	10	18.34 (25.30)	30.43 (33.46)	17.61 (24.79)	7.22	6.55	6.67
	20	17.56 (24.72)	11.45 (19.72)	1.03 (5.41)	7.33	7.44	7.78
	40	13.76 (21.75)	26.13 (30.72)	15.68 (23.30)	8.11	10.22	10.89
Uptake of Glycerin (%)	10	9.47 (17.89)	37.39 (37.67)	-32.60 (34.79)	8.67	12.78	13.11
	20	5.55 (13.58)	25.67 (30.41)	-11.29 (19.59)	10.55	14.22	14.56
	40	12.54 (20.71)	33.82 (35.52)	-21.17 (27.36)	12.22	18.44	19.00
Control		79.87 (63.46)	81.07 (64.23)	-82.76 (65.51)	5.00	4.33	4.00
CD (P=0.05)		1.787	1.670	1.569	0.511	0.813	0.698

our findings where the change in weight varies not only with concentration and method of glycerinization but also with type of leaf/plant.

The method and concentration of glycerine significantly affected the time taken by different foliages to dehydrate (Table 2). The air drying of all foliages took less days in comparison to other treatments in all foliages. The time taken for dehydration in 40% glycerine by uptake method was more for all foliages and least for dip treatment in 10%glycerine. The foliage of Asparagus was dehydrated in 7.22 days when glycerinized by dip treatment in 10% glycerine and took 12.22 days in dehydrating by uptake method in 40% glycerine. The corresponding values for Fern were respectively 6.55 days and 18.44 days and for Silver Oak were respectively 6.67 days and 19 days.

The variation in time taken for dehydration in different foliages could be explained due to difference in size and density of plant tissue. The texture of foliage influences the absorbing capacity of plant tissue which affects the time taken for dehydration (Bale, 2). Further, the method of glycerinization also depends upon the type of leaf as dip method is more suitable for small or dissected leaves like Fern whereas uptake method is better for broad leaves like Magnolia (Brown *et al*., 3).

The foliage dehydrated with glycerine turned greenish brown to brown in colour. Although the colour retention score of all dehydrated leaves was less than 3 except Asparagus (7.78) dehydrated by dip method in 40% glycerine yet the change in colour was acceptable. The different treatments were at par for dehydrated foliage of Fern and Silver Oak where the colour retention scored 1 or 2 (Table 3). The dehydrated foliage of Asparagus differed significantly w.r.t. colour retention for different treatments. The dip treatment @ 20% glycerine resulted in highest colour retention score of 7.78 whereas foliage dehydrated by uptake method exhibited low colour retention at all glycerine concentrations. The loss in colour could be explained due to loss of chlorophyll in the

Table 3. Effect of dehydration treatments on colour and shape retention of foliage of Asparagus, Fern and Silver Oak after drying.

Dehydration Treatment		Colour retention			Shape retention		
		Asparagus	Fern	Silver Oak	Asparagus	Fern	Silver Oak
Dip in Glycerin (%)	10	2.44	1.00	1.00	10.00	9.56	9.56
	20	7.78	2.00	2.00	10.00	10.00	9.88
	40	3.00	1.00	1.00	10.00	9.44	9.44
Uptake of Glycerin (%)	10	1.00	1.00	1.00	7.56	3.00	3.56
	20	1.00	1.00	1.00	7.44	3.22	2.78
	40	2.33	1.00	1.00	6.56	3.67	1.89
Control		1.00	1.00	1.00	1.00	0.11	0.11
CD (P=0.05)		0.415	NS	NS	0.379	0.549	0.479

leaves which might be due to the replacement of water with glycerine during dehydration. Cheour *et al*. (4) reported loss of chlorophyll in barley under water stress.

Glycerinization significantly affected the shape retention after all treatments in foliage of all the plants (Table 3). The foliage of all three types treated with glycerin (@ 10, 20 and 40%) by dip treatment had high score of more than 9.5 for shape retention. The foliage of Asparagus treated with uptake method also had high score of more than 6.5 in comparison to Fern where the score was 3.00, 3.22 and 3.67 respectively, for 10, 20 and 40% glycerine and the corresponding values for Silver Oak were respectively 3.56, 2.78 and 1.89. The air dried leaves were highly distorted with least score (≤1) for shape retention. Our results of high shape retention of leaves by dipping in glycerine are in accordance with earlier findings of Paul and Joyce (10), Dana and Lerner (6).

The different foliages differed significantly with different treatments for texture retention (Table 4). The leaves of all the foliages showed high score (8.56 - 9.78) for texture retention when dehydrated with dip treatment in comparison to uptake method (1.56-2.55). The texture retention with dip treatment might be due to replacement of natural moisture present in leaf with glycerine that maintains texture and form (Bale, 2).

Higher the brittleness of dried material lesser is its acceptability. The air dried foliage was highly brittle whereas the brittleness decreased in dehydrated foliage. The foliage dehydrated with uptake method was more brittle in comparison to that of dehydrated with dip method. The foliage of Silver Oak dehydrated with dip treatment @40% glycerine was least brittle (1.44) indicating its higher acceptability but when dehydrated with uptake treatment @40% glycerine, the foliage showed high brittleness (8.33) indicating its low acceptability (Table 4). The reduction in brittleness with glycerine could be explained due to plasticizing and softening action of glycerine. Several studies are in concomitant with our findings that glycerine dehydrated materials are more pliable and in natural shape (Anonymous, 1).

Based on all above parameters, overall acceptability of a treatment was calculated [{C+S+T+(10-B)}/4]. The air dried foliage was not acceptable at all. The dehydration with glycerine improved the acceptability of all foliages (Fig. 1). The dip treatment @20% glycerine resulted in high acceptability of 8.31 for Asparagus, 7.17 for Ferns and 7.08 for Silver Oak. The acceptability of Silver oak dehydrated foliage with dip treatment @ 20 and 40% was at par so keeping cost in mind the treatment @ 20% was considered to be the best. The foliage of Silver Oak and Ferns dehydrated with uptake method was least or not acceptable as the acceptability score was less than 2.5 and Asparagus was moderately acceptable with score of less than 6.

The acceptability of foliage of Asparagus dehydrated by uptake method declined with increase in storage duration whereas the acceptability of foliage dehydrated by dipping at all concentrations showed a little decline during first two months and later it became stable (Table 5). Similar pattern for acceptability during storage was observed for dehydrated foliage of Ferns where dip treatment @ 20% glycerine showed highest score of 7.04 for acceptability after 6 months of storage (Table 6). The foliage of Silver Oak dehydrated by uptake method at all concentrations had low acceptability score that further declined during storage. After 4 or 5 months of storage, the dehydrated foliage (uptake method) became non acceptable. The foliage dehydrated with dip treatment at all concentrations retained high score of acceptability even after 6 months of storage.

Table 4. Effect of dehydration treatments on texture retention and brittleness of foliage of Asparagus, Fern and Silver Oak after drying.

Dehydration Treatment		Texture retention			Brittleness		
		Asparagus	Fern	Silver Oak	Asparagus	Fern	Silver Oak
Dip in Glycerin (%)	10	8.44	8.33	8.56	3.33	3.22	2.56
	20	8.33	8.88	8.67	3.00	2.22	2.22
	40	8.44	8.44	9.78	2.00	2.00	1.44
Uptake of Glycerin (%)	10	7.89	2.55	2.44	4.33	8.67	7.33
	20	7.44	2.33	2.78	8.00	8.22	8.11
	40	7.67	1.56	3.44	8.11	7.33	8.33
Control		3.33	0.89	0.77	10.00	10.00	10.00
CD (P=0.05)		0.535	0.464	0.549	0.397	0.397	

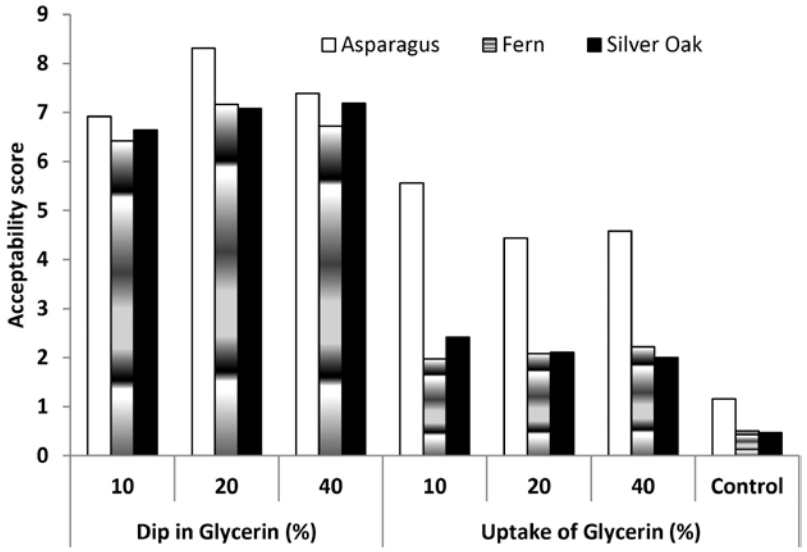

Fig. 1. Effect of dehydration treatments on overall acceptability based on colour, shape, texture and shattering of foliage of Asparagus, Fern and Silver Oak after drying.

Table 5. Overall acceptability based on colour, shape, texture and brittleness of dried foliage of *Asparagus setaceus* during 6 months of storage.

Dehydration Treatment		Storage Duration (months)					
		1	2	3	4	5	6
Dip in Glycerin (%)	10	6.92	6.85	6.71	6.43	6.43	6.43
	20	8.31	8.24	8.24	8.24	8.24	8.24
	40	7.29	7.29	7.29	7.29	7.29	7.29
Uptake of Glycerin (%)	10	5.55	5.32	4.67	4.67	3.87	3.87
	20	4.34	4.25	4.17	3.67	3.30	2.92
	40	4.52	4.37	4.13	4.13	3.65	3.58
Control		NA	NA	NA	NA	NA	NA
CD (P=0.05)		0.342	0.188	0.133	0.188	0.213	0.165

(Score card: 1 < 10%; 2 < 20%.....10 ≤ 100% ; NA – not acceptable)

Table 6. Overall acceptability based on colour, shape, texture and brittleness of dried foliage of *Nephrolepis exaltata* during 6 months of storage.

Dehydration Treatment		Storage Duration (months)					
		1	2	3	4	5	6
Dip in Glycerin (%)	10	6.40	6.21	6.09	5.59	5.59	5.54
	20	7.17	7.15	7.04	7.04	7.04	7.04
	40	6.65	6.40	6.27	6.27	6.27	6.27
Uptake of Glycerin (%)	10	1.55	1.23	0.54	NA	NA	NA
	20	1.95	1.27	0.98	0.34	NA	NA
	40	2.05	1.21	0.98	0.46	NA	NA
Control		NA	NA	NA	NA	NA	NA
CD (P=0.05)		0.213	0.131	0.416	0.167	0.464	0.113

(Score card: 1 < 10%; 2 < 20%.....10 ≤ 100% ; NA – not acceptable)

Table 7. Overall acceptability based on colour, shape, texture and brittleness of dried foliage of *Grevilla robusta* during 6 months of storage.

Dehydration Treatment		Storage Duration (months)					
		1	2	3	4	5	6
Dip in Glycerin (%)	10	6.56	6.32	6.15	5.98	5.98	5.74
	20	7.05	6.92	6.89	6.89	6.74	6.69
	40	7.14	7.03	6.99	6.79	6.65	6.45
Uptake of Glycerin (%)	10	2.34	1.57	1.08	0.69	NA	NA
	20	1.95	1.47	0.58	0.34	NA	NA
	40	1.87	1.21	0.48	NA	NA	NA
Control		NA	NA	NA	NA	NA	NA
CD (P=0.05)		0.213	0.131	0.416	0.167	0.464	0.113

(Score card: 1 < 10%; 2 < 20%.....10 ≤ 100% ; NA – not acceptable)

Thus, the foliage of Asparagus, Ferns and Silver Oak dehydrated with dip treatment @ 20% glycerine showed high score of acceptability after 6 months of storage (Table 7). The dehydrated foliage could be used for decorations and other purposes even after six months of storage.

The results depicted above revealed that for the three types of foliages under study, the foliage dehydrated with dip treatment at all concentrations had higher acceptability score than uptake treatments. The earlier studies have reported that glycerinization with uptake method is suitable for foliage with broad leaves whereas dip treatment is suitable for single or narrow leaves (Jawaharlal *et al*., 9). This might be due to structural differences in broad and narrow leaves. Thus, in our study the dip treatment was found to be most effective for leaves of all three type as all the leaves to be dehydrated were narrow/ dissected.

CONCLUSIONS

Comparison of different methods of drying of foliages revealed air drying to be simplest and cheapest but had no acceptability due to brittleness, distorted shape and colour fading. Among different methods, glycerinization was found to be the best method for dehydrating foliages of different types. Further, results revealed that all the three foliages could be dehydrated best by dipping them in 20% glycerine solution in well ventilated dark room for 7-8 days and stored for more than 6 months with high acceptability score. The easy approach to this technology will promote the use of dehydrated foliages in floral arrangements and as gift items. This will also be helpful in entrerpreneurship development for unemployed youths, housewives and rural women as demand of dehydrated floral products is increasing at a great pace.

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