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HORTICULTURE

Standardization of dehydration techniques of some ornamental foliages

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Abstract

The eco-friendly dehydrated foliages and plant parts secured much popularity among users and becoming key components in floriculture industry. Foliages with highly variable keeping quality are used as filler element in flower-vase. Dehydration of foliages has not been studied at large. This investigation was carried out with ornamental foliage's of three species viz. *Araucaria cunninghamii*, *Thuja orientalis* and *Juniperus chinensis*. White sand, silica gel and boric acid were used as embedding materials and two drying conditions of microwave oven and room drying were adopted for three durational treatments of viz. 10, 20 and 30 seconds and 4, 8 and 16 days respectively. In both *Araucaria* and *Thuja orientalis,* silica gel + microwave oven combination for 30 and 20 seconds respectively exhibited best results in respect of moisture loss (49.23 and 58.33 per cent) and quality concern. White sand + room condition also caused 61.41per cent moisture loss in *Thuja orientalis* while treated for 16 days. In *Juniperus chinensis,* white sand + microwave oven and silica gel + room condition for 20 seconds and 16 days respectively showed moisture loss of 44.26 and 50.16 per cent respectively. Boric acid as embedding materials also found effective in dehydration of these species. All the three species were treated with glycerin : water solution of 1:1 and 1:3 (vol/vol) for 24, 48 and 96 hours followed by drying with aid of hot air oven at 70-80^{o}C for 5 hours and open air of room condition for 24 hours. Significant moisture loss of 60.56 to 62.56 per cent was recorded in *Thuja orientalis* while dehydrated in hot-air-oven for 96 hours.

Highlights

- Well-liked, environmentally benign desiccated foliages and plant parts can be potentially employed as filler substance in flower-vase, pivotal element in floriculture industry not expansively investigated.
- White sand, silica gel and boric acid as desiccating agents and microwave oven and ambient condition as dehumidifying state for 10, 20 and 30 seconds and 4, 8 and 16 days respectively were manoeuvred for dehydrating 3 ornamental foliages presently.
- Regarding moisture loss of *Araucaria cunninghamii*, *Thuja orientalis* and *Juniperus chinensis* silica gel and white sand+ microwave oven combination for 30 and 20 seconds evinced unparallel.
- Abet of hot air oven at 70-80° C for 5 hours only *Thuja orientalis* manifested notable moisture loss after treating with glycerin: water solution of 1:1 and 1:3 (vol/vol) for 96 hours.

Keywords: Dehydrated, foliage, desiccant, embedding, post-drying, preserve

Drying and preserving flowers, foliages and plant materials are a form of artistic expression that was very popular during Victorian age and has once again gained popularity in the modern age. The decoration value of dehydrated plant parts led to the use of vase decoration, bouquets and arrangements of gifts as well as ceremonial decoration of both home and working places. Dried plant materials with decorative value have now been accepted globally as natural, eco-friendly, long lasting and inexpensive. India is one of the major exporters of dried flowers to the tune of 5 per cent world trade in dry flowers. This industry shows a growth rate of 15 percent annually. Potpourris are a major segment of dry flower industry where the country holds a large contribution to the world market. In the context of international trade floriculture of India, dried flowers and plant parts are the key segment and constitute 70 per cent of total share of floriculture products exported from India (Singh 2005 and Sheela 2008). The reasons for development of dry flower industry in India is possibly due to easy availability of varied fresh materials from forests and different localities, manpower availability for labor intensive craft making and availability of wide range of materials throughout the year. Zizzo and Fascella (1997) opinioned that the dried materials can be enjoyed the whole year by arranging them in vases, creating arts, candle holders and in other home decorations. Possibly the most common use of dried materials is in a wreath or floral arrangement, but one can also use to ornament gift packages, masks, hats and lamp shades. Dried materials often embellish stationery or are used to create unique pictures. The reasons of entry of dry flowers in the florist trade can be identified as of fulfilling conscious demand for eco-friendly natural materials for using in living room and fresh flowers are the best solution but these are perishable, delicate and even after different post harvest treatment for enhancing shelf-life it can only be extended to an extent of forty percent (Ranjan and Mishra 2002). On the other hand dried plant materials are extra special as they possess the characteristics of novelty, eco-friendly, aesthetically near to fresh flowers, flexibility and year round availability (Joyce 1998). In the situation of climatic abnormalities in different parts of the country which is not congenial for growing or keeping cut flowers in vases, dried flowers here have established its tremendous potentiality which is very much observed during the last decades (Dhatt *et al.* 2007). The country has ample scope of developing dry specimens and it is claimed now India stands first in dry materials export owing to the availability of variety plants (Swarnapriya and Jayasekhar 2008). Export of dry flowers and plants from India is about ₹ 100 cores per year.

Moisture holding of dried flowers and foliages influence the quality and longevity (Singh *et al*. 2003). Gill *et al*. (2002) while studying the efficacy of various methods of drying viz. drying in microwave oven, drying by embedding in a desiccant, solar drying, press drying and preservation in glycerin for drying fern, asparagus (*Asparagus* sp.) and silver oak (*Grevillea robusta*) leaves for commercial and domestic purpose. They observed that, drying by embedding in silica gel for 30 hr was the best for drying ferns for commercial purposes whereas drying embedding in silica gel for 36 hr and press drying for 60 hr best for domestic purpose. In the light of the above information, the present investigation was undertaken with three species of ornamental foliage plants. Leaves of these species are widely used for vase decoration and other decorations. In order to develop dry materials of these species, this experiment was conducted to standardize suitable method. Aiming in view of different methods viz. embedding in silica gel and drying in microwave oven and open air (room) condition and preservation in glycerin were attempted.

Materials and Methods

The present study was conducted to find out the efficacy of three methods of drying viz. drying in open air (room condition), microwave oven by embedding and preservation in glycerin of leaves of three different ornamental species of conifers viz. *Araucaria cunninghamii,* Sweet, commonly known as Hoop pine belongs to the family Aracariaceae, *Thuja orientalis,* Linn., commonly known as Chinese thuja belongs to the family Cupressaceae and *Juniperus chinensis*, Linn., commonly known as Chinese juniper belongs to the same family of thuja for using in domestic commercial purposes. Mature fresh young green foliages with more or less uniform in size and shape were collected from Agri-Horticultural Society of India, Kolkata and National Library, Kolkata in the morning hours between 8.00 a.m. to 9.00 a.m. followed by bagging in polyethylene bag to avoid further desiccation at the time of brought them to laboratory and immediate documentation of fresh weight and size of foliages. The experiment was conducted in the laboratory of the Department of Horticulture, Institute of Agricultural Science, University of Calcutta.

Being measured initial moisture content all three types of foliages were embedded in pure drying media viz. silica gel, boric acid and white sand followed by drying under microwave oven (600 wt) for 10, 20 and 30 seconds and open air in room condition for 4, 8 and 16 days of durational treatment. Leaf samples were placed horizontally on five inch thick layers of well-spread desiccants at the bottom of microwave resistant glass containers followed by covering of about a depth of two inch and filling up to neck with the same media to avoid further moisture absorption from air being tightened the lid. Optimum drying was considered on the basis of post drying characteristics taken being kept for two hours in ambient condition especially after taking out from microwave oven condition. For glycerin preservation each type of foliages were submerged in plastic flat containers holding two concentrations of glycerin-water solution viz. 1:1 and 1:3 for 24, 48 and 96 hours durational treatment using boiling water in which glycerin was added slowly, gently and then drying under hot-air-oven at 70-80° C for 5 hours and open air of room condition for 24 hours were performed. To loss excess glycerin-water solution, after taking out of the submerged materials allowed to keep in hanging position firstly. Glycerin produce preserved flowers by replacing the internal moisture of the fresh materials and also having good effect on softening of the materials. Whereas chlorophyll content (mg./gm.) considered as a key post drying parameter among others estimation of it was done following the method of Buzarbarua (2000) being refrigerated one gram leaf tissue in 80% acetone for a week followed by crushing, filtering, making up of volume with fresh acetone and finally measuring optical density (O.D) of colored solution through 645 and 663 nm. wave length in a spectrophotometer against acetone.

In both the experiment each treatment replicated thrice considering one specimen as replication and average data of each parameter are presented. The data analyzed using completely randomized block design with factorial concept (CRD) (Panse and Sukhatme 1985).

Results and Discussion

Microwave oven drying and room temperature drying's results revealed (Table 1) that accelerated moisture loss proportional with the increase of duration in all three desiccants and species. Highest moisture loss was recorded in silica gel, nothing but a chemically stable, highly hygroscopic, non-corrosive, irregular crystal like granules, embedded *Thuja orientalis* and *Araucaria cunninghamii* foliage materials with an average moisture loss percentage of 58.33 for 20 seconds and 49.23 for 30 seconds durational treatment in respect of their initial moisture content viz. 67.64 and 67.54 per cent respectively under microwave oven condition. Tandon (1982); Bhutani (1990) and Datta (1999) established silica gel as the best embedding material followed by borax and sand. Surprisingly, in case of *Juniperus chinensis* initially had 58.98 percent of moisture, fine textured, granular, non-toxic, cheap white sand proved itself best being loosed 44.26 percent moisture under white sand + microwave oven condition for 20 seconds treatment (Table 1). Electronically produced microwaves liberate moisture from organic substances by agitating the water molecules is the principle lying behind the quickest microwave oven drying (Bhutani 1990a). In all the three species the effect of white sand and boric acid as desiccants were almost at par. Size reduction of leaves were increased keeping pace with the extend of treatment duration. Regarding average foliage size reduction parameter white sand and boric acid both performed better than silica gel but maximum size reduction of chrysanthemum flowers were reported while embedded in silica gel and dried in microwave condition (Bhalla *et al.* 2006). In *Araucaria cunninghamii* and *Juniperus chinensis* 5.92 and 4.64 were the average foliage size reduction percentage with aid of white sand desiccant for 30 seconds treatment while 4.27 percent leaf size reduction using boric acid for 30 seconds was noted in *Thuja orientalis* under microwave condition evident from Table 1. Dried leaves with better chlorophyll content could be obtained with minimum duration of treatment since it's the main pigment content of foliages and play vital role for the determination of dried plant part's attractiveness. In regard to chlorophyll restorability, silica gel embedded materials showed maximum chlorophyll recovery with 0.26 and 0.44 mg/gm. of chlorophyll for 10 seconds treatment in *Araucaria cunninghamii* and *Juniperus chinensis* while the actual chlorophyll content of them were 0.72 and 0.65 mg/gm. before subjecting them under drying

Table 1: Effect of different embedding media in drying of three different foliages under different drying conditions

Microwave oven condition										
Embedding Materials	Duration of treatments (sec.)	Average moisture loss (%)	Average size reduction (%)	Chlorophyll content (mg/gm.)	Average moisture loss (%)	Average size reduction (%)	Chlorophyll content (mg/gm.)	Average moisture loss (%)	Average size reduction (%)	Chlorophyll content (mg/gm.)
		Araucaria cunninghamii			*Thuja orientalis*			*Juniperus Chinensis*		
Silica gel	10	39.48c	2.64c	0.26a	56.66a	1.10b	0.35a	35.40c	1.20b	0.44a
	20	46.37b	3.32b	0.20b	58.33a	1.30a	0.30a	40.28b	1.50b	0.37b
	30	49.23a	3.88a	0.16c	57.07a	1.40a	0.23b	41.45a	2.10a	0.24c
White sand	10	23.47c	3.82b	0.13a	29.02c	1.20b	0.35a	40.44b	3.58b	0.43a
	20	32.30b	4.01b	0.07b	45.63b	2.19a	0.29b	44.26a	4.51a	0.35b
	30	39.53a	5.92a	0.05b	49.91a	2.23a	0.16c	43.83a	4.64a	0.22c
Boric acid	10	29.19c	2.67c	0.14a	35.04c	1.07b	0.38a	33.60b	0.12b	0.38a
	20	34.80b	4.02b	0.09b	53.92a	3.75a	0.28b	35.75b	0.13b	0.29b
	30	40.88a	4.89a	0.06b	50.86b	4.27a	0.17c	40.40a	3.33a	0.21c
Room condition										
		Araucaria cunninghamii			*Thuja orientalis*			*Juniperus Chinensis*		
Embedding Materials	**Duration of treatments (days)**	**Average moisture loss (%)**	**Average size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Average size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Average size reduction (%)**	**Chlorophyll content (mg/gm.)**
Silica gel	4	49.72a	5.90a	0.40a	44.07b	3.27a	0.25a	31.48b	2.23c	0.36a
	8	53.40a	6.03a	0.25b	57.86a	3.85a	0.22a	33.09b	3.53b	0.31a
	16	56.16a	6.19a	0.21b	60.36a	3.86a	0.21a	50.16a	4.42a	0.28b
White sand	4	27.64b	4.50a	0.37a	22.58c	3.14b	0.23a	20.39c	1.71c	0.24a
	8	50.09a	5.50a	0.28b	48.73b	3.26b	0.20a	26.16b	2.27b	0.15b
	16	50.21a	5.53a	0.22b	61.41a	4.22a	0.19b	45.90a	3.11a	0.11b
Boric acid	4	12.38c	2.06a	0.30a	19.75b	1.04b	0.21a	16.47c	2.00c	0.29a
	8	31.59b	2.15a	0.24b	56.20a	3.04a	0.18b	36.72b	2.93b	0.23b
	16	37.04a	2.62a	0.18c	60.68a	3.90a	0.16b	49.07a	4.90a	0.23b

N.B. Similar words are statistically at par.

process. Appreciably boric acid in *Thuja orientalis* acted as best desiccant with maximum chlorophyll recovery of 0.38 mg/gm. markedly deteriorated as compare with earlier 0.69 mg/gm. of chlorophyll for only 10 seconds treatment. Meman and Barad (2009) observed higher pigment reduction at higher temperature which was consistent with our obtained result. Sharma *et al*. (2000) also explained that carotenoids are highly susceptible to auto oxidative degradation during processing and storage of products that causes discoloration. Here, no marked variation on the basis of shape and texture in the post drying foliages were observed.

Room temperature drying experiment comprising of 4, 8 and 16 days durational treatment using same three ornamental foliages. Extended duration of treatment here also facilitate the moisture reduction percentage. The activity of all three desiccants were more or less at par under room conditions drying but among them silica gel accomplished well being reduced 56.16 per cent of moisture for 16 days treatment followed by white sand with moisture loss of 50.09 and 50.21 per cent for both 8 and 16 days treatment in *Araucaria cunninghamii*. Moisture reduction percentages of *Thuja orientalis* leaves were seemed similar under all embedding materials with a trend of losing 60.82 percent moisture while silica gel and boric acid lose 50.16 and 49.07 per cent moisture from *Juniperus chinensis* leaves respectively but white sand failed to show effective result. Ranjan Misra (2002) established the fact that dried flowers and leaves with specific moisture level can be stored for a very long period without losing their appearance and decorative value. Regarding size reduction parameter three desiccants resulted different utmost after-effects for used foliages belong to different genera i.e for *Araucaria cunninghamii* silica gel (6.19%), for *Thuja orientalis* white sand (4.22%) and for *Juniperus chinensis* boric acid (4.90%) evident from Table.1. whereas boric acid acted unbeatable being reduced minimum size of *Araucaria cunninghamii*'s and *Thuja orientalis*'s leaves (2.06 and 1.04%). Color preservation was much better in room drying than microwave oven drying and sand media stood first in this aspect since main principle of drying is to diminish moisture content to a point at which the biochemical changes are minimized maintaining cell structures, pigment level and actual shape of flowers or foliages (Dana and Larner 2002).

In another part of experiment, foliages of the three species were allowed to absorb in two concentrations of glycerin-water solution viz. 1:1 and 1:3 for 24, 48 and 96 hours. Lee *et al*. (2003) exclaimed that dye with glycerin give the flowers and foliages a more vibrant color to its soft and pliable feel. It is evident from Table 2 that moisture loss from materials with the increase of imbibitions time of glycerin-water irrespective of drying techniques. Highest moisture loss was recorded with leaves of all three species treated for 96 hours in both concentrations of glycerin used. Insignificant variation of moisture loss from leaves due to use of different concentration of glycerin were also observed. Among three species, *Thuja orientalis* leaves resulted utmost moisture loss percentage of 62.50 under hot-air-oven drying after 96 hours absorption in 1:1 glycerin-water solution while the same trend was also noted under room condition drying. Leaf size reduction was minimum after 24 hours absorption in 1:1 glycerin-water solution for *Thuja orientalis* and *Juniperus chinensis* leaves both under hot-air-oven and room condition drying but surprisingly in *Araucaria cunninghamii* foliages 1:3 glycerin-water solution showed prominent effect with 1.20 and 2.04 per cent size reduction under both drying condition after least absorption period. Chlorophyll deterioration trend was prominent with the increase of treatment duration in regards to all species. Campbell *et al*. (2001) and Sohn *et al*. (2003) experimented and proved glycerol as an appropriate preservative for *Eucalyptus cinerea* and *Magnolia grandiflora* for retaining natural in appearance as it replenishes the natural moisture of the leaf with a substance that maintains leaf fall, texture, color and sugar level.

Conclusion

Dehydration is an important post harvest technology for enhancing ornamental keeping quality of flowers and foliages as quickly deteriorates the moisture content to a point at which biochemical changes occurs little, keeping cell structure and shape unaffected. Dry foliages on the other hand, can be stored for unlimited period if they are well-secured from the damage of atmospheric high humidity. Since last three decades scientists are putting their effort to standardize the dehydration techniques for flowers and foliages need special care to protect

Table 2: Effect of glycerin preservation of three different foliages under different drying conditions

Hot-air-oven condition										
Treatments	**Duration of treatments (hrs.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**
		Araucaria cunninghamii			*Thuja orientalis*			*Juniperus Chinensis*		
Glycerin-water (1:1)	24	13.81c	2.01b	0.24a	24.48c	3.44c	0.25a	26.79c	2.05c	0.36a
	48	24.62b	2.90a	0.17b	42.23b	4.02b	0.21a	32.12b	2.38b	0.25b
	96	33.33a	3.06a	0.12b	62.50a	4.47a	0.15b	33.95a	4.23a	0.20c
Glycerin-water (1:3)	24	22.98b	1.20c	0.25a	24.40c	3.49a	0.22a	24.60c	3.19c	0.31a
	48	23.44b	2.62b	0.16b	36.81b	3.51a	0.19b	30.50a	4.20b	0.22b
	96	30.08a	2.79a	0.11b	60.56a	3.59a	0.13b	31.50a	5.30a	0.18c
Room condition										
		Araucaria cunninghamii			*Thuja orientalis*			*Juniperus Chinensis*		
Treatments	**Duration of treatments (hrs.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**	**Average moisture loss (%)**	**Foliage size reduction (%)**	**Chlorophyll content (mg/gm.)**
Glycerin-water (1:1)	24	15.10c	2.56c	0.22a	27.20b	0.10b	0.23a	13.49c	1.33a	0.30a
	48	25.50b	2.86b	0.16b	28.30b	0.11ab	0.16b	20.50b	1.48a	0.22b
	96	34.40a	3.38a	0.14b	29.60a	0.12a	0.13b	22.80a	1.56a	0.15c
Glycerin-water (1:3)	24	23.50c	2.04b	0.20a	26.50b	0.14b	0.21a	10.00c	2.36b	0.28a
	48	25.50b	3.08a	0.14b	27.60ab	0.20a	0.14b	19.07b	2.58ab	0.21b
	96	31.50a	3.18a	0.09c	28.50a	0.23a	0.12b	21.65a	2.92a	0.13c

N.B. Similar words are statistically at par.

their shape, sizes and color while other plant parts like branches, cones, barks can be dried with little care. Aiming to this, our undertaken investigation succeeded to point out the efficacy of various desiccants and drying conditions for dehydrating selected foliages. Drying in microwave oven showed quicker result as compare to room drying since increased rate of moisture loss due to more conduction and convection of heat to foliage tissue and water evaporation from the surface might have caused rapid drying at microwave oven (Singh and Dhaduk 2005). Irrespective of media, moisture reduction was accelerated with the increased duration in all species of plants. Silica gel caused utmost moisture loss being attracted moisture by phenomenon known as physical absorption and capillary condensation irrespective of drying condition followed by boric acid and white sand. In microwave oven drying *Araucaria* sp. foliages reduced maximum size and on other hand, silica gel reduced maximum size under room condition. Sand media under microwave drying proved best for *Juniperus Chinensis*. Foliage color in all species got bleached to some extend while fading effect of boric acid had also been reported by Pamela (1992) and subsequently confirmed by Singh and Dhaduk (2005). Embedding methods were found appropriate for maintaining shape of foliages as it recommended for drying to get three dimensional views (Singh and Dhaduk 2005). It was observed through our experiment that glycerin uptake was increased with the increase of extended absorption duration. Utmost moisture loss percentage was obtained in *Thuja orientalis* leaves under hot-air-oven drying after 96 hours absorption in 1:1 glycerin-water solution. Similar findings also reported by Joyce and Dubious (1992). So owing to great availability of variety of plants, flowers and other artistic raw materials India has got enormous scope to propagate this field since dry flower market is still small in comparison to that of the fresh flower market might be due to more recent introduction in the floricultural trade.

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