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STANDARDIZATION OF DRYING METHODS FOR VALUE ADDITION OF ORNAMENTAL FOLIAGE IN *ARAUCARIA HETEROPHYLLA, JUNIPERUS SQUAMATA* AND *GREVILLEA ROBUSTA*

Vishnupriya K.V.[1*], Kunal Adhikary[1], Abhirami A.[1], MiluNalwa N.[1], Nafees Khan[3] and Sahim Khan[3]

[1]Department of Floriculture and Landscaping, School of Agricultural Sciences, GD Goenka University, Sohna Road, Gurugram-Haryana, India

[2]Department of Agronomy, School of Agricultural Sciences, GD Goenka University, Sohna Road, Gurugram-Haryana, India

*Corresponding author E-mail: vishnupriyaky85@gmail.com

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ABSTRACT

The goal of the study was to improve the postharvest quality, shelf life, and acceptability of three attractive foliage species *Araucaria heterophylla, Juniperus squamata, and Grevillea robusta* for commercial decorative use by standardizing effective drying methods. There are eight treatments including glycerinization,silica gel embedding, air drying, hot air oven drying, sand drying, and a control were assessed using a two-factorial completely randomized design. While sensory characteristics like texture, brittleness, form, and color were evaluated on the ninth day using a 9-point Hedonic scale, leaf length, width, weight, and area were measured at four intervals. Significant effects of species, drying technique, and their interactions were revealed by the results. By allowing homogeneous moisture removal or cellular water replacement, silica gel drying with moderate glycerin concentrations (10–20%) successfully reduced shrinkage, maintained structural integrity, and retained color. Rapid dehydration brought on by a hot air oven and sand drying resulted in brittleness, distortion, and pigment loss. *Juniperus squamata* showed the most shrinkage and quality loss, while *Grevillea robusta* showed the greatest resistance to desiccation. Overall, the best techniques for creating stable, visually pleasing dried vegetation with increased market potential were found to be regulated desiccation and glycerinization.

***Key words*:** Brittleness, Drying, Dehydration, Desiccation, Embedding, Glycerinization, Shelf life

Introduction

Floriculture is one of the most promising branches of horticulture and has emerged as a profitable business in many parts of the world. Cut flowers and foliages contribute the most to the global floriculture trade. Though, their shelf life is limited to just a few days, which decrease their longevity. The scope of flower and leaf drying is growing due to customer preferences for long-lasting and environmentally friendly ornamental materials. To achieve consistent quality, color preservation, and structural integrity, drying processes must be standardized and subjected to rigorous research. Globally, the dry flower and foliage industry has enormous potential, especially in India's mountainous regions. It is possible to properly dry and preserve around 80% of flower species worldwide, and the availability of wild plant resources contributes to the industry's expansion. Because dry flower technology can be used to generate a plethora of aesthetically pleasing and decorative items, this business also offers substantial employment prospects, particularly for housewives and rural women. Therefore, in order to fully realize its potential, market value must be increased, government funding must be provided, and entrepreneurship must be encouraged through conferences, workshops, exhibitions, and training programs. (Vidhya *et al*., 2021; Rani & Reddy, 2015).

Native to Norfolk Island and a member of the Araucariaceae family, the evergreen conifer *Araucaria heterophylla* is prized for both indoor and outdoor decorative applications due to its symmetrical growth habit and rich green leaves. It is a popular choice for wreaths, floral arrangements, and craft applications because of its delicate, needle-like leaves. However, the use of fresh greenery in long-lasting compositions is limited due to its short shelf life and quick loss of turgidity in ambient settings. In order to preserve the leave's structural integrity, keep them green, and turn them into lightweight, portable materials with significant commercial potential in the decorative business, appropriate drying is crucial (Kumari *et al.*, 2024). The evergreen shrub or small tree *Juniperus squamata*, also known as Himalayan juniper belongs to the family Cupressaceae. It is mainly grown for its lovely silvery-blue, needle-like leaf and spreading growth habit. For *Juniperus squamata*, to maintain foliage quality, aroma, and bioactive components, drying is essential. Drying is an essential post-harvest procedure that lowers moisture content and guards against microbial spoiling, discoloration, and quality degradation while being stored. In order to provide a longer shelf life and a greater market value, proper drying techniques assist maintain the foliage's original color, fragrance, and chemical

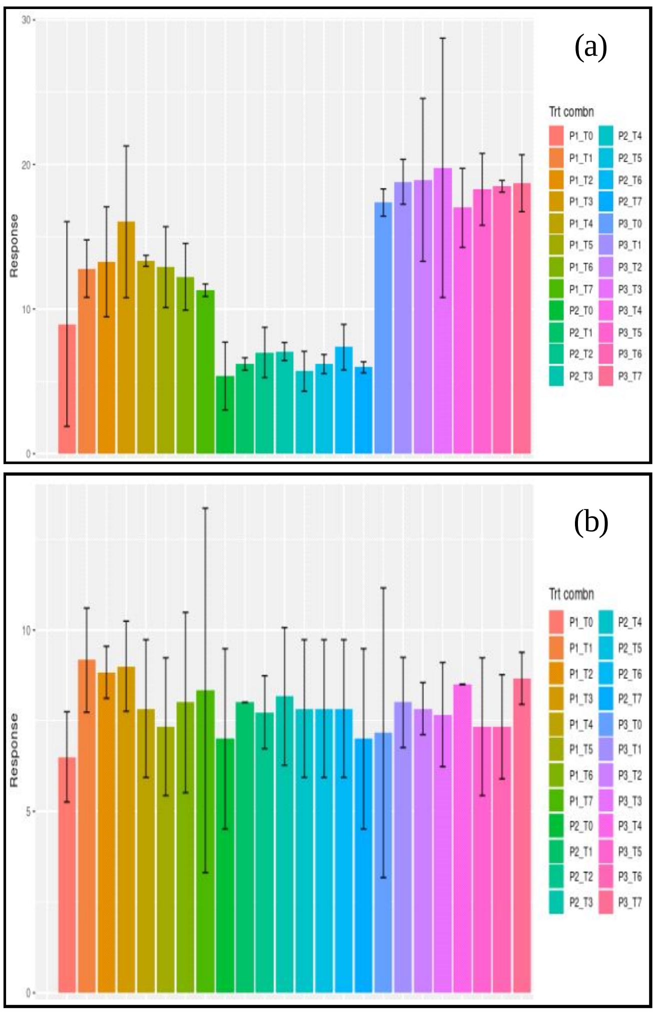

Fig. 1: Effect of different drying methods on (a)leaf length (b)leaf texture.

Fig. 2: Glycerinization in, *Grevillea robusta*, *Araucaria heterophyllaand Juniperussquamata*, on first day.

content. Additionally, dried foliage becomes lighter and more manageable, making it appropriate for commercial use in floriculture, fragrance, and traditional crafts. Similar to this, *Grevillea robusta*, an evergreen tree in the Proteaceae family that is widely grown in tropical and subtropical areas for its timber, aesthetic value, and use as a shade tree in tea and coffee plantations, is native to eastern Australia. It is also known as silk oak or silver oak. Its leaves are also utilized in landscape decorating, floral arrangements, and environmentally friendly crafts. Its leaf must be dried in order to maintain its utility, structure, and aesthetic appeal throughout time. Improper drying can cause wilting, discoloration, and microbial deterioration because young leaves have a high moisture content (Macchindra and Khandekar, 2025). For dried floral designs, interior decor, and other value-added floriculture goods, controlled drying preserves the foliage's original color, texture, and form. Additionally, dried foliage has a longer shelf life, is lighter, and is easier to transport and store, which increases its commercial potential and reduces post-harvest losses.

In small-scale floriculture, air drying is a straightforward, inexpensive technique where freshly picked foliage is knotted in bunches and hung upside down

Fig. 3: Effect of glycerinization in *Araucaria heterophylla*, *Juniperussquamata*, *Grevillea robusta*on ninth day.

Table 1: Effect of species and drying treatments on leaf length (cm) at different observation periods.

Factor A	**Y1**	**Y2**	**Y3**	**Y4**
a1	14.45 ± 1.10^{b}	14.00 ± 1.46^{b}	12.68 ± 1.87^{b}	12.60 ± 2.28^{b}
a2	7.92 ± 0.56^{c}	7.77 ± 0.60^{c}	6.89 ± 0.76^{c}	6.36 ± 0.81^{c}
a3	20.83 ± 1.54^{a}	20.53 ± 2.01^{a}	19.04 ± 1.75^{a}	18.42 ± 1.61^{a}
CD (A)	0.63	0.79	0.74	0.76
SE(m)	0.22	0.28	0.26	0.27
SE(d)	0.31	0.39	0.37	0.38
Factor B	**Y1**	**Y2**	**Y3**	**Y4**
b1	13.36 ± 5.29^{b}	12.84 ± 5.47^{c}	11.07 ± 5.47^{d}	10.57 ± 5.54^{c}
b2	15.13 ± 5.92^{a}	14.59 ± 5.83^{ab}	13.21 ± 5.49^{abc}	12.60 ± 5.48^{b}
b3	14.99 ± 5.93^{a}	14.78 ± 5.85^{ab}	13.74 ± 5.57^{ab}	13.07 ± 5.36^{ab}
b4	14.90 ± 5.85^{a}	15.30 ± 6.34^{a}	14.20 ± 5.78^{a}	14.29 ± 6.03^{a}
b5	14.18 ± 5.39^{ab}	13.54 ± 5.05^{bc}	12.16 ± 4.98^{cd}	12.01 ± 5.03^{b}
b6	14.19 ± 5.56^{ab}	13.97 ± 5.53^{bc}	12.76 ± 5.28^{bc}	12.46 ± 5.30^{b}
b7	14.22 ± 5.24^{ab}	13.73 ± 4.94^{bc}	12.89 ± 4.85^{bc}	12.70 ± 4.86^{b}
b8	14.27 ± 6.21^{ab}	14.06 ± 6.26^{abc}	12.94 ± 5.87^{bc}	11.99 ± 5.55^{b}
CD (B)	1.03	1.28	1.21	1.25
SE(m)	0.36	0.45	0.43	0.44
SE(d)	0.51	0.64	0.6	0.62
A×B	**Y1**	**Y2**	**Y3**	**Y4**
a1×b1	12.73 ± 0.31	11.53 ± 1.63	9.26 ± 1.98	8.97 ± 2.85
a1×b2	15.33 ± 1.43	14.10 ± 0.52	13.30 ± 0.85	12.80 ± 0.80
a1×b3	15.27 ± 0.81	15.30 ± 1.14	13.90 ± 1.48	13.27 ± 1.53
a1×b4	15.20 ± 0.69	15.57 ± 1.32	14.83 ± 1.62	16.03 ± 2.11
a1×b5	14.60 ± 0.66	14.13 ± 0.85	12.80 ± 1.05	13.33 ± 0.15
a1×b6	14.50 ± 1.22	14.23 ± 1.10	12.93 ± 1.12	12.90 ± 1.13
a1×b7	14.23 ± 0.55	13.70 ± 0.61	12.16 ± 0.24	12.23 ± 0.93
a1×b8	13.77 ± 0.35	13.47 ± 0.47	12.27 ± 0.31	11.30 ± 0.17
a2×b1	7.60 ± 0.62	7.37 ± 0.64	6.00 ± 0.92	5.37 ± 0.95
a2×b2	8.30 ± 0.10	8.13 ± 0.12	6.86 ± 0.05	6.20 ± 0.17
a2×b3	8.23 ± 0.59	8.03 ± 0.61	7.50 ± 0.50	7.00 ± 0.70
a2×b4	8.20 ± 0.36	8.33 ± 0.50	7.67 ± 0.32	7.07 ± 0.25
a2×b5	7.80 ± 0.80	7.53 ± 0.81	6.20 ± 0.56	5.70 ± 0.56
a2×b6	7.67 ± 0.32	7.50 ± 0.26	6.63 ± 0.21	6.20 ± 0.26
a2×b7	8.20 ± 0.78	8.07 ± 0.72	7.70 ± 0.69	7.37 ± 0.64
a2×b8	7.40 ± 0.26	7.20 ± 0.26	6.57 ± 0.21	5.97 ± 0.15
a3×b1	19.73 ± 0.31	19.63 ± 0.32	17.97 ± 0.15	17.37 ± 0.38
a3×b2	21.77 ± 1.47	21.53 ± 0.81	19.47 ± 0.58	18.80 ± 0.62
a3×b3	21.47 ± 2.89	21.00 ± 2.94	19.83 ± 2.70	18.93 ± 2.27
a3×b4	21.30 ± 2.69	22.00 ± 4.33	20.10 ± 3.73	19.77 ± 3.61
a3×b5	20.13 ± 0.85	18.97 ± 1.38	17.47 ± 1.25	17.00 ± 1.10
a3×b6	20.40 ± 0.46	20.17 ± 0.71	18.70 ± 0.95	18.28 ± 1.00
a3×b7	20.23 ± 0.61	19.43 ± 0.06	18.80 ± 0.17	18.49 ± 0.16
a3×b8	21.63 ± 1.18	21.50 ± 1.59	20.00 ± 1.08	18.70 ± 0.79
CD (A×B)	-	-	-	-
SE(m)	0.63	0.78	0.74	0.76
SE(d)	0.89	1.11	1.04	1.08

Y1- Leaf length at 0^{th} day; Y2- Leaf length at 3^{rd} day; Y3- Leaf length at 6^{th} day; Y4- Leaf length at 9^{th} day; a1- *Araucaria heterophylla* ; a2- *Juniperus squamata* ; a3- *Grevillea robusta* ; b0-Control; b1-Glycerine 40%; b2- Glycerine 20%; b3- Glycerine 10%; b4-Silica gel;b5-Air dry; b6-Hot air oven; b7- Sand

in a ventilated, shaded area to gradually lose moisture. Although the process may take days or weeks, ideal temperatures are 25–35°C and 40–60% humidity to prevent yellowing, fading, and microbial growth (Jain *et al.*, 2016). Although it develops slower, weather-sensitive, and may make delicate leaves brittle, it works well for robust foliage. By spreading leaves on trays in a heated oven at 40–60°C for a few hours to a day, hot air oven drying provides quicker, more controlled drying while maintaining color, texture, and lowering contamination (Raghupathi and Gantait, 2024). However, it necessitates energy, equipment, and supervision. Sand drying is a low-cost but labor-intensive method of preserving the shape and fine features of fragile foliage by burying leaves in dry sand in a ventilated, shady area for a few days to two weeks (Singh and Laishran, 2010). In contrast, glycerin drying is soaking leaves or stems in a solution of glycerin and water, which replaces natural moisture and preserves color while keeping foliage supple, flexible, and long-lasting (Bhardwaj *et al*., 2021). When making crafts and beautiful arrangements where a natural, malleable aspect is sought, this technique is particularly helpful.

Materials and Methods

In the present investigation titled "standardization of drying methods for value addition of ornamental foliage in *Araucaria heterophylla*, *Juniperus squamata* AND *Grevillea robusta*", experiments were initiated in February 2025-2026 in the Horticultural Laboratory of our institution, G. D. Goenka Horticultural Laboratory situated in Sohna, Gurugram, Haryana, India, located at approximately 28°152 N latitude and 77°042 E longitude, targeting three ornamental foliage species: *Araucaria heterophylla*, *Juniperussquamata* and *Grevillea robusta*. The experiment consisted of eight treatments, each representing a specific drying or preservation technique. Treatment T€ served as the control, in which no drying or chemical treatment was applied. This treatment acted as a baseline for comparing the effects of other methods on foliage quality and moisture loss. Treatment T_1 involved 40% glycerining, where foliage samples were immersed in a glycerin–water solution (Fig. 2). Glycerin, being a hygroscopic compound, replaces the natural moisture within plant tissues,

Table 2: Effect of species and drying treatments on leaf width (cm) at different observation periods.

Factor A	Y5	Y6	Y7	Y8
a1	14.28 ± 1.80^{a}	13.80 ± 2.32^{a}	12.48 ± 2.23^{a}	11.97 ± 2.38^{a}
a2	3.05 ± 0.60^{c}	2.62 ± 0.57^{c}	2.33 ± 0.63^{b}	2.37 ± 0.58^{b}
a3	12.61 ± 1.74^{b}	12.27 ± 1.63^{b}	12.10 ± 1.59^{a}	11.91 ± 1.58^{a}
CD (A)	0.71	0.78	0.74	0.83
SE(m)	0.25	0.27	0.26	0.29
SE(d)	0.36	0.39	0.37	0.41
Factor B	**Y5**	**Y6**	**Y7**	**Y8**
b1	8.84 ± 4.88^{d}	8.96 ± 5.09^{cd}	8.24 ± 4.73^{cde}	8.12 ± 4.57^{cd}
b2	11.01 ± 6.12^{ab}	10.48 ± 6.09^{ab}	9.39 ± 5.67^{abc}	9.36 ± 5.70^{abc}
b3	10.58 ± 5.56^{abc}	10.22 ± 5.59^{ab}	9.71 ± 5.41^{ab}	9.58 ± 5.47^{ab}
b4	11.41 ± 5.90^{a}	10.92 ± 5.97^{a}	10.54 ± 5.82^{a}	10.26 ± 5.69^{a}
b5	9.93 ± 5.63^{bcd}	9.93 ± 6.17^{abc}	9.21 ± 5.49^{bcd}	8.38 ± 4.49^{bcd}
b6	9.18 ± 4.64^{d}	8.54 ± 4.39^{d}	8.18 ± 4.42^{de}	8.03 ± 4.44^{cd}
b7	9.72 ± 5.24^{cd}	9.30 ± 5.37^{bcd}	8.93 ± 5.35^{bcd}	8.89 ± 5.39^{bc}
b8	9.16 ± 4.94^{d}	8.12 ± 4.54^{d}	7.53 ± 4.25^{e}	7.37 ± 4.00^{d}
CD (B)	1.17	1.27	1.21	1.36
SE(m)	0.41	0.45	0.43	0.48
SE(d)	0.58	0.63	0.6	0.67
A×B	**Y5**	**Y6**	**Y7**	**Y8**
a1×b1	12.87 ± 1.31	12.63 ± 1.30	10.71 ± 0.99^{de}	10.47 ± 1.05
a1×b2	15.63 ± 3.13	15.37 ± 3.13	13.07 ± 3.65^{abc}	12.53 ± 4.16
a1×b3	14.20 ± 0.62	13.97 ± 0.78	12.93 ± 0.64^{abc}	13.13 ± 0.12
a1×b4	15.83 ± 0.23	15.27 ± 0.95	14.37 ± 0.51^{a}	14.10 ± 0.62
a1×b5	15.13 ± 0.86	15.97 ± 2.44	14.17 ± 1.07^{a}	11.33 ± 2.10
a1×b6	13.23 ± 1.56	12.13 ± 1.93	11.57 ± 2.15^{bcde}	11.43 ± 2.17
a1×b7	14.13 ± 2.46	13.97 ± 2.60	13.43 ± 2.42^{ab}	13.53 ± 2.84
a1×b8	13.17 ± 1.48	11.07 ± 1.01	9.60 ± 0.44^{e}	9.20 ± 0.40
a2×b1	2.50 ± 0.53	2.27 ± 0.64	2.03 ± 0.67^{f}	2.13 ± 0.25
a2×b2	3.23 ± 0.57	2.77 ± 0.55	2.27 ± 0.86^{f}	2.37 ± 0.78
a2×b3	3.30 ± 0.95	2.90 ± 0.61	2.63 ± 0.57^{f}	2.40 ± 0.36
a2×b4	3.60 ± 0.85	3.03 ± 1.01	2.83 ± 1.02^{f}	2.73 ± 1.10
a2×b5	2.73 ± 0.15	2.33 ± 0.15	2.17 ± 0.35^{f}	2.60 ± 0.10
a2×b6	3.23 ± 0.35	2.93 ± 0.35	2.53 ± 0.61^{f}	2.40 ± 0.96
a2×b7	3.07 ± 0.55	2.53 ± 0.55	2.13 ± 0.67^{f}	2.13 ± 0.51
a2×b8	2.77 ± 0.25	2.17 ± 0.25	2.00 ± 0.26^{f}	2.17 ± 0.29
a3×b1	11.17 ± 0.72	11.97 ± 0.76	11.97 ± 0.55^{bcd}	11.77 ± 0.55
a3×b2	14.17 ± 1.44	13.30 ± 1.15	12.83 ± 0.72^{abc}	13.17 ± 1.40
a3×b3	14.23 ± 1.75	13.80 ± 1.84	13.57 ± 1.81^{ab}	13.20 ± 1.87
a3×b4	14.80 ± 0.66	14.47 ± 0.61	14.43 ± 0.72^{a}	13.93 ± 0.65
a3×b5	11.93 ± 1.25	11.50 ± 1.25	11.30 ± 1.25^{cde}	11.20 ± 1.11
a3×b6	11.07 ± 0.76	10.57 ± 0.70	10.43 ± 0.75^{de}	10.27 ± 0.80
a3×b7	11.97 ± 0.64	11.40 ± 0.70	11.23 ± 0.67^{cde}	11.00 ± 0.69
a3×b8	11.54 ± 1.24	11.13 ± 1.26	11.00 ± 1.21^{cde}	10.73 ± 1.02
CD (A×B)	-	-	2.09	-
SE(m)	0.71	0.77	0.74	0.83
SE(d)	1	1.09	1.04	1.17

Y5- Leaf width at 0th day; Y6- Leaf width at 3rd day; Y7- Leaf width at 6th day; Y8- Leaf width at 9thday; a1- *Araucaria heterophylla* ; a2- *Juniperus squamata* ; a3- *Grevillea robusta* ; b0-Control; b1-Glycerine 40%; b2- Glycerine 20%; b3- Glycerine 10%; b4-Silica gel; b5-Air dry; b6-Hot air oven; b7- Sand

maintaining flexibility and a natural appearance after drying. Similarly, (Fig. 3), T_2 and T_3 consisted of 20% and 10% glycerining, respectively. Treatment T_4 employed the embedded silica gel drying method, in which foliage samples were carefully buried in silica gel crystals to allow controlled desiccation by absorbing moisture while preserving the original shape and structure of leaves. Treatment T_5, the air drying method, relied on natural evaporation under ambient laboratory conditions, representing a simple and cost-effective traditional approach. Treatment T_6 involved the hot air oven drying method**,** where samples were dried at a controlled temperature to achieve faster dehydration, enabling the study of the effects of artificial heat on foliage color and brittleness. Finally, Treatment T_7 used the sand drying method**,** in which leaves were embedded in fine, clean sand to absorb moisture gradually, promoting uniform drying with minimal deformation.

The leaf length and leaf width of *Araucaria heterophylla*, *Juniperus squamata*, and *Grevillea robusta* was measured on the 0th, 3rd, 6th, and 9th days of the experiment using a standard measuring scale. Measurements were taken carefully at each interval to record any changes during the drying process, which helped in assessing the extent of shrinkage and structural changes occurring under different drying treatments. The leaf weight of *Araucaria heterophylla*, *Juniperus squamata*, and *Grevillea robusta* was measured on the 0th, 3rd, 6th, and 9th days of the experiment using a digital weighing balance. Weights were recorded at each interval to determine the progressive loss of moisture content during the drying period, which helped in evaluating the efficiency of different drying treatments on dehydration rate and final dry matter content. Sensory parameters such as texture, brittleness, shape, and color were evaluated on the ninth day using a 9-point Hedonic scale, where a higher score indicated superior quality and greater resemblance to fresh foliage (Fig. 1). This evaluation helped determine the overall aesthetic quality and effectiveness of each drying treatment.

Statistical analysis

In order to examine the individual and combined effects of two independent factors

Table 3: Effect of species and drying treatments on leaf weight (cm) at different observation periods.

Factor A	**Y9**	**Y10**	**Y11**	**Y12**
a1	8.08 ± 2.00^{a}	7.28 ± 2.66^{a}	6.80 ± 2.65^{a}	6.30 ± 2.55^{a}
a2	0.90 ± 0.16^{c}	0.88 ± 0.48^{c}	0.77 ± 0.49^{c}	0.65 ± 0.41^{c}
a3	1.99 ± 0.48^{b}	1.89 ± 1.05^{b}	1.65 ± 1.07^{b}	1.50 ± 1.05^{b}
CD (A)	0.65	0.66	0.63	0.55
SE(m)	0.23	0.23	0.22	0.19
SE(d)	0.32	0.33	0.32	0.27
Factor B	**Y9**	**Y10**	**Y11**	**Y12**
b1	3.54 ± 3.66	2.70 ± 2.70^{bc}	2.39 ± 2.54^{bc}	2.21 ± 2.40^{bc}
b2	4.00 ± 3.83	4.56 ± 4.08^{a}	4.27 ± 3.96^{a}	4.01 ± 3.86^{a}
b3	3.94 ± 3.53	4.60 ± 3.78^{a}	4.37 ± 3.66^{a}	4.05 ± 3.62^{a}
b4	4.37 ± 4.08	4.98 ± 4.01^{a}	4.75 ± 3.79^{a}	4.57 ± 3.70^{a}
b5	3.76 ± 3.95	3.07 ± 3.52^{b}	2.79 ± 3.30^{b}	2.10 ± 2.10^{bc}
b6	2.58 ± 2.04	1.87 ± 1.68^{c}	1.66 ± 1.55^{c}	1.52 ± 1.60^{c}
b7	3.69 ± 3.60	2.10 ± 2.20^{bc}	1.79 ± 2.02^{bc}	1.64 ± 1.93^{bc}
b8	3.38 ± 3.16	2.95 ± 3.10^{b}	2.58 ± 3.02^{bc}	2.42 ± 2.90^{b}
CD (B)	-	1.07	1.04	0.9
SE(m)	0.37	0.38	0.36	0.32
SE(d)	0.53	0.53	0.52	0.45
A×B	**Y9**	**Y10**	**Y11**	**Y12**
a1×b1	8.31 ± 1.28	6.21 ± 1.07^{bc}	5.68 ± 1.05^{bc}	5.30 ± 1.24^{b}
a1×b2	8.71 ± 2.62	9.54 ± 2.75^{a}	9.10 ± 2.73^{a}	8.67 ± 2.90^{a}
a1×b3	8.53 ± 0.65	9.46 ± 1.28^{a}	9.09 ± 1.25^{a}	8.72 ± 1.14^{a}
a1×b4	9.69 ± 1.12	10.03 ± 2.02^{a}	9.49 ± 1.98^{a}	9.24 ± 1.63^{a}
a1×b5	8.51 ± 3.34	7.28 ± 3.02^{b}	6.79 ± 2.66^{b}	4.87 ± 0.02^{bc}
a1×b6	5.23 ± 0.42	4.04 ± 0.39^{d}	3.67 ± 0.58^{d}	3.61 ± 0.35^{cd}
a1×b7	8.10 ± 2.61	4.68 ± 1.92^{cd}	4.05 ± 2.06^{cd}	3.72 ± 2.17^{cd}
a1×b8	7.55 ± 0.41	7.05 ± 0.56^{b}	6.56 ± 0.70^{b}	6.24 ± 0.71^{b}
a2×b1	0.76 ± 0.11	0.66 ± 0.17^{h}	0.52 ± 0.11^{g}	0.47 ± 0.11^{g}
a2×b2	0.92 ± 0.35	1.14 ± 0.48^{gh}	1.01 ± 0.42^{efg}	0.88 ± 0.28^{fg}
a2×b3	0.94 ± 0.06	1.45 ± 0.32^{fgh}	1.42 ± 0.39^{efg}	1.03 ± 0.24^{efg}
a2×b4	0.98 ± 0.20	1.57 ± 0.31^{efgh}	1.47 ± 0.25^{efg}	1.31 ± 0.34^{efg}
a2×b5	0.96 ± 0.12	0.73 ± 0.05^{h}	0.64 ± 0.09^{g}	0.57 ± 0.14^{g}
a2×b6	0.85 ± 0.19	0.47 ± 0.19^{h}	0.50 ± 0.06^{g}	0.37 ± 0.15^{g}
a2×b7	0.90 ± 0.10	0.39 ± 0.30^{h}	0.23 ± 0.18^{g}	0.21 ± 0.18^{g}
a2×b8	0.87 ± 0.09	0.65 ± 0.09^{h}	0.36 ± 0.06^{g}	0.33 ± 0.06^{g}
a3×b1	1.54 ± 0.40	1.23 ± 0.38^{fgh}	0.97 ± 0.29^{efg}	0.87 ± 0.25^{fg}
a3×b2	2.38 ± 0.53	2.99 ± 0.60^{def}	2.71 ± 0.67^{de}	2.48 ± 0.62^{de}
a3×b3	2.33 ± 0.71	2.87 ± 0.79^{defg}	2.59 ± 0.78^{def}	2.40 ± 0.77^{def}
a3×b4	2.44 ± 0.12	3.35 ± 0.72^{de}	3.30 ± 0.61^{d}	3.16 ± 0.53^{d}
a3×b5	1.81 ± 0.28	1.20 ± 0.67^{fgh}	0.93 ± 0.58^{efg}	0.87 ± 0.52^{fg}
a3×b6	1.66 ± 0.38	1.08 ± 0.33^{gh}	0.81 ± 0.33^{fg}	0.57 ± 0.44^{g}
a3×b7	2.08 ± 0.28	1.22 ± 0.13^{fgh}	1.08 ± 0.11^{efg}	0.98 ± 0.02^{efg}
a3×b8	1.71 ± 0.08	1.15 ± 0.34^{fgh}	0.81 ± 0.33^{fg}	0.68 ± 0.41^{g}
CD (A×B)	-	1.85	1.8	1.55
SE(m)	0.65	0.65	0.63	0.55
SE(d)	0.91	0.92	0.89	0.77

Y9- Leaf weight at 0th day; Y10- Leaf weight at 3rd day; Y11- Leaf weight at 6th day; Y12- Leaf weight at 9th day; a1- *Araucaria heterophylla* ; a2- *Juniperus squamata* ; a3- *Grevillea robusta* ; b0-Control; b1-Glycerine 40%; b2- Glycerine 20%; b3- Glycerine 10%; b4-Silica gel; b5-Air dry; b6-Hot air oven; b7- Sand

drying methods and ornamental foliage species the experiment employed a two-factorial design within a Completely Randomized Design (CRD). These variables were used to create eight treatment combinations, each of which was repeated three times to guarantee dependability. Three leaves were used as the sampling unit to measure the response variables within each replication. This design made the analysis statistically sound and the results more broadly applicable by enabling precise estimation of the major effects of each factor, their interaction, and the experimental error. The Resin and Grapes program, created by Kerala Agricultural University, was used for statistical analysis, allowing for effective data calculation and interpretation. A p-value of less than 0.05 indicated that there were significant differences between treatments. Duncan's Multiple Range Test (DMRT) was used to further identify particular treatment differences, offering more lucid insights into pair wise comparisons of treatment means. All things considered, the factorial CRD provided a useful framework for assessing several factors at once, particularly where interaction effects are relevant.

Result and Discussion

Leaf length (cm)

The greatest average values was recorded in *Grevillea robusta* (a_3) and *Juniperussquamata* (a_2) the lowest, while *Araucaria heterophylla* (a_1) showed intermediate results (Table 1). Factor A (species) demonstrated a highly significant effect ($p < 0.01$) on leaf length at all growth intervals. Additionally, factor B (drying or preservation treatments) showed a substantial impact ($p < 0.05$ or $p \le 0.01$), with the control (b_1) exhibiting the largest shrinkage and silica gel drying (b_1) keeping the longest leaves. By preserving tissue elasticity and lowering dehydration stress through moisture replacement effects, glycerin treatments (particularly 20–40%) some what protected leaf length (Mir., 2021). *G. robusta* under silica gel or glycerin drying demonstrated the best retention, whereas *J. squamata* under control conditions had the worst, despite the fact that the species × treatment (A×B) interaction was not statistically significant. Overall, the findings show that *G. robusta* was more resistant to

Table 4: Effect of species and drying treatments on leaf area (cm^2) at different observation periods.

Factor A	Y13	Y14	Y15	Y16
a1	206.64 ± 32.28^{b}	195.61 ± 42.30^{b}	159.53 ± 40.98^{b}	152.96 ± 48.19^{b}
a2	24.32 ± 5.64^{c}	20.50 ± 5.60^{c}	16.22 ± 5.44^{c}	15.12 ± 4.56^{c}
a3	263.38 ± 46.55^{a}	252.49 ± 47.58^{a}	230.79 ± 41.69^{a}	219.67 ± 38.24^{a}
CD (A)	13.39	15.24	13.42	14.42
SE(m)	4.71	5.36	4.72	5.07
SE(d)	6.66	7.58	6.67	7.17
Factor B	**Y13**	**Y14**	**Y15**	**Y16**
a1	206.64 ± 32.28^{b}	195.61 ± 42.30^{b}	159.53 ± 40.98^{b}	152.96 ± 48.19^{b}
a2	24.32 ± 5.64^{c}	20.50 ± 5.60^{c}	16.22 ± 5.44^{c}	15.12 ± 4.56^{c}
a3	263.38 ± 46.55^{a}	252.49 ± 47.58^{a}	230.79 ± 41.69^{a}	219.67 ± 38.24^{a}
CD (A)	13.39	15.24	13.42	>
SE(m)	4.71	5.36	4.72	5.07
SE(d)	6.66	7.58	6.67	7.17
A×B	**Y13**	**Y14**	**Y15**	**Y16**
a1×b1	163.90 ± 18.20^{f}	147.07 ± 34.63^{f}	100.20 ± 28.18^{i}	95.85 ± 39.20^{g}
a1×b2	238.08 ± 40.67^{bc}	228.92 ± 39.81^{bc}	172.56 ± 44.14^{fg}	159.17 ± 49.98^{ef}
a1×b3	216.47 ± 4.15^{bcde}	213.11 ± 3.85^{bcd}	179.14 ± 9.71^{efg}	174.27 ± 20.72^{def}
a1×b4	240.72 ± 13.06^{b}	238.39 ± 33.76^{b}	213.51 ± 29.55^{cde}	226.91 ± 38.68^{bc}
a1×b5	220.57 ± 2.89^{bcd}	224.34 ± 21.21^{bc}	180.80 ± 10.93^{efg}	151.29 ± 29.65^{ef}
a1×b6	190.70 ± 9.31^{def}	172.17 ± 24.49^{def}	148.84 ± 23.16^{gh}	145.90 ± 14.55^{f}
a1×b7	201.32 ± 37.88^{cdef}	191.63 ± 39.53^{cde}	163.40 ± 30.28^{fg}	166.30 ± 43.06^{def}
a1×b8	181.39 ± 22.40^{ef}	149.24 ± 17.64^{ef}	117.84 ± 8.16^{hi}	103.96 ± 4.83^{g}
a2×b1	18.90 ± 3.54^{g}	16.56 ± 4.12^{g}	12.53 ± 5.78^{j}	11.59 ± 3.25^{h}
a2×b2	26.81 ± 4.53^{g}	22.50 ± 4.51^{g}	15.57 ± 6.02^{j}	14.65 ± 4.80^{h}
a2×b3	27.42 ± 9.15^{g}	23.50 ± 6.30^{g}	19.57 ± 3.11^{j}	16.63 ± 0.98^{h}
a2×b4	29.33 ± 5.80^{g}	25.45 ± 9.54^{g}	21.83 ± 8.32^{j}	19.47 ± 8.48^{h}
a2×b5	21.40 ± 3.38^{g}	17.64 ± 2.93^{g}	13.51 ± 3.12^{j}	14.78 ± 0.90^{h}
a2×b6	24.81 ± 3.17^{g}	22.02 ± 2.99^{g}	16.84 ± 4.37^{j}	15.01 ± 6.53^{h}
a2×b7	25.38 ± 6.76^{g}	20.66 ± 6.26^{g}	16.73 ± 6.87^{j}	15.92 ± 5.26^{h}
a2×b8	20.52 ± 2.56^{g}	15.64 ± 2.35^{g}	13.17 ± 2.18^{j}	12.91 ± 1.38^{h}
a3×b1	220.39 ± 15.48^{bcd}	234.81 ± 11.88^{b}	215.04 ± 11.28^{cde}	204.49 ± 14.13^{cd}
a3×b2	309.75 ± 50.86^{a}	286.35 ± 26.83^{a}	249.70 ± 12.94^{bc}	247.10 ± 20.64^{ab}
a3×b3	306.21 ± 59.95^{a}	291.16 ± 65.22^{a}	269.63 ± 55.77^{ab}	250.15 ± 47.95^{ab}
a3×b4	314.15 ± 28.02^{a}	316.91 ± 54.26^{a}	289.39 ± 50.89^{a}	274.02 ± 40.49^{a}
a3×b5	239.91 ± 21.65^{b}	217.19 ± 14.40^{bc}	196.33 ± 7.63^{def}	189.59 ± 6.66^{cde}
a3×b6	225.73 ± 15.78^{bcd}	213.00 ± 14.23^{bcd}	195.39 ± 21.99^{def}	187.99 ± 22.78^{cde}
a3×b7	242.12 ± 14.51^{b}	221.53 ± 13.36^{bc}	211.23 ± 13.73^{de}	203.39 ± 11.98^{cd}
a3×b8	248.79 ± 14.71^{b}	238.97 ± 28.46^{b}	219.61 ± 22.88^{cd}	200.63 ± 21.06^{cd}
CD (A×B)	37.88	43.11	37.95	40.8
SE(m)	13.32	15.16	13.35	14.35
SE(d)	18.84	21.44	18.88	20.29

Y13- Leaf area at 0th day; Y14- Leaf area at 3rd day; Y15- Leaf area at 6th day; Y16- Leaf area at 9th day; a1- *Araucaria heterophylla* ; a2- *Juniperus squamata* ; a3- *Grevillea robusta* ; b0-Control; b1-Glycerine 40%; b2- Glycerine 20%; b3- Glycerine 10%; b4-Silica gel; b5-Air dry; b6-Hot air oven; b7- Sand;

desiccation and that, in contrast to quick or severe drying techniques like air or oven drying, glycerinization, which replaces cellular water with a humectants effectively preserved leaf structure and pliability (Kant, 2018; Kotla *et al.*, 2022).

Leaf width (cm)

The study found that both species (factor A) and preservation techniques (factor B) significantly ($p < 0.01$) influenced leaf width across all observation periods (Table 2). Silica gel drying (b_1) and glycerin at 20% and 10% (b_2, b_3) were the most successful preservation methods in reducing shrinkage, preserving structural integrity by controlling moisture loss, and averting cell collapse (Singh and Kumar, 2023).

On the other hand, due to mechanical stress and cell wall rupture, fast dehydration using a hot air oven (b_2) and sand drying resulted in significant width decreases. Biologically significant trends revealed that Araucaria under silica gel or glycerin treatments demonstrated greater width preservation compared to Juniperus, demonstrating species-specific anatomical robustness, even if the interaction (A×B) was only significant at the sixth day (Nakra, 2025). The degree of shrinkage resistance and preservation efficacy was influenced by the combination of species morphology and drying intensity, whereas moderate glycerin concentrations generally offered the greatest balance between infiltration and stability.

Leaf weight (g)

The ANOVA results showed that both species (factor A) and preservation techniques (factor B) significantly affected leaf weight over time (Table 3). *Araucaria heterophylla* had the highest mean weights, followed by *Grevillea robusta* and *Juniperus squamata*, indicating intrinsic species-level variations in biomass and moisture retention (Reddy, 2015). Because glycerin is hygroscopic it replenishes intracellular water, slows down rapid dehydration, and maintains tissue turgidity treatments with glycerin, especially at 20% and 10%, were most successful in preserving leaf weight. Conversely, silica gel and air drying offered only moderate retention, but hot air oven and sand drying

Table 5: Effect of species and drying treatments on leaf width (cm) at different observation periods.

Factor A	Y17	Y18	Y19	Y20
a1	8.12 ± 1.17	7.02 ± 2.14[a]	7.10 ± 1.52	6.62 ± 1.42[ab]
a2	7.68 ± 0.75	6.58 ± 2.07[b]	7.04 ± 1.05	6.50 ± 1.38[b]
a3	7.81 ± 0.81	6.58 ± 1.80[b]	6.71 ± 1.29	6.98 ± 1.17[a]
CD (A)	-	0.37	-	0.37
SE(m)	0.17	0.13	0.15	0.13
SE(d)	0.24	0.18	0.22	0.18
Factor B	**Y17**	**Y18**	**Y19**	**Y20**
b1	6.89 ± 1.02[c]	5.06 ± 0.98[d]	6.39 ± 1.02[bc]	5.28 ± 0.91[d]
b2	8.39 ± 0.70[a]	8.89 ± 0.33[a]	8.28 ± 0.62[a]	8.00 ± 0.35[a]
b3	8.13 ± 0.60[ab]	8.56 ± 0.39[a]	7.89 ± 0.33[a]	8.06 ± 0.63[a]
b4	8.28 ± 0.79[a]	8.50 ± 0.71[a]	8.44 ± 1.01[a]	7.94 ± 0.46[a]
b5	8.06 ± 0.63[ab]	7.83 ± 0.79[b]	6.67 ± 1.03[b]	6.72 ± 1.03[b]
b6	7.50 ± 0.71[bc]	3.78 ± 1.30[e]	5.72 ± 0.97[c]	5.83 ± 0.79[cd]
b7	7.72 ± 0.75[ab]	5.11 ± 0.55[d]	5.89 ± 0.60[c]	6.00 ± 1.20[c]
b8	8.00 ± 1.37[ab]	6.11 ± 0.78[c]	6.33 ± 0.79[bc]	5.78 ± 0.79[cd]
CD (B)	0.77	0.6	0.72	0.6
SE(m)	0.27	0.21	0.25	0.21
SE(d)	0.38	0.3	0.36	0.3
A×B	**Y17**	**Y18**	**Y19**	**Y20**
a1×b1	6.50 ± 0.50	5.67 ± 0.58[def]	6.00 ± 0.50	5.67 ± 0.29[ghij]
a1×b2	9.17 ± 0.58	9.00 ± 0.00[ab]	8.83 ± 0.29	8.17 ± 0.29[ab]
a1×b3	8.83 ± 0.29	9.00 ± 0.00[ab]	7.83 ± 0.29	7.67 ± 0.29[abcd]
a1×b4	9.00 ± 0.50	9.33 ± 0.29[a]	9.17 ± 0.29	8.17 ± 0.29[ab]
a1×b5	7.83 ± 0.76	8.33 ± 1.04[abc]	7.50 ± 0.50	7.50 ± 0.50[abcd]
a1×b6	7.33 ± 0.76	3.50 ± 0.50[hi]	4.83 ± 0.76	5.17 ± 0.29[ij]
a1×b7	8.00 ± 1.00	5.17 ± 0.76[ef]	5.83 ± 0.76	4.67 ± 0.29[j]
a1×b8	8.33 ± 2.02	6.17 ± 0.76[de]	6.83 ± 0.76	6.00 ± 1.32[fghi]
a2×b1	7.00 ± 1.00	5.50 ± 0.87[def]	6.50 ± 1.50	5.00 ± 0.50[ij]
a2×b2	8.00 ± 0.00	8.83 ± 0.29[ab]	7.83 ± 0.76	8.17 ± 0.29[ab]
a2×b3	7.73 ± 0.40	8.33 ± 0.29[abc]	7.83 ± 0.29	8.50 ± 0.50[a]
a2×b4	8.17 ± 0.76	8.17 ± 0.29[bc]	8.17 ± 1.04	7.50 ± 0.50[abcd]
a2×b5	7.83 ± 0.76	7.67 ± 0.76[c]	6.83 ± 1.04	5.50 ± 0.50[hij]
a2×b6	7.83 ± 0.76	2.67 ± 0.76[i]	6.33 ± 1.04	5.67 ± 0.29[ghij]
a2×b7	7.83 ± 0.76	5.17 ± 0.58[ef]	6.33 ± 0.29	6.33 ± 1.04[efgh]
a2×b8	7.00 ± 1.00	6.33 ± 1.04[d]	6.50 ± 0.50	5.33 ± 0.29[hij]
a3×b1	7.17 ± 1.61	4.00 ± 0.50[gh]	6.67 ± 1.15	5.17 ± 1.61[ij]
a3×b2	8.00 ± 0.50	8.83 ± 0.58[ab]	8.17 ± 0.29	7.67 ± 0.29[abcd]
a3×b3	7.83 ± 0.29	8.33 ± 0.29[abc]	8.00 ± 0.50	8.00 ± 0.87[abc]
a3×b4	7.67 ± 0.58	8.00 ± 0.50[bc]	8.00 ± 1.32	8.17 ± 0.29[ab]
a3×b5	8.50 ± 0.00	7.50 ± 0.50[c]	5.67 ± 0.58	7.17 ± 0.58[bcde]
a3×b6	7.33 ± 0.76	5.17 ± 1.04[ef]	6.00 ± 0.50	6.67 ± 0.76[defg]
a3×b7	7.33 ± 0.58	5.00 ± 0.50[fg]	5.50 ± 0.50	7.00 ± 0.50[cdef]
a3×b8	8.67 ± 0.29	5.83 ± 0.76[def]	5.67 ± 0.76	6.00 ± 0.50[fghi]
CD (A×B)	-	1.04	-	1.05
SE(m)	0.47	0.36	0.44	0.37
SE(d)	0.66	0.52	0.62	0.52

Y17- Leaf texture; Y18- Leaf brittleness; Y19- Leaf shape; Y20- Leaf colour ; a1- *Araucaria heterophylla* ; a2- *Juniperus squamata* ; a3- *Grevillea robusta* ; b0-Control; b1-Glycerine 40%; b2- Glycerine 20%; b3- Glycerine 10%; b4-Silica gel; b5-Air dry; b6-Hot air oven; b7- Sand

resulted in significant weight loss due to faster water evacuation and cell breakdown. Treatment performance differed by species, according to significant interaction effects (A×B); Araucaria associated with glycerin treatments (a_1b_2, a_1b_3) maintained the highest weights, whereas Juniperus under oven and sand drying (a_2b_3, a_2b_3) had the largest decreases. Overall, glycerinization was found to be more effective for long-term stabilization; the degree of structural preservation and resistance to dehydration was determined by both species architecture and treatment intensity (Singh *et al*., 2018).

Leaf Area (cm²)

Grevillea robusta showed the largest mean leaf area across all stages, followed by *Araucaria heterophylla*, while *Juniperus squamata* had the smallest due to its needle-like structure and limited moisture capacity (Table 4). ANOVA revealed highly significant effects ($p \leq 0.01$) of both species (factor A) and preservation methods (factor B) on leaf area. All species leaf areas gradually shrank over time, indicating tissue shrinking and dryness (Nivrutti, 2021). Glycerin treatments (b_2, b_3) preserved pliability and decreased desiccation stress by substituting humectant for water, while silica gel drying (b_1) was the most successful treatment in maintaining leaf area, minimizing shrinkage through uniform moisture removal, and reducing cell collapse (Babu *et al*., 2018). On the other hand, fast dehydration and structural deformation were generated by air drying (b_2) and hot air oven drying (b_1). *G. robusta* under silica gel (a_3b_4) retained the largest leaf area, while *J. squamata* under control or air-drying conditions (a_2b_1, a_2b_1) displayed the sharpest reductions, according to the significant interaction (A×B). Overall, species morphology and drying technique had a significant impact on leaf area retention; broad-leaved species responded best to silica gel, while moderate glycerin levels supported flexibility and shape maintenance

Sensory parameter

The sensory evaluation (texture Y17, brittleness Y18, shape Y19, and color Y20) showed that species (Factor A) significantly influenced brittleness and color, while preservation treatment (Factor B) had a highly significant effect ($p < 0.01$) on all four attributes (Table 5). This suggests that the aesthetic quality of preserved leaves was shaped by both the species' intrinsic morphology and the post-harvest technique used. *Araucaria heterophylla* (a_1) outperformed *Grevillea robusta* (a_3) and *Juniperus squamata* (a_2) among the species in texture (8.12), shape retention (7.10), and color stability (6.62). This is probably because of its higher moisture content and thicker cuticle, which prevent desiccation-induced brittleness. Because glycerin replaces intracellular free water as a humectant, preserving suppleness and color retention, the glycerin treatments particularly 20% (b_2) and 10% (b_3) achieved the highest mean sensory ratings (Dilta *et al.* ,2011). Rapid dehydrative techniques, such as sand drying and hot-air oven drying, on the other hand, had the worst outcomes: high brittleness, distorted shape, and faded color due to increased moisture loss and pigment degradation (Kumar and Bhardwaj, 2025). Species responded differentially to treatments, as seen by the significant interaction (A×B) for brittleness and color ($p < 0.01$). For instance, $a_1 \times b_2$ (Araucaria + 20% glycerin) achieved the greatest sensory profile, whereas $a_2 \times b_2$ (Juniperus + oven drying) had the poorest. Overall, the results show that the preservative technique and leaf structural characteristics work together to determine post-preservation aesthetic stability and that intermediate glycerin concentrations provide a better balance for preserving texture, form, and color in beautiful foliage (Chakrabarty and Datta, 2021; Malakar *et al.*, 2023).

Conclusion

The study emphasizes that the quality and durability of ornamental leaves are significantly determined by the type of leaf and the drying technique selected. When it comes to drying methods, techniques that restore cellular water (like glycerinization) or manage moisture loss gradually function better than forceful drying procedures. Compared to oven or ambient air drying, which tends to cause brittleness, deformation, and discoloration, embedding in desiccants like silica gel or mild glycerin treatments preserves structural integrity and aesthetic appeal much better. From a commercial standpoint, it is therefore crucial to match the species with the right preservation technique: thin, needle-like foliage requires more specialized techniques to prevent rapid collapse, while foliage with favorable anatomy will maximize shelf-life, aesthetic quality, and market value with a moderate glycerin or desiccant treatment. The interplay of leaf morphology, water-holding capacity, and drying schedule ultimately determines the value-added potential of dried decorative foliage. When foliage is properly dried, it becomes lightweight, durable, and aesthetically pleasing for use in floral design, interior decor, and craft markets.

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