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# Application of microwave oven technology for dehydration of ornamental leaves

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**Abstract**

The standardization of microwave oven drying technology for dehydration of ornamental leaves was done. The embedding of leaves in silica gel and microwave oven drying (720 micro power, i.e. medium high) for 2 min was suitable technique for dehydration of ornamental leaves of *Swietenia mahagoni, Acacia auriculiformis* and *Hamelia patens* leaves. The time of 2.5 min was appropriate for leaves of *Alstonia scholaris*, *Rosa spp.*, *Hibiscus rosa-sinensis* and *Bougainvillea glabra*, 3 min for *Lagerstroemia speciosa* and 3.5 min for *Polyalthia longifolia* and *Ixora chinensis.*

**Key words:** Microwave oven, Dehydration, Technology, Ornamental leaves, Eco-friendly

The demand for natural, eco-friendly and biodegradable flower products is increasing rapidly throughout the world compared to artificial/synthetic flowers. Different decorative floral crafts/items can be prepared from dried flowers, which in turn add value and also generate employment (Datta and Roy, 2011). Indian entrepreneurs have a lot of opportunities to go into international floricultural trade as demand for dry flower industry is escalating at a remarkable rate of 8-10 % per annum (Singh, 2009). The country enjoys the benefit of cheap labour and favourable climate as against other countries. Lack of awareness regarding dry flowers, non-availability of dry flower products and of information has been foremost constraint in encouragement of dry flower production in India (Biswas and Dhua, 2010). Therefore, an experiment was set up with an objective to standardize the microwave oven drying technique for dehydration of ornamental leaves.

## Materials and Methods

The experiment was conducted at Dry Flower Laboratory at Department of Floriculture and Landscape Architecture, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia (District), West Bengal during 2018 to 2019. Fresh matured leaves free from blemishes, pest and disease were collected in morning after dew/moisture evaporation from university campus. Experiment was laid out in CRD (factorial) with five replications and 8 different treatment combinations with sand and silica as embedding media. After embedding, embedded glass containers were placed in the electrically operated microwave oven at fixed micro power of 720 power, i.e. medium high. Treatments were set based on trial-and-error method for 10 different foliages and dried samples were given subjective scores on average 10 points scale with reference to ornamental values, viz., colour, texture, brittleness and appearance/shape retention. Based on cumulative score, ranks were given and the best treatment combinations were worked out (Raj and Gupta, 2005).

## Results and Discussion

In *Alstonia scholaris* leaves silica gel ($M_2$) as drying media recorded significantly maximum moisture loss (54.98 %) and sensory attribute scores, for colour (7.0) and appearance (6.65) compared to sand ($M_1$) but sand noted highest score for brittleness (7.85) in contrast to silica gel. Among drying durations $D_4$ recorded greatest moisture loss (61.48 %), which is statistically far with D1 (28.99 %). In Swietenia mahagoni, principal moisture loss (42.72 %) and sensory score for colour (7.10) and appearance (7.13) noted in silica gel ($M_2$), which are significantly far with sand ($M_1$) in microwave oven dried mahagoni tree leaves (Table 1). Extreme moisture loss was recorded in $D_4$ (47.16 %), which is statistically far with $D_1$ (27.76 %) among drying duration.

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**Table-1:** Effect of drying media (M), duration (D) and their interaction on micro oven dried devils tree and mahogany tree leaves

| | *Alstonia scholaris* | | | | | | | *Swietenia mahagoni* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | FW (g) | DW (g) | ML (%) | Colour | Texture | Brittleness | Appearance | FW (g) | DW (g) | ML (%) | Colour | Texture | Brittleness | Appearance |
| $M_1$ | 1.30 | 0.74 | 42.94 | 6.20 | 6.15 | 7.85 | 5.55 | 0.73 | 0.46 | 37.22 | 5.78 | 5.98 | 7.33 | 6.10 |
| $M_2$ | 1.21 | 0.56 | 54.98 | 7.00 | 6.70 | 6.40 | 6.65 | 0.73 | 0.42 | 42.72 | 7.10 | 6.10 | 6.95 | 7.13 |
| S.Em **(±)** | 0.01 | 0.00 | 0.28 | 0.04 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.03 |
| CD at 5 % | 0.02 | 0.01 | 0.82 | 0.10 | 0.10 | 0.09 | 0.09 | N/A | 0.01 | 0.00 | 0.10 | 0.08 | 0.09 | 0.10 |
| $D_1$ | 1.31 | 0.93 | 28.99 | 4.20 | 4.30 | 8.60 | 4.50 | 0.68 | 0.49 | 27.76 | 5.15 | 4.95 | 7.55 | 5.40 |
| $D_2$ | 1.25 | 0.69 | 45.55 | 6.80 | 6.50 | 8.10 | 6.50 | 0.75 | 0.44 | 40.94 | 6.70 | 7.15 | 7.80 | 7.10 |
| $D_3$ | 1.22 | 0.49 | 59.82 | 7.70 | 7.80 | 6.60 | 7.00 | 0.70 | 0.39 | 44.02 | 6.95 | 6.95 | 7.55 | 7.05 |
| $D_4$ | 1.23 | 0.48 | 61.48 | 7.70 | 7.10 | 5.20 | 6.40 | 0.80 | 0.42 | 47.16 | 6.95 | 5.10 | 5.65 | 6.90 |
| S.Em **(±)** | 0.01 | 0.00 | 0.40 | 0.05 | 0.05 | 0.04 | 0.05 | 0.01 | 0.00 | 0.00 | 0.05 | 0.04 | 0.05 | 0.05 |
| CD at 5 % | 0.03 | 0.01 | 1.16 | 0.15 | 0.14 | 0.13 | 0.13 | 0.02 | 0.01 | 0.01 | 0.14 | 0.11 | 0.13 | 0.14 |
| $M_1D_1$ | 1.28 | 0.95 | 26.05 | 4.00 | 4.00 | 8.60 | 4.40 | 0.67 | 0.50 | 26.37 | 4.50 | 4.60 | 7.70 | 4.90 |
| $M_1D_2$ | 1.33 | 0.84 | 36.50 | 5.40 | 4.60 | 8.40 | 5.40 | 0.75 | 0.49 | 35.11 | 4.90 | 6.80 | 7.30 | 5.70 |
| $M_1D_3$ | 1.26 | 0.59 | 53.26 | 7.60 | 8.20 | 7.60 | 7.00 | 0.74 | 0.44 | 40.51 | 6.40 | 7.30 | 7.80 | 6.40 |
| $M_1D_4$ | 1.31 | 0.58 | 55.94 | 7.80 | 7.80 | 6.80 | 5.40 | 0.76 | 0.40 | 46.90 | 7.30 | 5.20 | 6.50 | 7.40 |
| $M_2D_1$ | 1.34 | 0.91 | 31.92 | 4.40 | 4.60 | 8.60 | 4.60 | 0.69 | 0.49 | 29.15 | 5.80 | 5.30 | 7.40 | 5.90 |
| $M_2D_2$ | 1.18 | 0.53 | 54.59 | 8.20 | 8.40 | 7.80 | 7.60 | 0.74 | 0.39 | 46.76 | 8.50 | 7.50 | 8.30 | 8.50 |
| $M_2D_3$ | 1.18 | 0.40 | 66.38 | 7.80 | 7.40 | 5.60 | 7.00 | 0.66 | 0.35 | 47.42 | 7.50 | 6.60 | 7.30 | 7.70 |
| $M_2D_4$ | 1.15 | 0.38 | 67.01 | 7.60 | 6.40 | 3.60 | 7.40 | 0.83 | 0.44 | 47.53 | 6.60 | 5.00 | 4.80 | 6.40 |
| S.Em **(±)** | 0.01 | 0.01 | 0.57 | 0.07 | 0.07 | 0.06 | 0.06 | 0.01 | 0.00 | 0.00 | 0.07 | 0.06 | 0.06 | 0.07 |
| CD at 5 % | 0.04 | 0.02 | 1.65 | 0.21 | 0.20 | 0.18 | 0.18 | 0.02 | 0.01 | 0.01 | 0.19 | 0.16 | 0.18 | 0.19 |

{$M_1$- Sand, $M_2$- Silica gel ($D_1$- 1.5 min, $D_2$- 2.5 min, $D_3$- 3.5 min, $D_4$- 4.5 min), ($D_1$- 1 min, $D_2$- 2 min, $D_3$- 3 min, $D_4$- 4 min)}

**Table-2:** Effect of drying media (M), duration (D) and their interaction on micro oven dried pride of India tree and ashoka tree leaves

| | *Lagerstroemia speciosa* | | | | | | | *Polyalthia longifolia* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | FW (g) | DW (g) | ML (%) | Colour | Texture | Brittleness | Appearance | FW (g) | DW (g) | ML (%) | Colour | Texture | Brittleness | Appearance |
| $M_1$ | 1.18 | 0.53 | 54.27 | 4.10 | 4.65 | 7.00 | 4.50 | 0.62 | 0.33 | 45.81 | 3.30 | 5.33 | 5.88 | 3.90 |
| $M_2$ | 1.19 | 0.49 | 58.32 | 5.80 | 6.25 | 7.45 | 5.55 | 0.51 | 0.20 | 62.23 | 6.35 | 6.68 | 6.85 | 7.05 |
| S.Em **(±)** | 0.01 | 0.00 | 0.29 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.34 | 0.03 | 0.03 | 0.03 | 0.03 |
| CD at 5 % | N/A | 0.01 | 0.84 | 0.07 | 0.09 | 0.09 | 0.07 | 0.01 | 0.01 | 0.98 | 0.07 | 0.09 | 0.09 | 0.09 |
| $D_1$ | 1.02 | 0.52 | 49.04 | 3.90 | 4.50 | 8.10 | 4.30 | 0.58 | 0.33 | 40.97 | 3.75 | 5.65 | 6.70 | 5.05 |
| $D_2$ | 1.14 | 0.51 | 55.74 | 5.20 | 5.00 | 7.70 | 5.50 | 0.59 | 0.31 | 49.18 | 4.70 | 5.55 | 5.95 | 4.45 |
| $D_3$ | 1.25 | 0.51 | 59.32 | 5.40 | 5.90 | 7.40 | 5.10 | 0.53 | 0.21 | 60.97 | 6.05 | 6.45 | 6.65 | 5.65 |
| $D_4$ | 1.33 | 0.52 | 61.06 | 5.30 | 6.40 | 5.70 | 5.20 | 0.55 | 0.20 | 64.96 | 4.80 | 6.35 | 6.15 | 6.75 |
| S.Em **(±)** | 0.01 | 0.00 | 0.41 | 0.04 | 0.04 | 0.05 | 0.04 | 0.00 | 0.00 | 0.48 | 0.04 | 0.04 | 0.04 | 0.04 |
| CD at 5 % | 0.03 | N/A | 1.18 | 0.10 | 0.12 | 0.13 | 0.10 | 0.01 | 0.01 | 1.38 | 0.10 | 0.13 | 0.13 | 0.13 |
| $M_1D_1$ | 0.94 | 0.50 | 46.61 | 2.80 | 3.60 | 7.80 | 4.00 | 0.50 | 0.40 | 21.67 | 2.40 | 4.90 | 6.40 | 3.70 |
| $M_1D_2$ | 1.21 | 0.57 | 52.73 | 3.80 | 4.40 | 7.60 | 4.00 | 0.68 | 0.43 | 37.72 | 1.80 | 4.50 | 4.60 | 1.80 |
| $M_1D_3$ | 1.33 | 0.56 | 58.07 | 4.40 | 5.00 | 7.20 | 4.60 | 0.65 | 0.26 | 59.26 | 4.00 | 5.20 | 5.60 | 3.20 |
| $M_1D_4$ | 1.22 | 0.49 | 59.65 | 5.40 | 5.60 | 5.40 | 5.40 | 0.63 | 0.22 | 64.59 | 5.00 | 6.70 | 6.90 | 6.90 |
| $M_2D_1$ | 1.10 | 0.53 | 51.46 | 5.00 | 5.40 | 8.40 | 4.60 | 0.66 | 0.26 | 60.27 | 5.10 | 6.40 | 7.00 | 6.40 |
| $M_2D_2$ | 1.06 | 0.44 | 58.75 | 6.60 | 5.60 | 7.80 | 7.00 | 0.50 | 0.20 | 60.64 | 7.60 | 6.60 | 7.30 | 7.10 |
| $M_2D_3$ | 1.17 | 0.46 | 60.58 | 6.40 | 6.80 | 7.60 | 5.60 | 0.42 | 0.16 | 62.68 | 8.10 | 7.70 | 7.70 | 8.10 |
| $M_2D_4$ | 1.43 | 0.54 | 62.46 | 5.20 | 7.20 | 6.00 | 5.00 | 0.48 | 0.17 | 65.32 | 4.60 | 6.00 | 5.40 | 6.60 |
| S.Em **(±)** | 0.01 | 0.01 | 0.58 | 0.05 | 0.06 | 0.06 | 0.05 | 0.01 | 0.00 | 0.68 | 0.05 | 0.06 | 0.06 | 0.06 |
| CD at 5 % | 0.04 | 0.02 | 1.67 | 0.15 | 0.17 | 0.19 | 0.15 | 0.02 | 0.01 | 1.96 | 0.15 | 0.18 | 0.18 | 0.18 |

{$M_1$- Sand, $M_2$- Silica gel ($D_1$- 2 min, $D_2$- 3 min, $D_3$- 4 min, $D_4$- 5 min), ($D_1$- 1.5 min, $D_2$- 2.5 min, $D_3$- 3.5 min, $D_4$- 4.5 min)}

In *Lagerstroemia speciosa*, silica gel ($M_2$) recorded significantly maximum moisture loss (58.32 %) and sensory scores, i.e. for colour (5.80), texture (6.25) and appearance (5.55) compared to sand ($M_1$) in microwave oven dried pride of India tree (Table 2). Between drying duration, moisture loss varied significantly from 49.04 % ($D_1$) to 61.06 % ($D_4$). In *Polyalthia longifolia*, application of silica gel ($M_2$) as embedding media recorded maximum of moisture loss (62.23 %) and sensory attribute scores, i.e. for colour (6.35), texture (6.68), brittleness (6.85) and appearance (7.05), which are statistically far with sand ($M_1$). Between drying duration, moisture loss noted highest in D4 (64.96 %), which is significantly far with $D_1$ (40.97 %). In *Rosa spp*., chief moisture loss (50.92 %) was recorded in silica gel ($M_2$), which is significantly far with sand ($M_1$) (41.90 %) in microwave oven dried rose leaves (Table-3). Colour and texture score found insignificant among drying media. Between drying duration, maximum moisture loss was observed in D4 (52.46 %) and highest score for texture and brittleness was recorded in D1 (8.0, 8.40) respectively.

In *Acacia auriculiformis* maximum moisture loss percent (51.28 %) was noted in silica gel ($M_2$), whereas colour, texture and appearance scores were insignificant among drying media. Drying duration $D_4$ recorded supreme moisture loss (59.05 %), which is statistically far with $D_1$ (26.71 %). In *Hamelia patens*, silica gel ($M_2$) as drying media noted maximum moisture loss percent (69.99 %) and highest quality parameter scores i.e. for colour (7.0), texture (6.20) and appearance (7.25), whereas brittleness score (7.25) found maximum in sand (M1). Drying duration $D_4$ (68.10 %) recorded extreme moisture loss, which is significantly far with $D_1$ (54.38 %). In *Ixora chinensis*, moisture loss and brittleness score were insignificant among media, whereas colour (5.13), texture (6.18) and appearance (6.30) score recorded significantly higher in silica gel (M2) compared to sand ($M_1$) in microwave oven dried ixora leaves.

Among drying duration, moisture loss varied significantly from 51.92 % ($D_1$) to 58.17 % ($D_4$). In *Hibiscus rosa-sinensis*, moisture loss (69.04 %) and quality parameter score, i.e. for colour (7.56), texture (7.25) and appearance (7.68) were recorded highest in silica gel ($M_2$) compared to sand ($M_1$) in microwave oven dried hibiscus leaves (Table-5). Among drying duration, moisture loss varied from 62.21 % ($D_1$) to 67.88 % ($D_4$). In *Bougainvillea glabra*, silica gel ($M_2$) as drying media noted highest moisture loss (65.93 %) and sensory attribute score, i.e. for colour (7.58), texture (7.43) and appearance (7.40), which are significantly far with sand (M1) in micro oven dried bougainvillea leaves. Moisture loss percent found highly significant among drying duration as it varied from 37.96 % ($D_1$) to 71.0 % ($D_4$), whereas quality parameter scores found insignificant.

Among interactions, greatest moisture loss was recorded in $M_2D_4$ and least was noted in $M_1D_1$, i.e. 67.01 % and 26.05 % in *Alstonia scholaris*, 47.53 % and 26.37 % in *Swietenia mahagoni*, 62.46 % and 46.61 % in *Lagerstroemia speciosa*, 65.32 % and 21.67 % in *Polyalthia longifolia*, 56.10 % and 34.45 % in *Rosa spp*., 62.16 % and 21.85 % ($M_2D_1$) in *Acacia auriculiformis*, 73.24 % and 43.67 % in *Hamelia patens*, 58.57 % and 51.70 % ($M_2D_1$) in *Ixora chinensis*, 71.01 % and 56.72 % in *Hibiscus rosa-sinensis,* 74.13 % and 24.88 % in *Bougainvillea glabra*.

As the drying duration increased, moisture loss was also increased rapidly; it might be due to long-term exposure of plant material to microwaves, which in turn agitated the water molecules in living plant cells. Loss of moisture was very fast in silica gel ($M_2$) compared to sand ($M_1$), it might be due to light weight, hygroscopic nature and particle density of it, which helped microwaves to penetrated through media easily and removed the moisture. These results are in accordance with Ranjan and Misra (2002), Raghupathi and Gantait (2020), Hemant *et al.*, (2016), Aravinda and Jayanthi (2004), Biswas and Dhua (2010).

Uppermost sensory score for colour, i.e. 8.50 in Devils tree, 8.50 in Mahagany, 6.60 in Pride of India, 7.80 in Rosa, 8.60 in Acacia, 7.60 in Hamelia was observed in M2D2, whereas M2D3 recorded highest score, i.e. 8.10 in Ashok tree, 6.70 in Ixora, 8.50 in Hibiscus and 8.50 in Bougainvillea. Colour is an important quality parameter criterion for any final product marketing as its appearance matters for customers. Improper moisture loss resulted in poor scoring for colour and high moisture loss also adversely affected colour pigments in dried leaves.

Similar results were also reported by White *et al.*, (2002) and Mishra *et al.* (2014). Chief texture score, i.e. 8.40 in Devils tree, 7.50 in Mahagany, 8.50 in Acacia, 7.60 in Hamelia, 8.50 in Hibiscus was recorded in interaction M2D2, whereas M2D3 recorded 7.70 in Ashok tree, 7.20 in Ixora, 8.40 in Bougainvillea and $M_2D_4$ (7.20) in Pride of India and M2D1 (8.40) in Rose. These results are in confirmation with findings of Kumari *et al.*, (2018) and Bhalla *et al.*, (2006). Maximum score for brittleness, i.e. 8.60 in Devils tree, 8.80 in Rose, 8.60 in Acacia, 8.0 in Hamelia and 7.80 in Bougainvillea was recorded in $M_1D_1$,

while 8.30 in Mahagany was noted in $M_2D_2$ and 8.40 in Pride of India, 7.70 in Ixora was observed in $M_2D_1$, 7.70 in Ashok tree was noted in $M_2D_3$ and 8.40 in Hibiscus was recorded in $M_1D_2$.

As the drying duration increased, brittleness score decreased, which is directly proportional to moisture loss in the plant cells. Low moisture loss also resulted in poor brittleness score. The results are in line with Renuka *et al.*, (2017) and Jawaharlal *et al.*, (2013). Highest score for appearance i.e. 7.60 in Devils tree, 8.50 in Mahagany, 7.0 in Pride of India, 8.20 in Rose was observed in M2D2, whereas 8.10 in Ashok tree, 7.60 in Hamelia, 7.60 in Ixora, 8.10 in Hibiscus and 8.30 in Bougainvillea was recorded in Interaction $M_2D_3$. Appearance is the overall acceptance of final dried product including its texture, colour and brittleness. Silica gel recorded better appearance scores compared to sand due to rapid evaporation of moisture. This result was in confirmation with the finding of Mathapati *et al.*, (2015) and Renuka *et al.*, (2016).

## Conclusion

It can be concluded that embedding in silica gel and microwave oven drying (720 micro power, i.e. medium high) for 2 min was suitable technique for dehydration of hamelia and mahogany tree leaves, 2.5 min was suitable for dehydration of rose, hibiscus, bougainvillea and devils tree leaves, 3 min was ideal for lagerstroemia tree leaves and 3.5 min for dehydration of ixora and ashoka leaves.

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