



E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 228-233
Received: 13-05-2020
Accepted: 15-06-2020

Priyaranjan Koley
Department of Horticulture,
M. S. Swaminathan School of
Agriculture, Centurion
University of Technology and
Management, Parlakhemundi,
Odisha, India

An overview of dehydration techniques

Priyaranjan Koley

Abstract

Dehydrate or drying flowers are also known as everlasting flowers as they can survive several months to a year without losing their shape and colour. Dehydration is a technique involving producing environmentally friendly, biodegradable drying products. This technique required low-cost machinery as well as less expert knowledge to operate and produce several dried products for utilizing as a preparation of bouquets, different floral arrangements and various floral handicrafts. The most promising techniques like Air drying, Sun drying, Water drying, Press drying, Embedded drying, Glycerine drying, Freeze drying are practiced on different plant parts. Dry flower products are exported from India is estimated about 71% of total export to various countries and earned 10-15 times more returns than the domestic market. Hence, this technique is economically viable and helps to uplift the economic status of many rural people, floriculturists, entrepreneurs and traders.

Keywords: Dehydration, dehydration techniques, special drying techniques, dried products

1. Introduction

Man is said to be born with flowers, to grow with flowers, and finally to depart with flowers. Flowers are maintained their significance in all the auspicious events, ceremonies, rituals and festivals. Since the dawn of mankind, they have been connected with our culture and are predominantly grown as cut and loose flowers. The Flowers are very perishable and can be preserved from few days to few weeks with proper post-harvest handling. But, Dehydrate flowers have tremendous potential to replace fresh flowers and foliage for home interior as well as utilization of artistic and industrial purposes. Dehydrate or drying flowers are also known as everlasting flowers as they can retain their shape and colour for several months even after harvesting (Malcolm, 1994) ^[1]. It is also said that dry flowers can be treasures for a longer time if they can be dried under proper techniques (Sheela, 2008) ^[2]. Dried or preserved ornamental products having a wide range of qualities including novelty, durability, artistic use, adaptability and year-round availability (Joyce, 1998) ^[3].

Flowers preservation is not a new concept; it has been used for different purposes since a long time ago. Egyptians have been used dried herbs embedded with mummified bodies to show their gratitude to the soul. In the Middle age, Monks have been used dried flowers, foliage and herbs to decorate the wall or even for their hand-printed manuscript (Brown *et al.*, 2016) ^[4]. In India, the British government was first introduced the dry flower industry in Kolkata because of the availability of exotic and various plans in the North East and Eastern regions (Bhattacharjee and De, 2003) ^[5].

Dry flower is gaining popularity in both the Indian and Global markets as people becoming more eco-conscious and preferring an environmentally friendly and biodegradable replacement for fresh flowers (Datta and Roy, 2011) ^[6]. The dry flower industry has been recognized as a promising foreign exchange business that covers up 15% of the global floral business where Netherlands occupied the first rank as an exporter to the USA followed by Mexico, India, Colombia and Israel (Sharavani and Divya sree, 2018) ^[7]. In India, it is estimated that dry flowers are exported to the United States, Japan, Australia, Russia and Europe around 71 percent of total exports (De *et al.*, 2016) ^[8]. Demand for dry flowers is growing tremendously at an 8-10% annual rate, which offers an opportunity for Indian entrepreneurs to join the global floriculture trade (Singh, 2009) ^[9]. Indian exporting companies earned 10-15 times more returns than the domestic market and are based primarily in Kolkata (West Bengal), Tuticorin (Tamil Nadu), Mumbai (Maharashtra) and Hyderabad (Andhra Pradesh) (Verma *et al.*, 2012) ^[10]. But, now-a-days some other states have focused on this industry. Nearly 60 percent of the raw materials in India come from natural forests and plains where only 40% of the flowers are grown for drying, bleaching and coloring purposes. Dry flower technique applies most to flowers like Allium, Anemone, Carnation, Chrysanthemum, Daffodil, Freesia, Lily, Marigold, Narcissus, Pansy, Rose, Sweet William, Stock, Zinnia, etc. and foliage like Aspidistra, Eucalyptus, Fern, Ivy, Magnolia etc. (De *et al.*, 2016) ^[8].

Corresponding Author:
Priyaranjan Koley
Department of Horticulture,
M. S. Swaminathan School of
Agriculture, Centurion
University of Technology and
Management, Parlakhemundi,
Odisha, India

It can be utilized for the preparation of flower vase or bouquets decoration just like fresh flowers, floral arrangements and various floral handicrafts like greeting cards, segments, wall hangings, calendars, candle, picture frames, floral jewelry, mirror decorative, arrangements in glass containers etc. (Bhutani, 1990) [11]. Dried flowers should be carefully handled because they are more delicate than fresh flowers. Potpourri is prepared by mixing dehydrated flowers with scented plant parts like berries, leaves, stem, roots etc. which is exported as a raw or scented within a small muslin bags. In the Indian dry flower industry, Potpourri is the largest sharer valued at Rs. 55 crores alone (Murugan *et al.*, 2007) [12].

India's biodiversity is abundant with a large variety of ornamental trees, shrubs, climbers, etc. Many of them are not suitable as cut flowers or loose flowers but their different sections are used in the dry flower industry. Dry flower quality can be depending on crop, cultivars, harvesting stage, moisture level after drying etc. Even, after drying some flowers lose their value, so the crop section is very much important factors for success. In general, flowers are harvested at full bloom stage with good color contrast and moisture percentage maintaining about 8-11% after drying otherwise it may hamper the shape and longevity of the flowers. The promising dehydration techniques are Air drying, Sun drying, Water drying, Press drying, Embedded drying, Glycerine drying, Freeze drying etc. Hence, we believe that Dry Flower Industries will give a significant contribution to the country's economy in the long run.

2. Advantages

- They are long-lasting and widely available throughout the year without much caring.
- Products are environmentally friendly, biodegradable and not weather dependent.
- Raw materials are easily available and year-round supplied from a garden or forest.
- Require low-cost machinery as well as less expert knowledge to operate (Malcolm, 1994) [1].
- It is a labor-intensive technique that provides job opportunities and self-employment to huge numbers of workers including housewives, physically handicapped and rural people.
- Dry flowers are cheaper than fresh flowers and used to decorate the home or office interior.
- Dry flowers and their items are used for the decoration of bouquets, different floral arrangements and various floral handicrafts such as greeting cards, segments, wall hangings, calendars, candles, picture frames, floral jewelry, decorative mirroring, glass jar arrangements etc. (Bhutani, 1990) [11].

3. Moisture retention after Drying

Moisture content within the product is an important factor to determine the longevity and storability of agricultural as well as horticultural produce. The flowers are mostly perishable which is highly dependent on the percentage of moisture present within petals and sepals (Kant and Arora, 2012) [13]. It is necessary to determine the moisture percentage before assuring drying for different flowers as moisture percentage influences flower shape, longevity and quality. It is recommended that a range of 8-11.5 percent moisture will ensure a quality preservation of flowers (Pandey, 2001) [14]. Higher moisture content after drying causes flowers to shrink while lower moisture content causes flowers to shed due to

excessive loss of moisture from the flowers lead to a softening of the middle lamella by weakening adhesion and cohesion forces in the tissue and may resulted abscission (Jain *et al.*, 2016) [15].

4. Determination of Harvesting Stage for Drying

In Dry flower industry, fresh flowers are harvested while old, faded flowers or foliages should be rejected. They are harvested at different harvesting stages (Paul and Shylla, 2002) [16] as per requirement in the industry. The flowers are usually harvested at a stage when they just mature (Padmavathamma, 1999) [17] where, dry grasses, seeds, pine cones and most seed heads are recommended to harvest at full maturity stage (Table-1) (Kamal, 2018) [18]. It is also reported that the half bloom stage is reducing the drying processing period (Safeena *et al.*, 2006a) [19]. Generally, flowers or foliage are collected from the field after one or two irrigation and often require removal of moisture, hence, it is better to harvest under dry season or sunny day.

Table 1: Different flowers with their suitable Harvesting Stages

Name of Flowers	Harvesting Stage
<i>Alstroemeria hybrids</i>	When 4 - 5 florets are open
<i>Althea rosea</i>	When 30% florets are open
<i>Anemone coronaria</i>	When buds are just starting to open
<i>Bellis perennis</i>	After flowers are fully open
<i>Bouvardia hybrids</i>	When flowers are starting to open
<i>Dahlia variabilis</i>	After flowers are fully open
<i>Eucharis grandiflora</i>	Just Before the fully open
<i>Helianthus annuus</i>	After flowers are fully open
<i>Papaver spp</i>	When buds are showing colour
<i>Thuja orientalis</i>	When flowers are at the immature stage

5. Techniques for Drying

Several methods are adopted in dehydration technique by removing excess moisture form plant parts under artificially produce heat or controlled temperature, humidity and airflow otherwise the quality of the product will be deteriorated (De *et al.*, 2016) [8]. Drying techniques largely depend on the nature or characters of the plants. Different drying methods are discussed below

A. Air Drying

This method is the oldest and easiest method without the requirement of any special equipment. This method is suitable for crisp flowers. Flowers or foliage are harvested at an immature stage and removed 1/4th of the lower parts. After that, bunches are tied with threads or rubber bands and hang upside down from a rope or wire or bamboo, so that flowers remain straight otherwise it will bended. This method required a well-ventilated with low humidity and a clean dark room (De *et al.*, 2016) [8]. Flowers may also be spread on blotting paper or clean newspaper and kept under dark or sun (Datta, 1997) [20]. Room temperature, relative humidity, airflow and moisture percentage are highly influenced the processing period, however, the whole process is completed within 3 -4 weeks. High relative humidity above 75% will encourage the mould growth inside the flower-like Bougainvillea, Paper flower, Statice, Strawflower etc. (Jain *et al.*, 2016) [15]. The main disadvantages of this technique are time-consuming processes and not able to retain their original colour. The most suitable flowers of this process are *Acroclinium*, *Gypsophilla*, *Helichrysum*, *Hydrangea*,

Larkspur, Limonium, Statice etc. In this method, flowers with blue and yellow colour petals retain their colour under air drying but, pink colour flowers are faded (Sharavani and Divya sree, 2018) [7].

B. Sun Drying

Through this process, as opposed to air drying, flowers are less shrinkage and maintain their diameter as well as appearance the same as fresh flowers (Wilson *et al.*, 2013) [21]. Flowers are harvested at the right stage and either hanged on the air or embedded in a container with drying medium such as silica gel, sand etc. followed by exposure to the sun daily for rapid dehydration. The most suitable flowers for this method are Carnation, Chrysanthemum, etc.

C. Water Drying

Water drying is suitable where petals are easily broken after drying. Flowers are harvested at the right stage and kept into the water at a few inches depth after removing lower leaves. Then, container and flowers are kept into dry, warm and dark conditions for the next 7-10 days for natural drying. Flowers are not exposed to direct sunshine. Initially, water is absorbed by flower followed by evaporation until drying. Hydrangea is the most suitable flower for this method. Other suitable flowers are Acacia, Bells of Ireland, Celosia, Delphinium, Gypsophila, Protea etc.

D. Press Drying

Previously, this method was applied by botanists or herbalists for the preparation of herbarium. This method is applicable where flower shape is not primarily important. In this method, flowers or foliage are harvested at the right stage and placed on newspaper or blotting paper. Another blotting paper is used for coving the flowers. Again, flowers are placed on a previous blotting paper and cover with another paper. Likewise, 4-5 layers of blotting papers are sets on a herbarium press and tightening the screw for ensuring the more pressure. Flowers are spread uniformly to ensure uniform pressure. A Corrugated board of the same size should be placed in between two blotting papers for easy evaporation of vapour from plant materials (Bhutani, 1990) [11]. The ideal size of the herbarium press is 6" X 12", but it may vary. Blotting papers, as well as flowers, are needs to turn on alternative day as an accumulation of moisture and cellulose leads to microbial attack. Generally, this technique took 1-3 weeks but, time can be reduced by keeping on the oven at the appropriate temperature. The drying process can be speeded up by placing the herbarium press under a hot air oven at 45-50°C for 24 hours (Datta, 1997) [20]. After completion of the process, dried flowers are store at a dry place in a sheet or in desiccators for future use. Besides this, another example of press drying is placing the plant sample within the books and allow for drying. The best examples of plants for this method are leaves of Adiantum, Silver Oak, Thuja, etc. and flowers of Aster, Bougainvillea, Candytuft, Chrysanthemum, Euphorbia, Hibiscus, Ixora, Lantana, Marigold, Melia, Rose, Verbena etc. Flowers and foliage became flat after drying; hence it is suitable for the preparation of different handicrafts like greeting cards and other floral arrangements to decorate the wall (Bhutani, 1990) [11].

E. Embedded Drying

This method is adopted to avoid petal shrinkage and preserving the better flower petal colour and shape (Datta, 1997) [20]. In this method, plant parts are harvested at a mature

stage with proper colour formation and embedded into desiccants like silica gel, sawdust, sand, borax, perlite or combination of these for the 4-14 days depending upon the thickness of plant materials. Desiccants are placed in metallic or plastic or earthen containers and leaving for dehydration at room temperature in a well-ventilated room. Plant samples are embedded into the desiccant at a 5 cm depth and gently covered without hampering the flower shape. After completion of the process, flower samples are collected by leaning of container followed by carefully removing desiccant over the sample. After that, remaining desiccants are removed from the sample by the help of small paintbrush and spraying dried flower preservatives on it to strengthen them. Sand and borax are easily available and cheaper but they take more time. Among these, silica gel is considered as the best desiccant for delicate flowers as it has the potential to penetrate to all microspore and hold the moisture by the action of adsorption and capillary condensation (Sharavani and Divya sree, 2018) [7]. Silica gels were blue when they are dry and change the colour to pink when they have absorbed the moisture. It can be reused by warmed up in the oven until it changes the colour from pink to blue.

Properties of good Desiccants

- A desiccant is a substance that helps to remove water vapours from the plant sample instead of any reaction with it during the drying process.
- The particle size of desiccants should be 0.02-0.2 mm and have the capability to spread properly throughout the container.
- It must tightly hold the samples in its original shape.
- It should be less adhesive and easily distinguishable from products.
- It should be easily available and cheaper.

This process can be hastening by exposing under different dryers like

Sun Drying: In this method, the container should be daily exposed under sunshine in an upside-down manner after embedding to hastening the dehydration process. It will take 3-4 days to complete dehydration. Suitable plants for this method are Anise, Chrysanthemum, Marigold, Pompon, Small Zinnia etc.

Oven Drying: After embedding, the container is placed in a hot air oven dryer at a temperature of 40-50°C. The important factors of this technique are the temperature and duration of the process which depends on plant types. It is reported that high temperatures may accelerate the process but deteriorate the flower pigments (Jain *et al.*, 2016) [15]. It is also reported that if flowers exposed under 45°C temperature then flowers like Chrysanthemum, Gerbera, Helipterum are dried within 48 hours where French marigold and African marigold are taken 72 hours and 96 hours respectively for complete drying.

Microwave Oven Drying: It is a very fast method and flower quality is not hampered. Embedding container is kept in a microwave with the addition of a cup of water. Extra cup of water is added to prevent the excess drying. After that led of microwave should be closed and set the time and temperature as per requirements. Standing time 10 min to few hours is give best result. The most suitable flowers for this method are Dahlia, Golden Rod, Gypsophilla, Lily, Rose, Violet, Zinnia etc.

Table 2: Microwave time and Standing time for few flowers (Brown *et al.*, 2016)^[4]

Flower	Heating Time (Min)	Standing Time (Hours)
Rose	2.5 min.	Overnight
Daisy-type flowers: Zinnia, Marigold, Daisy, Chrysanthemum	1.5 min	10 hours
Carnation	1.5 min.	10 hours
Large Dahlia	3.0 min.	36 hours
Large Chrysanthemum	3.0 min.	36 hours
Peony	3.0 min.	36 hours
Small Orchid	1.5 min.	24 hours
Large Orchid	2.5 min.	24 hours

Solar-Dryer drying: It is the fastest method and the result is just like hot air oven and microwave drying. Embedded materials are kept under the solar dryer and a moving tray is fixed at the bottom of the oven to control the temperature.

Vacuum Drying: Vacuum chamber is consisting of a vacuum pump and condenser that helps to maintain vacuum pressure and condensing the moisture respectively. Embedded materials are placed into this chamber and product quality is good.

Precautions during Embedded Drying

- Plants samples are embedded into the desiccants after removing of all undesirable parts and embedded immediately after harvesting.
- In the desiccant, only one type of flower or foliage is embedded at a time and two specimens of the same species should not be touch to each other or sides of the wall.
- Precaution should be taken during the cleaning of end products as dried flowers are more delicate.

F. Glycerine Drying

Glycerine drying is the technique that applied for the preservation of foliages rather than flowers. In this technique, foliages are preserved instead of drying and product quality will remain better as aqueous glycerine solution replaced the moisture (Paul and Shylla, 2002)^[16]. Generally, foliages are harvested at a mature stage and removed all undesirable parts from the stem. Stem is cut at desirable height and the cut end is crushed by a hammer. Then, the crushed portion is immersed into a 33% glycerine solution at 5-7 cm depth. Leaf are absorbed the solution and turn brown colour with glossy appearance within a week which is also depending upon the weather condition. Antibiotics are added in the glycerine solution to prevent microbial growth as glycerine is a good medium for microorganisms. Suitable plants for this technique are Eucalyptus, Gypsophilla, Hydrangea, Magnolia, Maple leaves etc.

G. Freeze Drying

This method is the most effective and popular in the present scenario. This method is technically known as lyophilization that refers to lowering the temperature inside the products followed by the removal of moisture in the form of vapor through a vacuum. This technique is based on the principle of sublimation, where the temperature goes below freezing point and moisture is removed through partial vacuum pressure (less than 4.58 torr) from ice to vapour without entering in a liquid state. Then, vapours are condensed and collecting separately outside of the chamber. After that, dried products

are acclimatized under room temperature. This process is completed without entering in liquid state; hence it does not allow any undesirable chemical reactions. Therefore, products obtained from this method are retained their original shape, colour and texture (Sankari and Anand, 2014)^[22]. Freeze-dried products are mainly used to decorate cake, wedding bouquets or decorating the table by scattering of dried products etc. Suitable plants for this technique are Alstroemeria, Amaranthus, Aster, Bird of Paradise, Calla Lily, Carnation, Daffodil, Dahlia, Delphinium, Freesia, Gardenia, Gladiolus, Gypsophilla, Hyacinth, Hydrangea, Iris, Lily, Narcissus, Orchid, Peony, Phaleonopsis, Rose, SnapDragon etc. The main disadvantages of this technique are the time-consuming process required about a month and high-cost investment for sophisticated instruments.

6. Special Preservation Techniques

A. Skeletonizing

This is also called fossil leaf, as it is a semi-transparent. It is a process by which we eliminate all tissues from leaf without hampering of veins. Although, heavy textured leaves are most suitable for this method. Leaves are boiled in 250 ml of water with the addition of 2 tablespoon lye for 40 minutes. Sometimes, 2 tablespoon household bench is added in water for 2 hours to intensifying the colour. After that, leaves should be rinsed in cold water and remove the tissue from leaves followed by drying. Then, leaves are easily coloured with different dye to enhance appearance. It is utilized as gift tags, greeting cards, scrapbooks, collages, papermaking, stamping or decorating wedding cards.

B. Bleaching and Dyeing

Bleaching is a process where chemicals are used for discolourizing or whitening. Dehydrated products are mainly less colour intensive and reduce the visual appearance. Therefore, flowers are introducing with bleaching followed by dyeing to better absorption of dye and give a classy look. Several chemicals are used as bleaching agents that can be categorized into two groups i.e. Oxidative bleaching chemical and Reductive bleaching chemical. Hypochlorite, Chlorite and Peroxide acts as an Oxidative chemical whereas Sulphite and Borohydride are used as Reductive bleaching chemicals. Alternatively oxidative and reductive bleaching is followed to avoid yellowing. Finally, products are washed with 2 % Barium hydroxide or Calcium hydroxide or Sodium bicarbonate or Aluminium sulphate to minimizing yellowing. Flowers can coloured by both natural dye and synthetic chemicals like enamel paints, interior paints, poster paints, tube paints etc. Bleaching with Sodium chlorite (10%) followed by Hydrogen peroxide (30%) was shown effective result on Gomphrena (Sharavani and Divya sree, 2018)^[7].

C. Sulphuring

Generally, Sulphur granules are brunt under close chamber along with dry flowers for 2 hours to check the enzymatic discolouration. Precautions are needed during the process as sulphur is very toxic.

7. Dry Flower Products

A. Potpourri

Potpourri is a mixture of dried, sweet-scented plant parts like flowers, leaves, seeds, stems and roots which emits a delightful smell. The oils are not eventually found within flowers but, they are found at their peak flowering season. Therefore, harvesting at the right stage is an important factor

for these crops. Potpourri can be made by two methods i. e. dry and moist. The dry method is the easiest, quickest and most common method. A fixative is required for proper absorption of aromatic oil and released them slowly. Potpourri is generally utilized as a room freshener, but it can be also used as a moth repellent and protects the woolen garments during storage. In India, Potpourri is the major segment in the dry flower industry valued at Rs. 55 crore (De *et al.*, 2016) [8]. Most suitable flowers for making potpourri are Gomphrena, Lotus pods, Marigold petals, Rose petals etc. and herbs like Achillea (yarrow), Anise, Artemesia, Basil, Geranium, Lavender, Marjoram, Mint, Rosemary, Sage, Thyme, Verbena etc.

B. Dry flower arrangement

Dry flowers can be decorated in a flower vase or bouquets like fresh flowers. In this process, less care is required as it is long-lasting. Dried flowers, foliage, grasses, seeds or pods can be arranged in a vase for interior decoration. Most suitable dry flowers for vase decoration are Achillea, Larkspur, Lavender, Nigella, Paper flower, Rose, Static, Strawflower etc.

C. Candle making

Dry flowers are also used for attractive candle making. It can be prepared by simply adding dry flowers to the outside of the plain candle. Otherwise, crushed dried flowers are spread on wax paper and filled with light melted wax and roll it.

D. Driftwood

Driftwood is a wood that has been washed in a river or sea and moved by winds, tides or waves. This is also considered as marine debris. It can also be prepared artificially by dipping of any wood into water for 10-12 days followed by drying. Appearance can be enhanced by using sandpaper and varnish and can be used as decorative.

8. Packing, Storage and Care of Dried Plant Products

Dry flowers are very fragile; they need special care during handling and storage. Therefore packaging materials should be protective and give support during transportation to minimizing bruising injury. Dry flowers and products should be store under the moisture-proof container. Otherwise, it will lose their shape and appearance within a short period. It is better to avoid direct sunlight or areas with high light intensity. Silica gel is best for absorbing excess moisture from the product; hence, silica gel pouches are kept at the bottom of the container before final packing. Final packing is done after ensuring the moisture percentage of dry products. Then packaging materials should be tightly covered with polythene to prevent the entry of outside moisture as well as protect from insect-pest. Proper packaging and storing will helps to retain their colour and shape for a longer time and increased the shelf-life of the products.

9. Conclusion

Dry flower products have become a choice over fresh flowers for its long-lasting property. More than 80 percent of flowers and foliage are suitable for drying. These techniques are very simple and not involving any sophisticated or expensive equipments. But, proper preservation techniques and some precautions throughout the preservation process can give the best result. Many workers including physically challenged, housewives or rural peoples can involve in this business and earn money. Some awareness programs will help to share

proper guidance and knowledge regarding dehydration technology. Dry flowers can be utilized in a flower vase or bouquets decoration just like fresh flowers, floral arrangements and various floral handicrafts like greeting cards, segments, wall hangings, calendars, candles, picture frames, floral jewelry, mirror decorative, glass jar arrangements etc. Indian exporting companies are earned 10-15 times more returns than the domestic market by exporting these products. Considering the above points we concluded that dehydration techniques will help to uplift the economic status of many rural people, floriculturists, entrepreneurs and traders.

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