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Qualitative Traits of Dry Rose Flowers 'Taj Mahal' as Influenced by Dehydration Methods

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MN and AMK designed the study, performed the statistical analysis, wrote the protocol and wrote the final draft of the manuscript. Authors IS, SM and PKP contributed in analyses of the study and drafting of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To optimize drying technique for the popular Dutch rose cultivar, Taj Mahal, by evaluating different drying methods and appraising the physical, biochemical and sensory quality of the product.
Study Design: Completely Randomized Design.
Place and Duration of Study: Department of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, during 2019-2020
Methodology: Flowers of rose cultivar 'Taj Mahal', at their prime beauty *i.e.,* half-opened bud stage, were subjected to embedded drying in silica gel at six different conditions *viz.* at room temperature (T_1), in hot air oven at $45^{\circ}C$, (T_2) and at $60^{\circ}C$, (T_3) in micro-wave oven at 100% power level (T_4), 80% power level (T_5) and at 60% power level (T_6). The quality of the ensuing dehydrated flowers was judged with respect to colour, weight, volume shrinkage and anthocyanin and carotenoid contents. Temperature during drying and time to reach optimum dehydrated condition

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under different drying techniques were recorded. Sensory evaluation for the quality of the products was done after six months of storage.
Results: The time taken for optimum drying ranged from 120 hours in case of room temperature drying (25.1°C) to 3 minutes in microwave oven on high power *i.e.,* 100% (130.4°C). Significant variation in final weight of the product was recorded between 18.34% to 28% of the fresh weight. Minimum shrinkage (42.85%) was noted in room drying (T_1) and hot air oven drying at 60°C (43.53%). Maximum anthocyanin concentration (3.528 mg/g) was recorded in flowers dried at room temperature, whereas, minimum among the dried flowers, was recorded in microwave oven drying at 100% power level (1.439 mg/g). Maximum Carotenoid content (16.780 µg/g) was recorded in flowers dried in hot air oven at 45°C. Out of six treatments in the present study, maximum sensory score (30.38 out of 36) was gathered by T_2, which was at par with T_1 and T_5.
Conclusion: Dehydrating 'Taj Mahal' rose flowers by embedding in silica gel and drying under room temperature (25°C) for 120 hours or hot air oven at 45°C for 27.5 hours or microwave oven at 80% power level for 3.5 minutes can be recommended for commercial dry flower production.

Keywords: Dry flower; rose; volume shrinkage; sensory evaluation; microwave drying; anthocyanin; carotenoid.

1. INTRODUCTION

Preserving flowers and plant materials by drying was one of the most popular artistic manifestations in Victorian Europe which is even accepted in today's world with greater admiration and fervor. The art of drying flowers is an age-old practice. Flowers have been dried, for various reasons from thousands of years and fragrant dried herbs were encased with mummified bodies in Egyptian pyramids. Many centuries later medieval monks harvested and dried the flowers and herbs by hanging bunches upside down in shade for medicinal use [1]. 'Herbarium' a form of dried flowers was used by the early botanists to identify the various species [2]. The artistic exploration of dry flowers started in Japan and evolved to 'Oshibana', a delicate art form with press-dried flowers. From Japan this craft was adopted in Victorian England where it flourished and became most essential fashion accessory among Victorian ladies [3]. The skill of drying red roses, pansies, stock and other single flowers in sand were first explained in 'The Florist', published in 1860 and Germany was the pioneer in commercial dried flowers business [3]. For centuries, Europe has been the forerunner in dry flower arrangements, which was adopted way back in 1700 AD [4]. With time, this process of drying flowers has moved from an art to a highly interdisciplinary science and has become a major economic activity on a global scale [5]. The demand for dry flowers in world market is enormous and is rising at 8-10% rate annually. This opened great opportunities for the Indian entrepreneurs to enter into the global floricultural trade and India has immerged as a major exporter of dry flowers [6]. Seventy one percent of the Indian floricultural export business comprises of dry flowers which are sent mainly to USA, Japan, Australia, Russia and Europe [7].

Dehydrated rose flowers are the most expensive of all the dry-flowers traded in the international market [8][9]. They are used in indoor decoration, artifacts, potpourris, cosmetics and even food products. In the process of drying, the moisture content of the flowers is reduced to a point at which biochemical changes are minimized while maintaining cell structure, pigment level and flower shape [10]. Due to absence of moisture, microbial activity and ageing effect is restricted, hence the flowers can be stored for longer period of time and practically become free from bondage of seasons [11]. However, the ultimate quality of the dried flowers depends on the drying method, which mainly involves, drying media, temperature and duration [12][13]. Variations in optimum drying conditions is reported among different cultivars of rose as well as the prevailing environmental conditions [14][15]. The present study aims at optimizing drying technique for the popular Dutch rose cultivar, Taj Mahal, by evaluating different drying methods.

2. MATERIALS AND METHODS

The present investigation was carried out in the laboratory of the Department of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, during 2019-2020. In the experiment, flowers of rose cultivar 'Taj Mahal', at their prime beauty - *i.e.,* half-opened bud stage, were subjected to embedded drying in silica gel at six different conditions, *viz.* at room temperature (T_1), in hot air oven at 45°C (T_2) and at 60°C (T_3), in microwave oven at 100% power level (T_4), 80% power level (T_5) and at 60% power level (T_6). For embedding, silica gel of 120mesh with blue colour indicator was used. Air tight containers with more than 12 cm depth was used for room temperature drying whereas, 250 ml borosilicate beakers were used for other methods. At first, a 2 cm thick layer of freshly charged silica gel was laid in the container. Then the flowers, with 1.5 cm stem, were arranged in upright position, tucking the stem in silica gel. Then silica gel was poured around the flowers, keeping the shape of the flower intact. The media was also poured over the flower so that it occupies the space in between the petals to achieve uniform drying. After drying, the flowers were taken out carefully from the media by tilting the containers and allowing the flowers to roll down and were collected. They were tapped by holding upside down to remove the excess desiccant material. Finally, the petals were also gently brushed with soft camel hair brush to remove the desiccant completely.

The quality of the ensuing dehydrated flowers was judged with respect to physical traits like colour, weight, volume shrinkage and biochemical parameters like anthocyanin and carotenoid contents. Temperature during drying and time to reach optimum dehydrated condition under different drying techniques were also recorded. The dried flowers were stored for six months in desiccators. After storage, sensory evaluation for the quality of the products was done by a panel of twenty semi-trained persons. The data recorded were analyzed as per standard statistical methods for Completely Randomized Design using Microsoft Excel and OPSTAT online statistical analysis software [16].

3. RESULTS AND DISCUSSION

3.1 Drying Temperature

The temperature of drying atmosphere was recorded at regular intervals. For room drying the maximum and minimum temperature and relative humidity was measured daily with digital Maximum-minimum thermometer, whereas, for hot-air oven drying, the temperature of the drier was set as per the treatments. For microwave oven, the temperature of the media was measured with probe type thermometer at 30 seconds intervals for all the power levels under study. In room temperature, the average maximum and minimum air temperature was of 25.1°C and 26.5°C, respectively; while the average daily Relative Humidity varied from 77.4% to 85.3%. In hot-air oven, the temperature was retained at 45°C ± 1°C for T_2 and 60°C ± 1°C for T_3. In microwave oven, the temperature of the media varied with the operating power level and time, which is presented in Fig. 1. It is obvious from the figure that the media temperature increased steadily with time irrespective of the power levels. The initial temperature, after 1 minute of operation, was lower in case of 60% and 80% power level (90°C and 91°C, respectively) compared to 100% power level (103°C). The media temperature reached 132.8°C after 6 minutes of operation at 60% power level. Similar high temperature (130.4°C) was obtained within 3.0 minutes when the oven was operated at maximum power level.

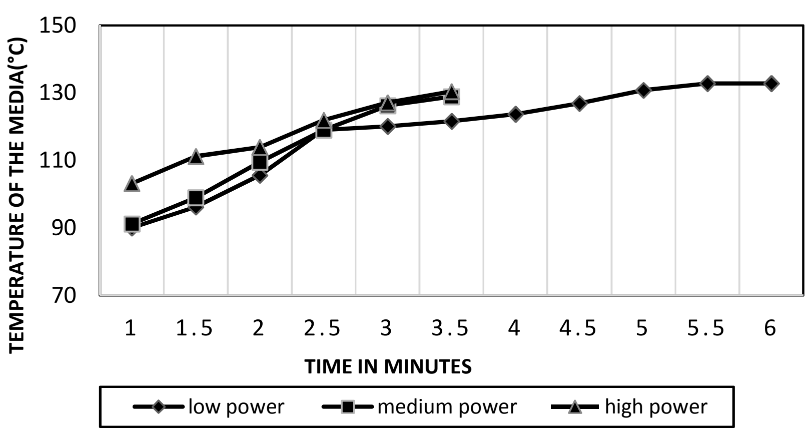

Fig. 1. Variation in temperature of silica gel embedding media with microwave power level and time

3.2 Drying Time

To determine the drying-time required to reach the optimum dehydrated condition, destructive sampling technique was used. These samples were drawn at different time intervals and corresponding quality and moisture content was examined. When a stagnation in weight was reached, and flowers displayed the best quality in terms of colour, form and texture, the duration was noted as optimum for the method and presented in Table 1.

Drying time ranged from 120 hours for room temperature drying to 3 minutes in microwave oven at high power. Variation in temperature in hot-air oven also showed significant variation in drying time. Similar trend was noted with microwave oven drying which were 3 minutes, 3.5 minutes and 6 minutes at 100%, 80% and 60% power levels, respectively. The results corroborate with the findings of Singh and Dhaduk [17] who reported that drying at higher temperature in oven and solar dryer showed quicker result as compared to lower temperature at room condition. The data also substantiate an earlier study claiming 4 minutes time suitable for drying rose in silica gel embedding in microwave oven [18]. Dutch rose cultivar Lambada was best dehydrated by embedding in silica gel and drying in microwave oven for 2.5 minutes while longer duration (3 minutes) resulted in poor texture and colour retention. Embedded drying in silica gel at 30ºC took 88.34 hours for optimum results [12].

3.3 Quality Traits of Dehydrated Flowers

3.3.1 Changes in colour

The colour of the dehydrated flowers were judged with reference to the standard RHS colour chart and presented in Table 2. The colour of fresh flowers was Red 53 A. Both inner and outer surface of the petals were considered for judging the colors. The data revealed that the colour of the flowers changed from Red group 53 A to Red purple group 59 A, for T_1, T_2 and T_3 and Red purple group 61 A for T_4, T_5 and T_6. It is obvious that the colour of the flowers became darker in shade after drying which may be due to the higher concentration of pigments mostly anthocyanin in flower tissue as a consequence of moisture loss during drying. The darker shade colour obtained in microwave oven dried flowers compared to the other methods might be due to the higher temperature prevailing in the former process. Significant difference in colour of dehydrated rose flowers *cv.* Gladiator, dried in different methods has already been reported [19]. They also noted that embedding drying in silica gel under shade and in hot air oven maintained the colour near to the fresh flowers.

3.3.2 Reduction in weight (%)

The weight of dehydrated flowers was recorded for each method and reported as percent of fresh weight of the corresponding flowers and presented in the Table 2. The data reveals highly significant variation among the different methods applied. The maximum weight was recorded with room temperature drying (28.0%) and hot air oven drying at 45°C (28.5%) whereas, the minimums were recorded in microwave oven drying irrespective of power levels i.e., T_4 (18.34%), T_5 (18.52%) and T_6 (19.0%). While working with four varieties of Hybrid Tea roses, Bintory et al*.,* [20] observed that the dry weight of air-dried roses was significantly higher (3.64 g) compared to hot air oven dried roses (2.24 g). The equilibrium moisture content leading to the final weight of dehydrated products is a function of diffusivity and rate of drying that vary significantly with methods of drying [21].

3.3.3 Change in flower weight with drying time

For each of the drying method employed in this study, weight of flower was measured at regular intervals during the drying processes until stagnation was reached. The change in flower weight is expressed as percentage of the fresh weight and plotted against time in Figs. 2-7. Repeated destructive sampling was done to record this data. These drying curves also indicated that the relative change in weight of flowers at the end of drying process varied with methods employed. Further perusal of the curves, revealed that the change in flower weight during the process of drying followed second order exponential patterns for all the methods employed. The extent of fall in weight at the initial period of drying was more and gradually decreased with the progress in the process. Values of the coefficient of determination (R^2) ranges from 0.967 to 0.99, which suggests high goodness of fit of the curves. The results corroborate with findings of El-Sayed et al., [22] in their studies with dehydration of chamomile flowers using different drying methods.

3.3.4 Volume shrinkage

Shrinkage is referred to as the decrease in volume and is an inevitable phenomenon in any drying process though is not desirable in case of flower drying. Removal of moisture from the biotic products due to heating leads to structural deformation and capillary collapse which results in deformed shape and reduction in volume. Embedded drying of flowers is suggested to minimize such undesirable changes by providing support to the delicate petals while removal of moisture. This helps to hold the flower in its original shape. However, certain amount of shrinkage is obvious as a result of moisture loss, because water content in tissues provides most of structural support to the flowers. Amount of shrinkage is generally considered to be equivalent to the moisture removed from the product.

In the present study the rose buds were considered as cylinders for calculation of their volume, as it is not possible to measure the specific volume in conventional procedure due to the intricate orientation of petals in the flowers. Hence, shrinkage was measure by deducting the calculated volume of the dehydrated flowers from that of the fresh flowers and expressed as a percentage of the fresh volume.

$$S = \left(\frac{VF - VD}{VF}\right) \times 100$$

Where, VF= Volume of fresh flower, VD= Volume of dry flower

Volume of flower was estimated by using the formula given below–

$$V = \pi r^2 \mathrm{h}$$

Where π = 3.14, r = radius, h = Height of flower

The data on volume shrinkage as presented in Table 2, shows highly significant variation due to varying methods of drying. Minimum shrinkage (42.85%) was noted in room drying (T_1), which is at par with hot air oven drying at 60°C, whereas, maximum (54.98%) was noted with microwave drying at 100% power level (T_4). Comparing the shrinkage between T_2 and T_3 *i.e.,* hot air oven drying at 45°C and 60°C, it can be noted that shrinkage percentage was more in lower temperature, however, this can be consequential to the longer duration of drying (27.5 hours) at low temperature. On the contrary, decrease in shrinkage was noted in microwave oven drying with decrease in power level *viz.* T_4, T_5 and T_6. Hence, it can be concluded from the observation that though room drying takes more time compared to other methods of drying, the volume

Table 1. Time for dehydration under different drying methods

Treatment	Time
Room temperature (T_1)	120.0 hr
Hot air oven at 45°C (T_2)	27.5 hr
Hot air oven at 60°C (T_3)	16.0 hr
Microwave oven at 100% power level (T_4)	3.0 min
Microwave oven at 80% power level (T_5)	3.5 min
Microwave oven at 60% power level (T_6)	6.0 Min

Table 2. Effect of drying methods on colour, weight and volume shrinkage of dehydrated rose flowers cv. Taj Mahal

Treatment	Colour	Reduction in weight (%)	Volume shrinkage (%)
Room temperature (T_1)	Red purple 59 A	28.00 (5.358)	42.85 (6.621)
Hot air oven at 45°C (T_2)	Red purple 59 A	28.50 (5.430)	45.80 (6.840)
Hot air oven at 60°C (T_3)	Red purple 59 A	21.42 (4.733)	43.53 (6.671)
Microwave oven at 100% power level (T_4)	Red purple 61 A	18.34 (4.398)	54.98 (7.481)
Microwave oven at 80% power level (T_5)	Red purple 61 A	18.52 (4.417)	52.80 (7.338)
Microwave oven at 60% power level (T_6)	Red purple 61 A	19.00 (4.471)	52.18 (7.292)
CD at 1%		0.149	0.163
SE(m) ±		*0.051*	*0.054*
C.V (%)		2.358	1.543

**(Figures in parenthesis are transformed values)* loss due to shrinkage is lower and therefore can result in better quality dehydrated flowers. On the other hand, hot air oven drying at 60°C also produces similar results as far as shrinkage is considered, and hence can be recommended. Microwave drying, though is a quick method, compromises with quality of dehydrated rose flowers on account of volume loss. This observation is in contrast with study by Hemant et al., [23] who observed minimum decrease in flower diameter (0.32 cm) and high petal intactness of rose flowers of cv. Shakira, dried in microwave oven with silica gel as embedding medium compared to air drying and hot air oven drying with or without embedding. Datta [24] recommended embedding drying in silica gel to avoid shrinkage and other morphological changes in flowers.

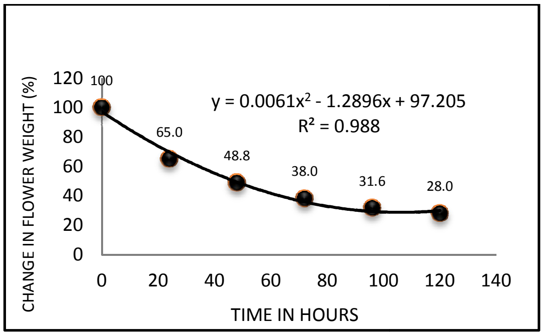

Fig. 2. Flower weight vs time in room temperature embedded drying

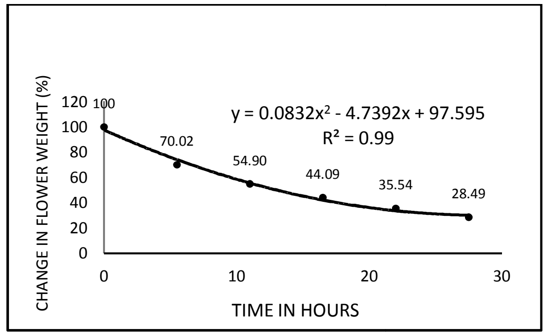

Fig. 3. Flower weight vs time in Hot air oven at 45°C

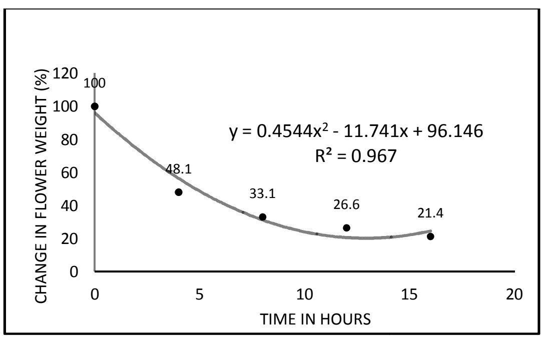

Fig. 4. Flower weight vs time in Hot air oven at 60°C

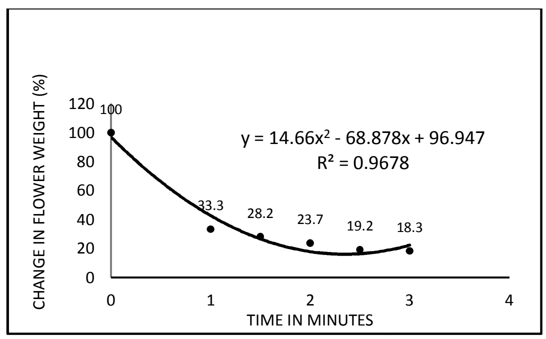

Fig. 5. Flower weight vs time in Microwave oven at 100% power level

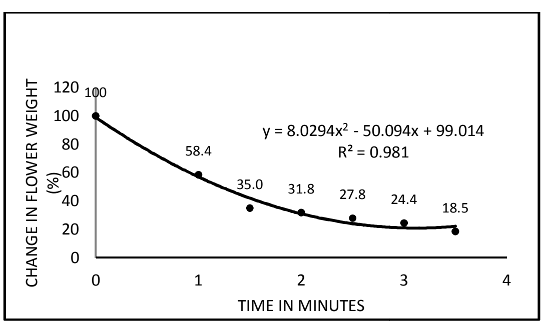

Fig. 6. Flower weight vs time in Microwave oven at 80% power level

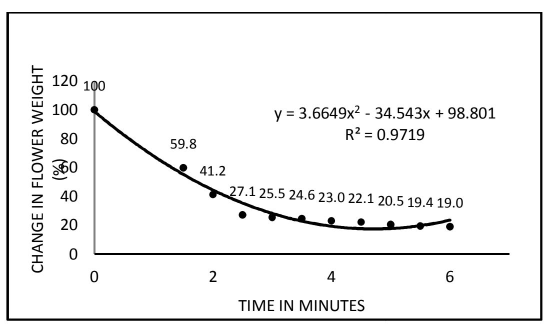

Fig. 7. Flower weight vs time in Microwave oven at 60% power level

Figs. 2-7. Pattern of change in flower weight against time for different methods of drying

3.4 Quality of Flowers after Storage

After drying, the flowers were stored in desiccators for six months and their keeping quality or storage life was judged by sensory evaluation. A panel of 20 semi-trained members from the students and staff of Horticulture Faculty acted as the jury. Four sensory parameters *viz.* colour, texture, appearance and overall acceptance were used to define quality. The dehydrated flower samples were given scores on a 9-points scale where, 9 points (liked extremely), 8 points (liked very much), 7 points (liked moderately), 6 points (liked slightly), 5 points (neither liked nor disliked), 4 points (disliked slightly), 3 points (disliked moderately), 2 points (disliked very much), 1 point (disliked extremely). Based on cumulative score, ranks were given and the best treatment was worked out. The results on the qualitative parameters are presented in Table 3.

3.4.1 Colour

Colour is the most important sensory attribute of dehydrated flowers and is prone to change during storage due to isomerization and oxidation of pigments, especially anthocyanin, and carotenoids and formation of phenolic compounds, which impart brown coloration in the flowers [25]. Sensory evaluation was performed to judge the effect of drying process on the stability of colour. The respective scores presented in Table 3 revealed that no significant difference in colour could be visually identified among the treatments, though the highest score (7.55 out of 9) was given to T_6, *i.e.,* flowers dried in microwave oven at 60% power level and lowest (6.50 out of 9) to T_4 *i.e.,* microwave oven drying at 100% power level.

3.4.2 Texture

Texture is the tactile quality of the dried flower and is an important parameter for consumers' acceptance hence, was monitored during storage. The sensory score data presented in Table 3 revealed significant perceivable variations in texture due to variation in drying method employed. Maximum score of (7.58) was marked to T_2 *i.e.,* hot air oven drying at 45°C which was at par with T_1, T_3 and T_5. Minimum score (4.67) was noted in T_4, *i.e.,* microwave oven drying at 100% power level. Texture of flowers varies due to the moisture level present in the tissue.

3.4.3 Appearance

The visual perceptions of form, deformities including bruises, petal loss and any other undesirable changes in the dehydrated flowers after six months of storage were considered in this parameter. The sensory score on this trait (Table 3), shows significant variation due to effect of drying methods. Maximum score (7.67) was marked to flowers dried in Hot air oven at 45°C. However, this was at par with T_1, T_3 and T_5. Minimum score of (4.73) was marked to flowers dried in microwave oven at 100% power level.

Table 3. Sensory scores of colour, texture, appearance and overall acceptance of dried flowers obtained through different drying methods after five months of storage

Treatment	Colour	Texture	Appearance	Overall acceptance	Total	Rank
Room temperature (T_1)	6.96	7.33	7.38	7.48	29.15	2nd
Hot air oven at 45°C (T_2)	7.17	7.58	7.67	7.96	30.38	1st
Hot air oven at 60°C (T_3)	7.38	7.02	7.08	7.16	28.64	4th
Microwave oven at 100% power level (T_4)	6.50	4.67	4.73	5.40	21.30	6th
Microwave oven at 80% power level (T_5)	7.42	7.29	7.23	7.19	29.14	3rd
Microwave oven at 60% power level (T_6)	7.55	6.63	6.42	6.53	27.13	5th
C.D at 1%	NS	0.781	1.090	0.803	2.658	
SE(m)±	0.262	0.275	0.384	0.283	0.935	
C.V. (%)	12.668	14.090	19.676	14.075	11.732	

3.4.4 Overall acceptance

The parameter, overall acceptance, was coined to demarcate customer's preference of the products. This is an overall observation of qualitative traits combining colour, texture, form, freedom from damages etc. The sensory score obtained by the different treatments under this parameter (Table 3) revealed highly significant variation in overall acceptance among the drying methods with maximum mark of 7.96 out of 9, offered to T_2, *i.e.,* hot air oven drying at 45°C which is at par with T_1, T_3 and T_5. Minimum score (5.40 out of 9) was obtained in T_4 *i.e.,* microwave oven drying at 100% power level.

Out of six treatments in the present study, maximum score (30.38 out of 36) was marked to T_2 *i.e.,* hot air oven drying at 45°C which was at par with T_1 and T_5. Minimum score (21.30 out of 36) was marked to T_4 *i.e.,* microwave oven drying at 100% power level. Consequent to the sensory evaluation data, hot air oven drying at 45°C (T_2) ranked highest among the treatments followed by room temperature drying (T_1) and microwave oven drying at 80% power level (T_5). On the other hand, microwave oven drying at 100% power level (T_4) got the sixth position. Among dehydration techniques for rose and water lily, highest sensory quality was obtained with microwave oven drying for three minutes over microwave oven drying for 2 and 4 minutes and hot air oven drying at 40°C, 50°C and 60°C [9]. Flowers of cv. First Red dried for 120 seconds in microwave oven, irrespective of setting time, offered higher sensory values after 30 days of storage [26].

3.5 Biochemical Traits

3.5.1 Anthocyanin content

Anthocyanin is the major pigment which imparts colour to the red rose flowers. It is water soluble and highly responsive to fluctuations of temperature and pH. Total anthocyanin content in the petals of the dried flowers was estimated before and after storage by the method described by Lee et al., [27] and presented in Table 4. The results revealed highly significant variations in anthocyanin content, both before and after storage, due to the drying methods. Maximum anthocyanin content before and after storage (3.53 mg/g and 3.36 mg/g, respectively) was recorded in flowers dried at room temperature, whereas, minimum was observed in microwave oven drying at 100% power level (1.44 mg/g and 1.13 mg/g, before and after storage, respectively). The anthocyanin content in fresh flowers was 0.69 mg/g which is remarkably low because of the high-water content in fresh tissues resulting in lower concentration of the pigment. Further perusal of the data revealed that anthocyanin content declined with temperature increment in drying environment in hot air oven. Similarly, an increase in anthocyanin content is evident, in both before and after storage, in microwave oven drying with reduced power level. Decline in the pigment content was noted with storage in all the treatments, except for T_2.

Table 4. Anthocyanin and carotenoid content in rose cv. Taj Mahal flower tissue as affected by method of drying and storage

Treatment	After drying		After six months storage	
	Anthocyanin (mg/g)	**Carotenoid (µg/g)**	**Anthocyanin (mg/g)**	**Carotenoid (µg/g)**
Room temperature (T_1)	3.53	6.94	3.36	6.93
Hot air oven at 45°C (T_2)	3.13	16.78	3.13	16.68
Hot air oven at 60°C (T_3)	2.27	2.89	1.87	2.88
Microwave oven at 100% power level (T_4)	1.44	5.01	1.13	5.01
Microwave oven at 80% power level (T_5)	1.70	6.94	1.43	6.85
Microwave oven at 60% power level (T_6)	2.58	15.69	2.18	15.62
C.D at 1%	0.002	1.684	0.071	0.234
SE(m)±	0.001	0.485	0.023	0.075
C.V. (%)	0.047	7.989	1.789	1.446

3.5.2 Carotenoid content

Carotenoid is a fat-soluble pigment and imparts orange, yellow, red colors in flowers. Total carotenoid content of the flowers dried under different drying methods was estimated following the method described by Carvalho et al., [28] after drying and again after six months of storage (Table 4). The data showed that highly significant variations in carotenoid content persisted among the flowers dried using six different methods. Maximum carotenoid content (16.780 µg/g and 16.677 µg/g, before and after storage, respectively) was recorded in flowers dried in hot air oven at 45°C which is at par with that of flowers dried in microwave oven at 60% power level (15.690 µg/g and 15.623 µg/g). Minimum values (2.890 µg/g and 2.883 µg/g) were recorded in T_3 *i.e.,* hot air oven at 60°C, for both before and after storage. On the other hand, a decrease in carotenoid content was noted in microwave oven drying with increase in power levels. When compared with carotenoid content in flower tissue just after drying, no significant changes were noted after six months of storage. Higher retention of pigments, anthocyanin (1.0 mg/g) and carotene (0.58 mg/g) in cv. Shakira was observed when flowers were dehydrated in microwave oven with silica gel as embedding medium [23].

3.6 Shelf Life (Days)

The shelf lives of the dehydrated flowers were assessed visually at periodic interval till the sixth months of storage. However, no significant changes in quality from that of just after drying were visible till then in any of the flowers. Hence, it can be stated that the shelf life of the dehydrated flowers obtained from any of the drying methods employed, is more than 180 days. The difference in quality among the products as revealed by sensory analysis is only a result of different drying methods.

4. CONCLUSION

It can be concluded from the study that dehydrating ‘Taj Mahal’ rose flowers by embedding in silica gel and drying under room temperature (25°C) for 120 hours or hot air oven at 45°C for 27.5 hours or microwave oven at 80% power level for 3.5 minutes can be recommended for commercial dry flower production. The choice of method varies with available infrastructure, time and season of production and scale of operation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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