

Effect of Hot Air Oven and Microwave Oven Drying on Production of Quality Dry Flowers of Dutch Roses

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Abstract

The present investigation was conducted to evaluate different oven drying methods for obtaining better quality dried flowers of four Dutch rose cultivars viz., Skyline, Lambada, Ravel and First Red. Flowers dried at 40°C in hot air oven with silica gel were more acceptable for colour (3.48), appearance (3.50) and texture (3.23). Flowers dried by non-embedding method took least time (52.32 hours) for drying compared to embedded method. Flowers of 'Lambada' dried without embedding took least time for drying (52.07 hours) in hot air oven compared to other cultivars. Quality parameters such as colour (3.48), appearance (3.51) and texture (3.29) were superior in flowers dried for 2.5 minutes in microwave oven by embedding in silica gel. Flowers of 'Lambada' dried for 2.5 minutes by embedding in silica gel were best for overall acceptability, while unacceptable quality was obtained in case of flowers dried without any embedding medium. With respect to mode of desiccation, embedded drying was best for quality parameters viz., colour (2.92), appearance (2.81) and texture (2.55); however, non-embedding methods were least acceptable for quality parameters. Flowers of cv. 'Lambada' dried by embedding in silica gel yielded best quality dried flowers as it scored maximum point for all the quality parameters studied.

Keywords: rose, hot air oven, microwave oven, silica gel

1. Introduction

Rose as cut flower has great demand in the internal as well as export markets. The demand for cut flowers is increasing day by day with the increasing standard of living, aesthetic sense and awareness in the people. Fresh rose flowers though exquisite in their beauty are highly perishable and delicate in nature and cannot retain their beauty and fresh look for a long time in spite of using best chemicals for enhancing vase life. Moreover, there is a non-availability of fresh flowers all round the year in all places (Datta, 2004). In this context rose flowers can be dried, preserved and processed to retain its beauty as well as everlasting value. Dried flowers are long lasting, can be used several times and also meet the decorative demand throughout the year (Susan, 1990). With growing eco-consciousness, the use of more and more nature-friendly things like dry flowers come as a natural choice for decoration. The life of dried flowers varies according to the species, texture of their petals and total consistency of flowers. Dried flowers can be effectively used for making decorative floral craft items for interior decoration and commercial exploitation (Ranjan & Misra, 2002). Considering the potential of Dutch roses in dry flower trade, the present studies were undertaken to study the effect of different techniques of drying to obtain better quality dried flowers of Dutch roses.

2. Materials and Methods

The present study on the effect of hot air oven and microwave oven drying on dry flower quality of Dutch roses was carried out in the laboratory of Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India. Four cultivars of Dutch roses viz., Yellow variety 'Skyline', Orange variety 'Lambada', Pink variety 'Ravel' and Red variety 'First Red' were used for the present study. All the four cultivars belong to the class of Hybrid Teas. Main characteristics of these cultivars are production of blooms on long canes, elongated buds and slow opening of flowers (Arora, 1990). The flowers were harvested at half bloom stage (around fifty per cent of the petals open) in the morning hours between 8.00 and 9.00 am by

cutting with a sharp knife. Immediately after harvest, the cut ends of the flower stalks were immersed in water. After bringing to the laboratory, the flowers were sorted for petal damage, pests and diseases. Stems of uniform size were selected and trimmed to uniform length and the treatments were imposed immediately. The temperature and its duration required for hot air oven drying were standardised by embedding the flowers in silica gel and keeping them in hot air oven at different temperatures (30°C, 40°C and 50°C) till they were dried. Experimental materials were dried by using with or without embedding material *i.e.*, silica gel. For microwave oven drying, half opened flowers of all the four cultivars were kept in IFB microwave oven at three different time levels (3.0 minutes, 2.5 minutes and 2.0 minutes) by with and without embedding in silica gel. Water was placed in a glass container at the back of microwave oven during the operation as suggested by the manufacturers. After drying, the flowers were left undisturbed in the container along with or without desiccant for 3 hours (called setting time) to eliminate the moisture. The experimental design followed was completely randomized design with factorial concept. Treatments were replicated three times. After dehydration, the containers were tilted for removing the desiccants over and around the flowers. The dried flowers were picked up by hand, cleaned by inverting them and tapping the stems with fingers slowly and gently. Remaining desiccants were finally removed with the help of fine brush. Observations on initial fresh weight of the flowers, weight of the flowers after drying, moisture loss percentage and time taken for drying were recorded. Fresh weight of the flowers before putting it for treatment was recorded and expressed in grams. Dry weight of the flowers after drying was recorded and expressed in grams. Loss of moisture due to drying was estimated by using the formula given below and expressed as percentage.

$$\text{Moisture loss (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

The time taken for drying of flowers by hot air oven drying method was recorded as number of hours at the end of drying. Quality parameters like colour, appearance and texture were assessed by means of sensory evaluation. Panel of judges assessed the quality parameters *viz.*, colour, appearance and texture by scoring on a five-point scale *i.e.* excellent, very good, good, bad and very bad with the weightage of 3.5-4.0, 2.5-3.4, 1.5-2.4, 0.5-1.4 and 0.0-0.4 respectively. Experimental data was analysed statistically using MSTAT computer programme. The limit of probability fixed for the level of significance was $P = 0.01$.

3. Results and Discussion

The data pertaining to different parameters *viz.*, dry weight, moisture loss, time taken for drying, flower colour, appearance and texture recorded during standardizing the temperature and time for drying of Dutch rose flowers in hot air oven are presented in Tables 1 to 3.

3.1 Standardization of the Temperature and Time Required for Drying of Dutch Rose Flowers in Hot Air Oven

3.1.1 Effect of Temperature and Different Mode of Desiccation in Hot Air Oven

The dry weight, moisture loss, time taken for drying and quality attributes of flowers dried at three different temperature levels *viz.* 30°C, 40°C and 50°C with and without embedding in silica gel and are presented in Table 1. Both dry weight and moisture loss as influenced by temperature and mode of desiccation did not differ significantly. The time taken for drying of rose flowers decreased as the temperature of the oven was increased from 30°C to 50°C. Among the temperature levels, drying of Dutch rose flowers in hot air oven at a temperature of 50°C took minimum time (39.40 hours), while drying at a temperature of 30°C took maximum time (80.72 hours). Time taken was least in case of flowers dried at 50°C due to faster removal of moisture at higher temperature. Maximum time was required at 30°C due to slow elimination of moisture. Significant differences were seen for quality of dried flowers due to temperature levels and mode of desiccation. Less time was taken by non-embedding method (52.32 hours) to dry the Dutch rose flowers when compared to flowers dried by embedding in silica gel (61.05 hours). Drying the flowers without embedding medium was desiccated at a faster rate when compared to drying with desiccants, irrespective of temperature levels for drying. Among the interaction effects, minimum time (36.32 hours) was taken by non-embedded drying at a temperature of 50°C, while maximum time was recorded by embedding at 30°C (88.34 hours) to dry the flowers. Embedded drying at 30°C required maximum duration compared to direct exposure of flowers to hot air oven at the same temperature level. This is because the hot air requires time to heat the desiccants before desiccating the flowers resulting in increased time for complete removal of moisture in embedded flowers. However, drying at 50°C without embedding required least time when compared to all other interaction effects. Direct exposure to higher temperature led to the drying of flowers at a faster rate. Mode of desiccation exhibited highly significant differences for the colour, appearance and texture of dried rose flowers. The flowers which were embedded and dried scored higher points for retention of colour (2.92), overall appearance (2.79) and texture (2.51), as compared to those flowers which were dried without embedding which

scored only 1.16 points, 1.14 points and 1.10 points for the same. In general, irrespective of temperature levels, the embedded drying scored higher points for all the quality attributes. Influence of different temperature levels on retention of colour, appearance and texture was found to be significant. The highest points of 2.39 for colour retention was scored by flowers dried at 40°C, while the least score was recorded by flowers dried at 30°C (1.66). The highest acceptability (2.36) for appearance was recorded by those flowers, which were dried at 40°C. The Dutch rose flowers dried at 30°C scored the least (1.60) points indicating thereby the poor acceptability for appearance. Among the different temperature levels, the flowers dried at 40°C scored maximum points of 2.24 for texture, while those flowers dried at 30°C scored the least points (1.27). Good colour, appearance and texture were recorded in the flowers dried at 40°C, irrespective of the mode of desiccation. At the temperature of 40°C, moisture is removed in a steady rate without affecting the structural integrity of the flowers. Flower drying at higher temperature of 50°C significantly damaged the quality parameters of the flowers and also resulted in petal fall. Significant differences with respect to retention of colour, appearance and texture were also noticed for interaction effects between temperature levels and mode of desiccation. The flowers dried at 40°C by embedding in silica gel scored the highest points for colour (3.48), overall appearance (3.50) and texture (3.23) while the Dutch rose flowers dried at 50°C without embedding scored the lowest points of 1.05 for colour, 1.04 for appearance and 0.97 for texture. Among the interaction effects, drying of flowers at 40°C by embedding in silica gel resulted in high quality dry flowers. The results are on line with those of Joykumar (1997) who obtained best quality dried flowers in aster and chrysanthemum by following embedded drying techniques. He also reported that colour of dried flowers of rose, aster and chrysanthemum were good in oven drying with silica gel as embedding medium. Kher and Bhutani (1979) reported that flowers embedded in silica gel remained intact throughout the drying process and also maintain the original shape and appearance.

Table 1. Influence of temperature and different mode of desiccation on dry weight, moisture loss, time taken for drying and quality attributes of Dutch rose flowers in hot air oven

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Time taken to dry (hours)	Colour	Appearance	Texture
Mode of desiccation (M)							
1.	Embedding in silica gel	3.23	65.80	61.05	2.92	2.79	2.51
2.	Without embedding	3.28	65.47	52.32	1.16	1.14	1.10
	S.Em±	0.026	0.163	0.063	0.005	0.009	0.006
	C.D. at 1%	NS	NS	0.240	0.018	0.033	0.024
Temperature level (T)							
1.	30°C	3.24	65.58	80.72	1.66	1.60	1.27
2.	40°C	3.27	65.72	49.93	2.39	2.36	2.24
3.	50°C	3.26	65.60	39.40	2.06	1.94	1.90
	S.Em±	0.032	0.199	0.077	0.006	0.011	0.008
	C.D. at 1%	NS	NS	0.294	0.022	0.041	0.029
Interaction effect (M x T)							
1.	Embedded drying in silica gel at 30°C	3.25	65.63	88.34	2.27	2.16	1.57
2.	Embedded drying in silica gel at 40°C	3.22	65.81	52.33	3.48	3.50	3.23
3.	Embedded drying in silica gel at 50°C	3.22	65.95	42.48	2.99	2.72	2.72
4.	Without embedding and drying at 30°C	3.24	65.53	73.10	1.12	1.17	1.08
5.	Without embedding and drying at 40°C	3.31	65.64	47.54	1.31	1.22	1.25
6.	Without embedding and drying at 50°C	3.30	65.25	36.32	1.05	1.04	0.97
	S.Em±	0.045	0.282	0.110	0.008	0.015	0.011
	C.D. at 1%	NS	NS	0.415	0.031	0.058	0.041

NS-Non-significant

Table 2. Influence of different mode of desiccation and cultivars on dry weight, moisture loss, time taken for drying and quality attributes of Dutch rose flowers in hot air oven

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Time taken to dry (hours)	Colour	Appearance	Texture
Mode of desiccation (M)							
1.	Embedding in silica gel	3.23	65.80	61.05	2.92	2.79	2.51
2.	Without embedding	3.28	65.47	52.32	1.16	1.14	1.10
	S.Em±	0.026	0.163	0.063	0.005	0.009	0.006
	C.D. at 1%	NS	NS	0.240	0.018	0.033	0.024
Cultivars (V)							
1.	Skyline	3.23	65.71	56.49	2.08	2.02	1.85
2.	Lambada	3.24	65.81	56.30	2.17	2.14	1.95
3.	Ravel	3.26	65.44	57.06	1.91	1.79	1.63
4.	First Red	3.30	65.57	56.89	1.99	1.93	1.77
	S.Em±	0.037	0.230	0.089	0.007	0.012	0.009
	C.D. at 1%	NS	NS	0.339	0.025	0.047	0.033
Interaction effect (M x V)							
1.	Embedding in silica gel x Skyline	3.24	65.75	60.70	2.97	2.85	2.56
2.	Embedding in silica gel x Lambada	3.23	65.89	60.52	3.06	2.95	2.69
3.	Embedding in silica gel x Ravel	3.23	65.73	61.56	2.77	2.64	2.31
4.	Embedding in silica gel x First Red	3.22	65.81	61.42	2.86	2.73	2.46
5.	Without embedding x Skyline	3.22	65.66	52.27	1.19	1.18	1.14
6.	Without embedding x Lambada	3.25	65.73	52.07	1.28	1.32	1.21
7.	Without embedding x Ravel	3.28	65.16	52.57	1.05	0.94	0.95
8.	Without embedding x First Red	3.38	65.34	52.37	1.12	1.12	1.09
	S.Em±	0.052	0.325	0.126	0.009	0.018	0.013
	C.D. at 1%	NS	NS	0.479	0.035	0.066	0.047

NS: Non-significant

3.1.2 Effect of Different Mode of Desiccation and Cultivars in Hot Air Oven

The data pertaining to the influence of different mode of desiccation and cultivars on dry weight, moisture loss, time taken for drying and quality attributes of Dutch rose flowers in hot air oven are depicted in Table 2. Dry weight and moisture loss as influenced by mode of desiccation and cultivars did not differ significantly. Flowers of 'Lambada' took least time for drying (56.30 hours) while flowers of 'Ravel' took maximum time (57.06 hours) for drying. Among the four cultivars evaluated, cv. 'Lambada' took shortest time for drying in hot air oven. This might be attributed to the low moisture content of flower. Also due to small size of the flowers, moisture was

lost at a faster rate. Least time of 52.32 hours was taken by flowers dried by non-embedding method when compared to flowers dried by embedding in silica gel (61.05 hours). Among the interaction effects, minimum time of 52.07 hours was taken by 'Lambada' dried without embedding method, while maximum time was recorded by 'Ravel' (61.56 hours) dried by embedding in powdered silica gel. Faster dehydration was due to low moisture content in the flowers of cv. 'Lambada' combined with quick dehydration action of silica gel. Time taken for drying of flowers of cv. 'Lambada' was shorter in both modes of desiccation compared to other cultivars. This may be due to low moisture content in the flowers of Lambada coupled with rapid dehydration due to papery structure of flowers. The retention of colour, appearance and texture of dried Dutch rose flowers was significant with respect to mode of desiccation and cultivars. Among the different cultivars evaluated, dry flowers of 'Lambada' scored maximum points (2.17) with respect to retention of colour, whereas least score of 1.91 points was recorded in 'Ravel'. The highest acceptability for appearance (2.14) was recorded in 'Lambada' whereas 'Ravel' scored least (1.79) points for appearance. 'Lambada' had good texture and received maximum rating of 1.95, whereas 'Ravel' obtained minimum rating of 1.63 with respect to flower texture. Similarly Datillo (2001) reported that rose colours that dry well and retain bright colour include orange, medium and dark yellow, medium red, medium and dark pink. Dark red tends to turn black and light pink becomes pale. Same result was obtained in the present investigation wherein 'First Red' turned darker and cv. 'Ravel' showed a pale colour on drying. The results of sensory evaluation for dry flower qualities revealed that the flowers which were embedded and dried scored higher points for retention of colour (2.92), appearance (2.79) and texture (2.51), as compared to those flowers which were dried without embedding which scored only 1.16, 1.14 and 1.10 points for the same. The flowers embedded in silica gel were found to produce good quality dry flowers as this desiccant prevents the direct removal of moisture from flowers by acting as an intermediate. This prevents shrinkage of the flower and degradation of colouring pigments, that could take place when petal tissues are exposed to high temperatures without embedding. Interaction effect of cultivars and different mode of desiccation showed significant difference on quality attributes of dried Dutch rose flowers. 'Lambada' dried by embedding in silica gel obtained maximum score of 3.06, while least score (1.05) was given to flowers of 'Ravel' dried without embedding with respect to retention of flower colour. The flowers of 'Lambada' dried by embedding in powdered silica gel recorded the highest score of 2.95 points for appearance while the flowers of 'Ravel' dried without embedding in hot air oven scored the lowest point of 0.94. Interaction effects of Dutch rose cultivars and mode of desiccation on dry flower texture was best in 'Lambada' dried by embedding in silica gel which scored the maximum point of 2.69. Least score (0.95) for texture was noticed in 'Ravel' without embedding. Silica gel method of flower drying was reported excellent for retaining the colour of flowers (Champoux, 1997). Silica gel has been reported to be the fastest acting desiccants (Naev, 1996). The results of the present study were in harmony with the aforesaid reports, wherein silica gel by acting as drying agent could produce better quality dry flowers.

3.1.3 Effect of Cultivars and Different Drying Temperatures in Hot Air Oven

The data pertaining to different parameters *viz.*, dry weight, moisture loss, time taken for drying, flower colour, appearance and texture as influenced by cultivars and different temperature levels are furnished in Table 3. There was no significant difference in dry weight and moisture loss as influenced by cultivars and different temperature levels. The time taken for drying was maximum for flowers of 'Ravel' which took 57.06 hours, while it was minimum (56.30 hours) for flowers of 'Lambada'. This may be due to low moisture content of flower, rapid dehydration of papery structure of flowers and also it might have lost the moisture at a faster rate due to smaller sized flowers. Among the temperature levels, drying of all the cultivars of Dutch rose flowers in hot air oven at a temperature of 50°C took least time (39.40 hours) while drying at a temperature of 30°C took maximum time (80.72 hours). Interaction effects between different cultivars and different temperature levels also varied significantly for time taken for drying. Among the interactions, 'Lambada' dried at 50°C took minimum time for drying (39.09 hours) while 'Ravel' dried at 30°C took maximum time (80.93 hours) for drying. Among the interactions between different temperature levels and cultivars, cv. 'Lambada' dried at 50°C took least time for drying. This might be due to the faster removal of moisture from small sized flowers at higher temperature. Among the four cultivars, maximum score (2.17) for colour retention was received by 'Lambada' followed by cv. 'Skyline' (2.08). Least score (1.91) for flower colour was recorded in 'Ravel'. Gordon (2004) opined that colours that came out close to the original when dried in silica are white, orange, yellow, lavender and blue (non-roses). Darker colours such as red tend to turn out even darker. So the result is in harmony with the aforesaid reports. The maximum score of 2.14 for dry flower appearance was recorded in 'Lambada' among the four cultivars evaluated. Least score of 1.79 points for appearance of the flower was recorded in 'Ravel'. Best size and shape of dry flower was obtained in cv. 'Lambada' owing to its varietal character. 'Lambada' had good texture and received highest rating of 1.95, whereas 'Ravel' obtained least rating of 1.63. All the quality display characters of the dry flowers were best in the cv. 'Lambada'. Among the different cultivars, 'Lambada' flowers showed better texture of dry

flower. This may be owing to its stalk strength and other flower characters as compared to others. Significant differences were observed due to different levels of temperature in hot air oven in which highest score for flower colour (2.39) was recorded in flowers dried at 40°C, while the least score (1.66) was recorded in flowers dried at 30°C. The highest acceptability for appearance (2.36) was recorded by those flowers, which were dried at 40°C. The flowers dried at 30°C scored the least (1.60) points indicating thereby the poor acceptability for appearance. The flowers dried at 40°C scored maximum points of 2.24 for texture, while those flowers dried at 30°C scored minimum points (1.27). With respect to interactions, cultivars and different levels of temperature showed significant differences on quality attributes of dry flowers. The flowers of 'Lambada' dried at 40°C recorded the maximum score of 2.51, 2.52 and 2.38 points with respect to flower colour, appearance and dry flower texture while the least score of 1.57 points for colour, 1.49 points for appearance and 1.16 points for texture was recorded in 'Ravel' dried at 30°C. Regarding interaction effects of cultivars and different temperature levels, cv. 'Lambada' dried at 40°C recorded maximum rating with respect to dry flower display qualities. This is because at 40°C, moisture is removed in a steady rate without affecting the structural integrity of flowers. Better appearance, texture and colour was retained in the cv. 'Lambada' owing to its characteristic feature.

Table 3. Influence of cultivars and different drying temperature on dry weight, moisture loss, time taken for drying and quality attributes of Dutch rose flowers in hot air oven

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Time taken to dry (hours)	Colour	Appearance	Texture
Cultivars (V)							
1.	Skyline	3.23	65.71	56.49	2.08	2.02	1.85
2.	Lambada	3.24	65.81	56.30	2.17	2.14	1.95
3.	Ravel	3.26	65.44	57.06	1.91	1.79	1.63
4.	First Red	3.30	65.57	56.89	1.99	1.93	1.77
	S.Em±	0.037	0.230	0.089	0.007	0.012	0.008
	C.D. at 1%	NS	NS	0.339	0.025	0.047	0.033
Temperature level (T)							
1.	30°C	3.24	65.58	80.72	1.66	1.60	1.27
2.	40°C	3.27	65.72	49.93	2.39	2.36	2.24
3.	50°C	3.26	65.60	39.40	2.06	1.94	1.90
	S.Em±	0.032	0.199	0.077	0.006	0.011	0.008
	C.D. at 1%	NS	NS	0.294	0.022	0.041	0.029
Interaction effect (V x T)							
1.	Skyline dried at 30°C	3.21	65.94	80.68	1.69	1.62	1.30
2.	Skyline dried at 40°C	3.26	65.65	49.45	2.45	2.43	2.32
3.	Skyline dried at 50°C	3.22	65.54	39.33	2.10	2.01	1.92
4.	Lambada dried at 30°C	3.23	65.86	80.47	1.77	1.73	1.37
5.	Lambada dried at 40°C	3.22	66.01	49.33	2.51	2.52	2.38
6.	Lambada dried at 50°C	3.27	65.57	39.09	2.23	2.16	2.10
7.	Ravel dried at 30°C	3.25	65.09	80.93	1.57	1.49	1.16
8.	Ravel dried at 40°C	3.28	65.71	50.56	2.24	2.15	2.00
9.	Ravel dried at 50°C	3.24	65.53	39.70	1.93	1.73	1.73
10.	First Red dried at 30°C	3.29	65.43	80.82	1.63	1.56	1.24
11.	First Red dried at 40°C	3.32	65.53	50.40	2.38	2.33	2.24
12.	First Red dried at 50°C	3.30	65.76	39.47	1.97	1.88	1.85
	S.Em±	0.064	0.398	0.155	0.011	0.021	0.015
	C.D. at 1%	NS	NS	0.587	0.043	0.081	0.058

NS: Non-significant

3.2 Standardization of Time Required for Drying of Dutch Rose Flowers in Microwave Oven

Various parameters, viz., dry weight, moisture loss, time taken for drying, colour, appearance and texture of dried Dutch rose flowers were recorded during standardizing the time for drying of Dutch rose flowers in microwave oven. The data pertaining to these parameters are presented in Tables 4 to 6.

3.2.1 Effect of Different Time Levels and Mode of Desiccation in Microwave Oven

The data pertaining to dry weight, moisture loss and quality attributes of Dutch rose flower as affected by different time levels and mode of desiccation are furnished in Table 4. Dry weight and moisture loss did not show significant differences either due to different time levels or due to embedding (mode of desiccation) and also due to their interactions. This indicated uniform removal of moisture from the flowers. Significant differences were observed due to mode of desiccation for the quality attributes of dried Dutch rose flowers. Among the mode of desiccation, embedding method scored higher points (2.92) for colour as compared to drying without embedding which scored only 1.19 points. Embedded flowers scored higher points (2.81) after drying as compared to flowers dried without embedding which scored 1.18 points for appearance. Embedded method was found to retain better texture by scoring 2.55 points. The flowers dried without embedding scored only 1.12 points thereby indicating the poor texture in these dried flowers. Between embedding and non-embedding methods, the flowers desiccated without embedding were poor in quality due to direct exposure to microwaves which might have caused tissue damages and charring effects, further leading to petal fall and degradation of anthocyanin pigments. On the other hand, silica gel pre treatment protected the flowers from such damages. Silica gel is composed of a vast network of interconnecting microscopic pores, which attract and hold moisture by a phenomenon known as physical adsorption and capillary condensation. Through this phenomenon, it acts as a dehydrating agent (Anon., 1997). Trinklein (2000) reported that since silica gel dries flowers quickly, more flowers can be moved in and out of the mixture during a single season than in the same quantity of a borax mixture. Significant difference were noticed due to different time levels, in which power output level for 2.5 minutes scored the highest points for colour (2.42), appearance (2.39) and texture (2.29). The flowers dried for 3 minutes scored the least by recording 1.67 points for colour and 1.63 points for appearance thereby indicating failure to retain the original appearance after drying and 1.29 points for texture. Among different time levels, subjecting the flowers to power output level for 2.5 minutes was found to be the best for drying of Dutch roses. Treating the flowers at this power output level was best with respect to colour, appearance and texture. Upon subjecting to longer duration of drying (3 minutes), the texture and colour retainment was poor. Increase in the temperature might have been the cause for poor colour. Interactions among different time levels and mode of desiccation were highly significant for quality attributes of dried flowers. Flowers embedded in silica gel and dried at power output level for 2.5 minutes scored the higher points for colour (3.48), retention of appearance (3.51) and texture (3.29) while those dried for 3 minutes without embedding scored minimum points of 1.07 for colour, 1.08 for appearance and 0.98 for texture of dried flowers. Among the interaction effects, embedding the flowers in silica gel and drying for 2.5 minutes was proved to be best. The acceptability for colour, appearance and texture was low when the flowers were directly exposed for drying without embedding and also drying in desiccant for longer duration. Probable reason is that on direct exposure to microwaves, there will be tissue damages and charring effects further leading to petal fall.

3.2.2 Effect of Mode of Desiccation and Cultivars in Microwave Oven

Dry weight and moisture loss as influenced by mode of desiccation and cultivars did not differ significantly (Table 5). The retention of colour, appearance and texture of dried Dutch rose flowers were significant with respect to mode of desiccation and cultivars. Among the four different cultivars evaluated, dry flowers of 'Lambada' scored maximum points with respect to retention of colour (2.20), appearance (2.16) and texture (1.97) whereas least score of 1.92 points for colour, 1.81 points for appearance and 1.67 points for texture was recorded in 'Ravel'. All the floral characteristics like colour, appearance and texture were best in the orange coloured cv. 'Lambada' followed by yellow coloured cv. 'Skyline'. This result is in confirmation with the findings of Datillo (2001) who opined that, brighter the flower longer the colour last. The bright orange roses such as Prominent, Fragrant cloud, Impatient, Marina, Tropicana, Carrot top and Holy Toledo will dry glorious orange. The results of the present study also indicated that cv. 'First Red' tend to become dark on drying and cv. 'Ravel' (Pink) did not retain their colour after drying which might be due to bleaching. The differences in flower colour may be due to varietal character and also the reaction of the flower colour to drying methods. Significant differences was observed due to mode of desiccation in which flowers dried by embedding mode scored the maximum rating of 2.92 for retention of colour, while flowers dried without embedding scored minimum points (1.19). Flowers dried by embedding in powdered silica gel scored maximum points of 2.81 for appearance whereas, flowers dried without embedding scored least points (1.18). The Dutch rose flowers dried by embedding in silica gel scored higher points (2.55) for texture as compared to those which were dried without embedding (1.12 points). Interaction effect of cultivars and different

mode of desiccation showed significant difference on quality attributes of dried Dutch rose flowers. Maximum score for colour (3.07), appearance (2.96) and retention of texture (2.71) was recorded by the flowers of 'Lambada' which were dried by embedding in silica gel. Flowers of 'Ravel' dried without embedding scored only 1.07 points for colour and 0.96 points for texture. All the cultivars desiccated by embedding in silica gel scored higher points than those dried without any desiccant for all the quality parameters. The quick action of silica gel for dehydration coupled with its smooth texture and light weight might have better supported the petal arrangement and prevented loss of pigments. Embedded drying retains good colour and form. The phenomenon of embedded drying is that during desiccation, the water content of the flower is completely absorbed by the surrounding desiccant material. Pertuit (2002) reported that silica gel as a desiccant can absorb about 40 per cent of its weight with water. It is appropriate for drying flowers with closely packed petals such as roses. Silica gel in powder form is the quickest acting desiccant.

Table 4. Dry weight, moisture loss, colour, appearance and texture of Dutch rose flowers as influenced by different time levels and mode of desiccation under microwave oven drying

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Colour	Appearance	Texture
Mode of desiccation (E)						
1.	Embedding in silica gel	3.22	65.74	2.92	2.81	2.55
2.	Without embedding	3.27	65.42	1.19	1.18	1.12
	S.Em±	0.026	0.191	0.005	0.004	0.004
	C.D. at 1%	NS	NS	0.019	0.016	0.015
Time level (M)						
1.	3.0 minutes	3.26	65.37	1.67	1.63	1.29
2.	2.5 minutes	3.23	65.74	2.42	2.39	2.29
3.	2.0 minutes	3.24	65.63	2.07	1.96	1.94
	S.Em±	0.032	0.234	0.006	0.005	0.005
	C.D. at 1%	NS	NS	0.023	0.019	0.018
Interaction effect (E x M)						
1.	Embedded drying in silica gel for 3.0 minutes	3.24	65.47	2.28	2.19	1.60
2.	Embedded drying in silica gel for 2.5 minutes	3.22	65.81	3.48	3.51	3.29
3.	Embedded drying in silica gel for 2.0 minutes	3.20	65.96	3.01	2.74	2.77
4.	Without embedding and drying for 3.0 minutes	3.28	65.28	1.07	1.08	0.98
5.	Without embedding and drying for 2.5 minutes	3.23	65.67	1.35	1.28	1.29
6.	Without embedding and drying for 2.0 minutes	3.29	65.30	1.16	1.18	1.10
	S.Em±	0.045	0.331	0.009	0.007	0.007
	C.D. at 1%	NS	NS	0.033	0.027	0.026

NS: Non-significant

Table 5. Influence of mode of desiccation and cultivars on dry weight, moisture loss, colour, appearance and texture of Dutch rose flowers under microwave oven drying

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Colour	Appearance	Texture
Mode of desiccation (E)						
1.	Embedding in silica gel	3.22	65.74	2.92	2.81	2.55
2.	Without embedding	3.27	65.42	1.19	1.18	1.12
	S.Em±	0.026	0.191	0.005	0.004	0.004
	C.D. at 1%	NS	NS	0.019	0.016	0.015
Cultivars (V)						
1.	Skyline	3.23	65.71	2.10	2.04	1.89
2.	Lambada	3.22	65.79	2.20	2.16	1.97
3.	Ravel	3.26	65.47	1.92	1.81	1.67
4.	First Red	3.28	65.35	2.01	1.97	1.82
	S.Em±	0.037	0.271	0.007	0.006	0.006
	C.D. at 1%	NS	NS	0.027	0.022	0.021
Interaction effect (E x V)						
1.	Embedding in silica gel x Skyline	3.23	65.76	2.97	2.86	2.61
2.	Embedding in silica gel x Lambada	3.20	65.68	3.07	2.96	2.71
3.	Embedding in silica gel x Ravel	3.23	65.73	2.77	2.66	2.39
4.	Embedding in silica gel x First Red	3.22	65.80	2.87	2.76	2.50
5.	Without Embedding x Skyline	3.22	65.66	1.22	1.21	1.18
6.	Without Embedding x Lambada	3.25	65.90	1.32	1.36	1.23
7.	Without Embedding x Ravel	3.28	65.21	1.07	0.96	0.96
8.	Without Embedding x First Red	3.33	64.90	1.15	1.18	1.14
	S.Em±	0.052	0.383	0.010	0.008	0.008
	C.D. at 1%	NS	NS	0.038	0.031	0.030

NS: Non-significant

3.2.3 Effect of Cultivars and Different Time Levels in Microwave Oven

There was no significant difference in dry weight and moisture loss as influenced by cultivars and different time levels (Table 6). Among the four cultivars, maximum rating for colour of 2.20 points was received by 'Lambada'. Least score (1.92) for flower colour was recorded in 'Ravel'. Maximum score of 2.16 points for appearance was received by 'Lambada'. Least score (1.81) for appearance was recorded in 'Ravel'. The flowers of 'Lambada' received the maximum score of 1.97 for flower texture, while the least score was recorded in flowers of 'Ravel' which scored only 1.67 points. The variation among the cultivars may be owed to the characteristic feature of the cultivar. Significant differences were noticed due to different time levels in microwave oven in which highest score for flower colour (2.42) was recorded in flowers dried for 2.5 minutes, while the least score (1.67) was recorded in flowers dried for 3 minutes. Highest score for appearance (2.39) was recorded in flowers dried for 2.5 minutes, while the least score (1.63) was recorded in flowers dried for 3 minutes. It was observed that drying for a period of 2.5 minutes in microwave oven scored maximum rating of 2.29 for flower texture, while the flowers dried for 3 minutes, scored only 1.29 points. The principle behind the microwave oven drying is liberating moisture by agitating water molecules in the organic substances with the help of electronically produced microwaves. Drying is exceptionally fast and gets completed within a few minutes and generates little heat (Bhattacharjee & De, 2003). Interaction between cultivars and different time levels in microwave oven for quality parameters was found to be significant. The flowers of 'Lambada' dried for 2.5 minutes scored maximum rating of 2.53 points with respect to flower colour, 2.56 points with respect to appearance and 2.41 points for flower texture.

Flowers of ‘Ravel’ dried for 3 minutes scored the least rating of 1.57 points for colour, 1.53 points for appearance and 1.19 points for texture. Overall acceptability was high for flowers of cv. ‘Lambada’ dried for 2.5 minutes in the microwave oven.

Table 6. Different parameters of Dutch rose flowers as influenced by cultivars and different time levels under microwave oven drying

Sl. No.	Treatments	Dry weight (g/flower)	Moisture loss (%)	Colour	Appearance	Texture
Cultivars (V)						
1.	Skyline	3.23	65.71	2.10	2.04	1.89
2.	Lambada	3.22	65.79	2.20	2.16	1.97
3.	Ravel	3.26	65.47	1.92	1.81	1.67
4.	First Red	3.28	65.35	2.01	1.97	1.82
	S.Em±	0.037	0.271	0.007	0.006	0.005
	C.D. at 1%	NS	NS	0.027	0.022	0.021
Time level (M)						
1.	3.0 minutes	3.26	65.37	1.67	1.63	1.29
2.	2.5 minutes	3.23	65.74	2.42	2.39	2.29
3.	2.0 minutes	3.24	65.63	2.08	1.96	1.94
	S.Em±	0.032	0.234	0.006	0.005	0.005
	C.D. at 1%	NS	NS	0.023	0.019	0.018
Interaction effect (V x M)						
1.	Skyline dried for 3.0 minutes	3.20	65.94	1.69	1.65	1.33
2.	Skyline dried for 2.5 minutes	3.26	65.65	2.48	2.45	2.39
3.	Skyline dried for 2.0 minutes	3.22	65.54	2.12	2.02	1.97
4.	Lambada dried for 3.0 minutes	3.23	65.57	1.77	1.76	1.39
5.	Lambada dried for 2.5 minutes	3.22	66.23	2.53	2.56	2.41
6.	Lambada dried for 2.0 minutes	3.22	65.57	2.29	2.17	2.11
7.	Ravel dried for 3.0 minutes	3.24	65.12	1.57	1.53	1.19
8.	Ravel dried for 2.5 minutes	3.21	65.76	2.26	2.16	2.06
9.	Ravel dried for 2.0 minutes	3.31	65.53	1.94	1.75	1.77
10.	First Red dried for 3.0 minutes	3.38	64.86	1.66	1.61	1.27
11.	First Red dried for 2.5 minutes	3.23	65.32	2.40	2.41	2.30
12.	First Red dried for 2.0 minutes	3.22	65.88	1.97	1.90	1.90
	S.Em±	0.064	0.469	0.012	0.010	0.010
	C.D. at 1%	NS	NS	0.046	0.039	0.036

NS: Non-significant

4. Conclusions

From the above findings it can be concluded that drying the Dutch rose flowers in hot air oven at 40°C by embedding in silica gel and drying the Dutch rose flowers at power out put level for 2.5 minutes in the microwave oven by embedding in silica gel results in best quality dry flower. Orange coloured cultivar ‘Lambada’ was found to be the most suitable Dutch rose cultivar for drying.

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