Studies on hot air oven-drying of *Gomphrena globosa* L

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ABSTRACT

The experiment on hot air oven-drying of *Gomphrena globosa* L was laid out in a completely randomized design (factorial). Two strains of *G globosa* viz Magenta (GGM) and White (GGW) were dried after embedding in four drying media viz M_1 (silica gel), M_2 (sand:silica gel, 50:50 v/v), M_3 (borax) and M_4 (sand:borax, 50:50 v/v) at three temperatures viz T_1 (50°C), T_2 (55°C) and T_3 (60°C) for three durations viz D_1 (24 h), D_2 (48 h) and D_3 (72 h) in hot air oven. In GGM and GGW maximum moisture loss (80.94 and 79.76% respectively) and size reduction (17.74 and 17.00% respectively) were recorded in flowers embedded in $M_1T_3D_3$ (silica gel + 60°C + 72 h) in hot air oven. However in terms of quality parameters maximum score (18.00 and 18.20 in GGM and GGW respectively) out of a total of 20 was allotted to flowers embedded in $M_1T_1D_1$ (silica gel + 50°C + 24 h).

Keywords: *Gomphrena globosa*; silica gel; borax; desiccants; embedding; hot air oven-drying

INTRODUCTION

Flowers and ornamental plants have been associated with mankind from the dawn of civilization. Dried flower production has been considered as an art for hundreds of years. In order to overcome the problem of short shelf-life of fresh flowers, techniques of dehydration and drying play vital role (Bhutani 1995). Dry flowers are gaining popularity as they are inexpensive, long-lasting and eco-friendly products that are available throughout the year. Dried and preserved ornamental products offer wide range of unique qualities which include novelty, longevity, aesthetic values, flexibility and round the year availability (Joyce 1998).

Dry flower industry is labour-intensive and can generate ample job opportunities to thousands of unemployed men and women. In global floriculture trade the Netherlands (51.20%) contributes maximum to the export of dry flowers to different countries followed by Israel (14.20%), Nigeria (5.60%) and India (4.80%). UK is the largest importer of dry flowers accounting for 65 million US$ import amounting to 40.7 per cent of the total followed by France and Japan (Anon 2014). The demand for dry flowers has increased manifold in the last decades and is increasing at an impressive rate of 8-10 per cent annually thus offering immense opportunities to the Indian entrepreneurs to enter the global floriculture trade (Singh 2009).

Indian flower industry comprises commercial production and marketing of cut flowers, loose flowers, cut greens, seeds, bulbs and landscape plants and their marketing and production of value-added products. The contribution of dry flower industry is 77.1 per cent followed by cut flowers, bulbs, rhizomes, cut foliage and others (Anon 2014).

Gomphrena globosa L is a popular commercial flower grown in the southern districts of Tamil Nadu used for garland making and also as a cut flower (Rajasekaran et al 1983). Due to its dry papery bracts of flowers it is highly suitable for making dry flower products. A number of value-added products like garlands, potpourri, button holes and flower arrangements etc can be prepared from the dried flowers.

However there is a dearth of literature on drying methodology of *G globosa*. Hence the present study was undertaken to find out the suitable technique for drying gomphrena flowers.

MATERIAL and METHODS

The study was conducted in the Department of Floriculture and Landscape Architecture of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP. Nursery of *G globosa* Magenta (GGM) and *G globosa* White (GGW) was raised on 22 March 2014 and transplanted in the experimental field of the department. Flowers of *G globosa* Magenta (Purple Group-78 A) and *G globosa* White (Yellow Green Group-149 D) as per RHS colour chart were harvested from the experimental field of the department in the month of August. Healthy, disease-free and uniform flowers of 1 cm long stalk length were harvested.

The experiment was laid out in a completely randomized design (factorial) consisting of two cultivars viz *G globosa* Magenta (GGM) and *G globosa* White (GGW) and four different drying media viz M_1 (silica gel), M_2 (sand:silica gel, 50:50 v/v), M_3 (borax) and M_4 (sand:borax, 50:50 v/v) were used for drying at three temperatures viz T_1 (50°C), T_2 (55°C) and T_3 (60°C) for three durations viz D_1 (24 h), D_2 (48 h) and D_3 (72 h) in hot air oven. Freshly harvested flowers were carried to the laboratory and observations on flower size and weight of fresh flowers were recorded. Heat resistant plastic containers were selected for drying and filled evenly with the desiccants up to 10 cm of height and flowers were placed evenly on the respective media. After embedding the flowers the medium was poured gently over the flowers for uniform covering. The medium was evenly distributed so as to equalize the pressure on all sides of the flower. The plastic containers were put inside the hot air oven for specified temperatures and durations. After drying the embedded flowers were taken out carefully by tilting the containers. Observations like flower weight, size, colour, texture, brittleness and shape retention were recorded. Quality of dried flowers was judged on these parameters and score were given on the basis of 9-point hedonic scale as suggested by Peryam (1957) and a modified score card was developed as shown in Table 1.

Table 1. Score card for evaluating the quality of dried flowers (modified after Peryam 1957) (score out of a total of 20)

	Flower colour retention (5) /shape retention (5)	Texture (5)		Brittleness (5)	
Excellent	5	Smooth	5	Intact	5
Very Good	4	Medium	3	Slightly brittle	3
Good	3	Rough	1	Brittle	1
Poor	2				
Very Poor	1				

RESULTS and DISCUSSION

The effect of different drying media (M), temperatures (T), durations (D) and their interaction (M x T x D) has been shown in Tables 2 and 3.

Effect on moisture loss (%)

Maximum moisture loss (70.24 and 69.61%) was recorded in flowers which were dried in M_1 (silica gel) and minimum (58.54 and 57.46%) in flowers dried by embedding in M_2 (sand:silica gel, 50:50 v/v) in flowers of GGM and GGW respectively (Table 2). Amongst the three temperatures maximum moisture loss (66.24 and 67.91%) was recorded in T_3 (60°C) and minimum (64.04 and 58.89%) in T_1 (50°C) in GGM and GGW respectively. Amongst different durations D_3 (72 h) resulted in maximum moisture loss of 69.53 and 69.31 per cent whereas minimum of 60.24 and 57.12 per cent in GGM and GGW respectively was observed in D_1 (24 h) of hot air oven. The interaction effect of drying medium x temperature x duration on drying of GGM and GGW shows that maximum moisture loss (80.94 and

Table 2. Effect of drying media (M), temperature (T) and duration (D) on moisture loss, decrease in size and quality parameters of *G globosa* Magenta (GGM) and *G globosa* White (GGW)

Treatment	Moisture loss (%)		Decrease in size (%)		Quality parameters (score out of 20)	
	GGM	GGW	GGM	GGW	GGM	GGW
M_1	70.24	69.61	12.96	12.63	15.64	15.11
M_2	58.54	57.46	7.04	7.50	15.22	13.44
M_3	67.08	64.76	9.57	9.13	8.11	6.80
M_4	65.00	60.47	9.54	7.85	10.76	10.29
$CD_{0.05}$	1.89	0.62	0.47	0.44	0.11	0.14
T_1	64.04	58.89	8.01	7.68	13.95	12.95
T_2	65.36	62.41	9.88	9.19	12.36	10.71
T_3	66.24	67.91	11.45	10.96	11.00	10.57
$CD_{0.05}$	1.64	0.54	0.41	0.38	0.09	0.12
D_1	60.24	57.12	7.19	6.46	13.42	12.59
D_2	65.88	62.78	10.01	9.35	12.46	11.76
D_3	69.53	69.31	12.12	12.02	11.43	9.87
$CD_{0.05}$	1.64	0.54	0.41	0.38	0.09	0.12

79.76% respectively) was recorded in $M_1T_3D_3$ (silica gel + 60°C + 72 h) and minimum (46.05 and 43.42% respectively) in $M_2T_1D_1$ (sand:silica gel, 50:50 v/v + 50°C + 24 h) (Table 3).

Drying of GGM and GGW flowers in silica gel increased the moisture loss from the flowers as compared to borax, mixture of sand and silica gel and mixture of sand and borax. This might be due to the strong hygroscopic nature of silica gel which leads to the rapid removal of moisture from the flowers. These results are in concordance with dehydration of zinnia flowers by Singh et al (2003) who also reported that maximum moisture loss was observed when flowers were embedded in silica gel as compared to sand and borax.

Effect on decrease in size

Table 2 depicts that in GGM and GGW maximum decrease in size (12.96 and 12.63% respectively) was recorded in M_1 (silica gel) whereas minimum (7.04 and 7.50% respectively) in flowers dried by embedding in M_2 (sand:silica gel, 50:50 v/v); amongst the temperatures used for drying, maximum decrease in size (11.45 and 10.96% respectively) was recorded in T_3 (60°C) and minimum (8.01 and 7.68% respectively) in T_1 (50°C). Out of drying durations D_3 (72 h) resulted in maximum decrease in size (12.12 and 12.02% respectively) whereas D_1 (24 h) resulted in the minimum (7.19 and 6.46% respectively). The interaction of drying medium x temperature x duration on decrease in size of GGM and GGW given in Table 3 elucidates that maximum decrease in size (17.74 and 17.00% respectively) was recorded in $M_1T_3D_3$ (silica gel + 60°C + 72 h) whereas minimum (3.03 and 3.86% respectively) in $M_2T_1D_1$ (sand:silica gel, 50:50 v/v + 50°C + 24 h).

These findings are in close conformity with the findings of Kher and Bhutani (1979) who reported that fine sand did not react with the water vapour released during the process of drying as in the case of silica gel and borax. It allows the water vapour to escape freely thereby causing minimum moisture loss and hence size reduction was minimum in case of mixture of sand and silica gel.

Effect on quality parameters of dried flowers

Data presented in Table 2 with respect to quality parameters of dried flowers show that maximum score (15.64 and 15.11 in GGM and GGW respectively) was attained by the flowers embedded in M_1 (silica gel) whereas minimum (8.11 and 6.80 respectively) was attained by the flowers embedded in M_3 (borax). GGM and GGW flowers dried at T_1 (50°C) attained maximum score (13.95 and 12.95 respectively) and minimum score (11.00 and 10.57 respectively) was obtained by those flowers which were dried at 60°C. Flowers attained maximum score (13.42 and 12.59) which were dried in treatment D_1 (24 h) while D_3 (72

Table 3. Interaction effect of drying media (M), temperature (T) and duration (D) on moisture loss, decrease in size and quality parameters of *G globosa* Magenta (GGM) and *G globosa* White (GGW)

Treatment	Moisture loss (%)		Decrease in size (%)		Quality parameters (score out of 20)	
	GGM	GGW	GGM	GGW	GGM	GGW
$M_1T_1D_1$	63.70	61.14	8.39	7.37	18.00	18.20
$M_1T_1D_2$	64.83	68.45	10.44	10.58	17.00	15.40
$M_1T_1D_3$	75.57	71.50	12.76	12.84	15.87	14.20
$M_1T_2D_1$	59.49	64.70	9.62	9.67	17.00	17.07
$M_1T_2D_2$	71.84	69.25	14.14	14.26	16.00	15.60
$M_1T_2D_3$	75.86	73.71	16.31	16.57	15.00	15.13
$M_1T_3D_1$	64.22	68.11	11.12	10.59	15.00	15.40
$M_1T_3D_2$	75.70	69.81	16.14	14.75	14.13	14.20
$M_1T_3D_3$	80.94	79.76	17.74	17.00	12.80	10.80
$M_2T_1D_1$	46.05	43.42	3.03	3.86	17.00	16.20
$M_2T_1D_2$	60.98	55.62	5.46	6.00	16.80	14.80
$M_2T_1D_3$	63.89	61.07	7.01	7.98	16.60	14.00
$M_2T_2D_1$	51.75	49.89	5.30	4.68	16.80	13.47
$M_2T_2D_2$	62.56	51.79	7.59	8.17	14.60	12.80
$M_2T_2D_3$	65.16	64.57	9.26	9.70	15.40	12.73
$M_2T_3D_1$	55.74	57.78	6.48	6.60	14.60	12.67
$M_2T_3D_2$	56.92	64.24	7.70	8.92	12.20	12.07
$M_2T_3D_3$	63.83	68.70	11.52	11.65	13.00	12.20
$M_3T_1D_1$	62.52	56.53	5.33	4.63	10.87	10.80
$M_3T_1D_2$	70.58	59.18	8.45	8.32	10.07	9.87
$M_3T_1D_3$	71.60	63.51	11.36	11.33	8.20	8.20
$M_3T_2D_1$	64.63	61.10	6.36	6.02	10.33	4.07
$M_3T_2D_2$	66.46	66.08	7.87	7.50	6.00	6.53
$M_3T_2D_3$	66.36	68.45	11.90	11.09	8.73	4.40
$M_3T_3D_1$	65.47	64.38	10.01	9.38	6.60	6.87
$M_3T_3D_2$	70.79	67.06	10.62	11.04	9.00	7.07
$M_3T_3D_3$	65.32	76.53	14.20	12.83	3.20	3.40
$M_4T_1D_1$	62.11	47.58	5.59	4.11	13.00	12.93
$M_4T_1D_2$	60.00	56.51	8.87	5.84	12.40	12.60
$M_4T_1D_3$	66.71	62.14	9.39	9.37	11.60	8.20
$M_4T_2D_1$	63.56	49.98	7.40	4.77	10.67	12.27
$M_4T_2D_2$	64.13	62.03	11.17	7.36	9.40	8.00
$M_4T_2D_3$	72.49	67.37	11.60	10.50	8.33	6.40
$M_4T_3D_1$	63.56	60.81	7.70	5.88	11.20	11.20
$M_4T_3D_2$	65.80	63.38	11.70	9.47	11.87	12.20
$M_4T_3D_3$	66.66	74.37	12.39	13.35	8.40	8.80
$CD_{0.05}$	5.69	1.86	1.42	1.32	0.33	0.41

h) resulted in minimum score (11.43 and 9.87) in GGM and GGW respectively. The interaction in Table 3 shows that maximum score (18.00 and 18.20 in GGM and GGW respectively) was attained by the flowers embedded in $M_1T_1D_1$ (silica gel + 50°C + 24 h) whereas minimum (3.20 and 3.40) by those flowers embedded in $M_3T_3D_3$ (borax + 60°C + 72 h).

There was a significant effect of drying medium, temperature and method of drying on quality parameters of dried flowers. Maximum score on quality parameters was given to those flowers which were dried for minimum of 24 hours and at minimum 50°C temperature. In hot air oven-dried flowers for prolonged durations maximum shedding of bracts of both GGM and GGW was observed which could be due to excessive loss in moisture resulting in weakened adhesion and cohesion forces in flower tissue causing softening of middle lamella leading to abscission.

These results are in agreement with the observations of Singh et al (2003) on drying of zinnia where moisture below 8 per cent showed shedding effect. Mathapati et al (2016) studied the interaction effects of varieties and desiccants used for drying of gerbera flowers and maximum score (3.98) was obtained by variety Impireal embedded in silica gel while minimum (2.49) was noticed in Goliath embedded in borax. These studies support the present findings.

Shedding of bracts was found to be more in silica gel embedded flowers which might be due to the strong hygroscopic nature of silica granules, which makes the flower more brittle with maximum moisture removal and because of prolonged durations of drying in hot air oven bracts drop off with slight pressure also. This is also in accordance to the findings of Nirmala et al (2008) in carnation cv Master where maximum petal loss was noticed with silica gel and borax in comparison to quartz sand.

Flowers which were embedded in borax and dried for 48-72 hours in hot air oven at 55 and 60°C showed diminutive colour retention after drying. Colour of flowers was influenced by the degradation of pigments as well as auto-oxidation of anthocyanin pigments. This may be due to the bleaching effect of borax which resulted in fading effect while no such result was observed in silica gel and mixture of sand and silica gel which were used for drying. Therefore all the treatments which contained borax scored less for quality parameters. These results are in concordance with the observation of Meman et al (2008) who reported bleaching of carotenoid pigments of calendula flowers using borax as drying media.

Flowers which were dried with borax at T_1 (50°C), T_2 (55°C) and T_3 (60°C) temperatures for 24 to 72 hours felt smooth textured based on feel method whereas silica gel and other desiccants which were used for drying showed rough texture. This is in conformity with the results of Meman et al (2008) on calendula where they explained that high temperature and silica gel exhibited rough texture of petals and rough surface of foliage in dried flower and foliage than low temperature with borax drying. This may be attributed to unevenness in the cell layer on shrinking due to excessive and rapid loss of moisture after specific drying.

Drying GGM and GGW in silica gel at 50°C for 24 h in hot air oven was found to be the best method which scored maximum (18.00 and 18.20 respectively) for quality parameters.

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