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Freeze Drying on Physiological Characteristics and Sensory Quality of Flowers

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Drying technique of many ornamental flowers by freeze drying retains the quality and longevity of flowers. In this experiment freeze drying effect on different flowers (rose, carnation, jasmine, orchid and chrysanthemum) for flower colour, flower physiology, tissue integrity and moisture content with dry flower shape were studied. Flowers which recorded optimum moisture loss provided rigidity and uniform cell contraction with shape retention while higher moisture loss resulted in shriveled flowers. Light colour flowers retained colour value compared to dark flowers. The carnation (pink) and jasmine flowers recorded optimum percentage of moisture loss due to freeze drying, which did not affect the pigment concentration and retained the colour and shape. These flowers scored better for quality parameters and found suitable for freeze drying in dry flower industry.

Key words: Dry flower industry; Freeze drying; Flowers; Quality

Dry flower industry with long history had developed many fold times usage in recent years. Dried flowers as well as plant parts are the major segment accounting for 70 % of the total share of floriculture products exported from India (Singh, 2000). Dried flowers refer plant products of lasting appreciation after the colour protecting, setting and dehydration processing with plant materials (Chunfang *et al.,* 2011). Freeze drying is relatively a new preservation process for the preserved plant material industry. Originally introduced in 1813 by William Hyde Wallaston to the Royal society in London, it wasn't until the late 80's the freeze drying industry discovered the allurement and longevity of freeze dried flowers. Freeze drying is a dehydration process that causes the vapourization of water directly from solid ice crystal to a vapour state without passing through the liquid state by a process called sublimation. The main advantage of freeze drying is that it results in product that appears almost like the fresh originals. It involves first freezing the flowers at (-) 10$_0$ C for at least 12 hours. A vacuum pump slowly pulls the water out of the flowers as a vapour and condenses as ice in another chamber. Because of this process the shape and natural colour of the flower is maintained (Arulmurugan *et al*., 2007). The absence of liquid phase during the dehydration process means that undesirable chemical reactions will not take place (Dilta *et al*., 2011).

Only a few references define the requirements of freeze drying flowers. Wilkins and Desborough (1986) reported froze chemically sprayed carnation flowers at -80$_0$C for 1 h and then dried them under a vacuum of less than 100 mm Hg for up to 7 days remained naturalistic in appearance without pretreatment. But the chemicals *viz.,* glycerin, clove oil, ethylene glycol dimethylsulfoxide and liquid detergent when used as pretreatments with or without wetting agent were unsuccessful in an attempt to render the flowers and stems more flexible. Brown (1999) conducted freeze drying with different varieties of roses and carnation and determined the freeze drying time and temperatures at which drying was perfect to keep the quality of flowers.

Chen *et al.* (2000) evaluated the effect of different freezing time (2 and 4 hours), freezing temperature (27$_0$C, 37$_0$C, 47$_0$C) on colour, moisture content, stem and petal strength of roses and carnations. Lower vacuum drying temperatures resulted in flowers with colour closer to fresh flowers. Higher temperatures resulted in increased loss of moisture content. Drying technique for many ornamental flowers is available but the suitability of the techniques varies with flower. Systematic and organized research on various aspects of the flower dehydration through freeze drying is meager. With the above literature the current study was taken to study the effect of freeze drying on quality of different flowers.

Materials and Methods

Studies were carried out in the Tamil Nadu Agricultural University, Coimbatore during the year 2010 – 13 under completely randomized design. Fully opened flowers of rose (red, orange and yellow), carnation (red, pink and white), orchids,

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chrysanthemum (green) and well developed flowers of jasmine were bought from nearby local flower market. The bulk of unwanted flower stem was removed by retaining only an inch to which wire may be fastened. The flowers were dried using freeze dryer (Model: FD5505, Make: ILSHIN, Korea). The freeze dryer consisted of a drying chamber, cold trap (condenser), vacuum pump and microprocessor control. The freeze drying process was in two phases
(1) the freezing phase where the flowers were frozen at atmospheric pressure and (2) the vacuum drying phase where the vacuum was placed on the product and the temperature was regulated to dry the flower. The flowers were frozen at – 40 $_0$C for 12 h and dried under a vacuum of 5 torr pressure with vacuum drying temperature 25 $_0$C for 7 days. Drying was complete when the flowers were crisp but not brittle (Dana and Lerner, 2002). Physiological parameters *viz.,* moisture content, colour value, petal thickness, percentage of shrinkage were measured immediately after freeze drying .The moisture content of five flowers from each treatment were measured using Laboratory hot air oven (Technico, Technico Laboratory Products, Chennai) before and after freeze drying . The samples were dried at 105 $_o$ C for 8 h. Flower colour was measured before and after freeze drying of 5 flowers in each treatment using Hunter lab colour flex meter (Make: Hunter Association laboratory, Inc., Reston, Virgina, USA). It works on the principle of focusing the light and measuring energy reflected from the sample across the entire visible spectrum. Tristimulus colour parameters L, a, b were measured 3 times at the same location of flowers. 'L' represents lightness of sample where a value of 100 represents white and 0 represents black; 'a' indicates redness when positive and greenness when negative; 'b' indicates yellowness when positive and blueness when negative. Petal thickness before and after freeze drying were measured using digital micrometer (Digimatic micrometer, Mitutoyo, Kawaski, Japan). Diameter of the flowers were measured before and after drying using a digital vernier caliper. Diameter shrinkage of flower material was measured as D

(%) = (d1-d2)*100/d1, where d1 and d2 were respectively the diameter of flower material before and after freeze drying. Also the flowers were sensorily scored by a panel of 14 scientific persons on a 9 point hedonic scale for quality characters like texture, shape retention and over all acceptability (Peryam, 1957). The data recorded were statistically analyzed for significance (Panse and Sukhatme, 1985).

Results and Discussion

Percentage of moisture content

Influences of freeze drying on different flowers were found to be significant and depend on the nature and colour of the flower. Moisture content in dried flowers influenced flower quality and longevity of flowers (Alka Singh *et al*., 2003). The results

Table 1. Effect of freeze drying on moisture content of different flowers

Treatments	Moisture content of flowers (%)		Percentage reduction in moisture content
	Before freeze drying	After freeze drying	
T_1 - Rose (red)	76.10	32.97	56.68
T_2 - Rose (orange)	77.85	32.03	58.86
T_3 - Rose (yellow)	79.41	29.14	63.30
T_4 - Carnation (red)	82.36	39.32	52.26
T_5 - Carnation (pink)	80.45	32.05	60.16
T_6 - Carnation (white)	81.46	46.43	43.00
T_7 - Jasmine	70.21	32.94	53.08
T_8 – Orchid (Dendrobium)	84.75	56.65	33.16
T_9 – Orchid (Phalenopsis)	80.16	47.85	40.31
T_{10} – Chrysanthemum (green)	87.43	61.97	29.12
SEd	0.920	1.730	1.085
CD (p=0.05)	1.920	3.609	2.265

revealed a strong correlation between the moisture loss pattern and shape retention. Maximum moisture loss percentage (Table 1) was observed on par in yellow rose (63.30 per cent) and pink carnation (60.16 per cent) respectively. This was followed by orange rose (58.86 per cent), red rose (56.68 per cent) and jasmine (53.08 per cent. Least percentage of moisture loss was recorded in green chrysanthemum (29.12 per cent). The difference in percentage of moisture loss in different flowers depends on the size and petal nature of the flowers. This is in accordance with the findings of Safeena *et al*. (2006), who reported in rose cultivar 'Lambada' moisture loss was rapid due to smaller size and papery nature of flowers. Though moisture loss percentage was high in Rose (yellow and orange) flowers were visually disliked. This may be due to excessive loss in moisture which results into weakened adhesion and cohesion forces in flower tissue which might have caused softening of middle lamella leading to abscission (Alka Singh *et al*., 2004). Those flowers which recorded optimum moisture loss *viz.*, jasmine and carnation (pink) were superior and this is attributable to the fact that an optimum moisture loss from the plant parts had ensured rigidity and uniform cell contraction with shape retention. This was in confirmation with the findings of Chunfang *et al.*(2011), who reported that moisture content at vacuum drying temperature 27$_0$ C the freeze dried flowers were closer to the fresh ones in shape retention and Chen *et al.* (2000) reported higher vacuum pressure drying resulted in higher drying rate for moisture transpiration.

Colour value

One of the important benefits of freeze drying is both preservation and retention of colour. Depending on the colour of the different flowers corresponding L, a, b values were discussed respectively. In (Table
2) we observe that more negative values of 'a' were recorded in dark flowers indicating that dark flowers become darker. Maximum change in 'a' value was

Table 2. Effect of freeze drying on colour values of different flowers

Treatments	Colour values (Before freeze drying)			Colour values (After freeze drying)			Change in colour values		
	L	a	b	L	a	b	L	a	b
T_1 - Rose (red)	17.21	43.69	24.32	17.29	10.43	1.09	0.08	-33.26	-23.23
T_2 - Rose (orange)	43.71	47.11	44.41	45.71	25.16	27.86	2.00	-21.95	-16.55
T_3 - Rose (yellow)	68.63	17.29	67.85	69.23	-1.23	25.34	0.60	-18.52	-42.51
T_4 - Carnation (red)	21.27	43.94	25.89	19.95	7.04	0.84	-1.32	-36.9	-25.05
T_5 - Carnation (pink)	36.53	46.43	6.98	40.31	14.55	12.9	3.78	-31.88	5.92
T_6 - Carnation (white)	81.78	-2.55	12.72	49.97	5.30	24.14	-31.81	7.85	11.42
T_7 – Jasmine	69.88	-2.70	27.95	62.23	10.28	22.12	-7.65	12.98	-5.83
T_8 – Orchid (Dendrobium)	37.64	9.48	1.24	36.45	8.74	-12.45	-1.19	-0.74	-13.69
T_9 – Orchid (Phalenopsis)	45.66	10.25	7.05	34.5	7.21	11.78	-11.16	-3.04	4.73
T_{10} – Chrysanthemum (green)	55.63	-6.98	32.27	50.46	-12.32	24.31	-5.17	-5.34	-7.96
SEd	-	-	-	0.981	0.257	0.407	0.241	0.464	0.417
CD (p=0.05)	-	-	-	2.047	0.536	0.848	0.502	0.967	0.870

in red carnation (-36.9) and was on par with red rose (–33.26). Followed by this pink carnation recorded a change in ‘a’ value of (-31.88). Rose (orange and yellow) recorded ‘a’ value change of (-21.95) and (-18.52) respectively. Least colour change in ‘a’ value (- 0.74) was recorded in orchid (dendrobium). This was in confirmation with findings of Chen *et al*. (2000).The darkening of flower could be due to increased moisture loss resulting in concentration of the pigments following water loss (Oren Shamir Deborah, 2001). Among the two white flowers, jasmine measured less ‘L’ value change (-7.65) and maximum change was recorded in white carnation (– 31.81). Change in ‘b’ value of green chrysanthemum was (-7.96). Brown (1999) reported drying was dependant on the original colour of the flower. Red and purple flowers changed more in

Table 3. Effect of freeze drying on petal thickness of different of flowers

Treatments	Petal thickness of flowers (mm)	
	Before freeze drying	After freeze drying
T_1 - Rose (red)	0.29	0.14
T_2 - Rose (orange)	0.28	0.11
T_3 - Rose (yellow)	0.24	0.13
T_4 - Carnation (red)	0.27	0.20
T_5 - Carnation (pink)	0.27	0.31
T_6 - Carnation (white)	0.19	0.14
T_7 – Jasmine	0.23	0.14
T_8 – Orchid (Dendrobium)	0.56	0.27
T_9 – Orchid (Phalaenopsis)	0.94	0.22
T_{10} – Chrysanthemum (green)	0.19	0.11
SEd	0.027	0.022
CD (p=0.05)	0.056	0.046

colour than white, pink or yellow ones. (Note - According to the colour of the flower respective values were explained. Here ‘b’ value is related

Diameter shrinkage

Influence of freeze drying on diameter of flowers were highly significant (Fig 1). Freeze drying causes vapourization of water molecules directly from solid to vapour state which physically retained the structure. Percentage of shrinkage was minimum in jasmine (5.33%) followed by dendrobium (7.06%),

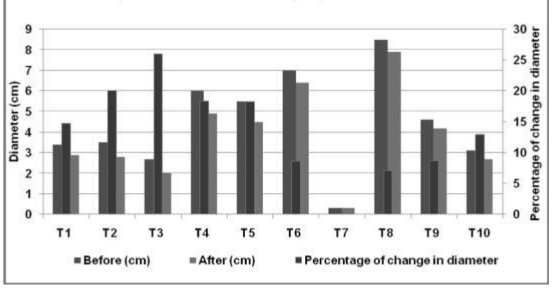

Fig. 1 Effect of freeze drying of flowers on diameter

only with chrysanthemeum. Hence, it has not been discussed for other flowers)

T_1 - Rose (red), T_2 - Rose (orange), T_3 - Rose (yellow), T_4 - Carnation (red), T_5 - Carnation (pink), T_6 - Carnation (white), T_7 – Jasmine, T_8
– Orchid (dendrobium), T_9 – Orchid (phalaenopsis), T_{10} – Chrysanthemum (green)

phalaenopsis (8.70%) respectively. Percentage of shrinkage was maximum in yellow rose (25.93%) followed by orange rose (20.00%). Wilkins and Desborough (1986) confirmed that after freeze drying for 5-6 days, flower diameter became lesser and the tissues reached equilibrium. The decrease in flower diameter is maximum in flowers with higher moisture loss which makes the flower to shrink and more brittle and petal drop with slight pressure (Nirmala *et al*., 2008).

Petal thickness

Petal thickness decreased in all the flowers except carnation (pink) where the petal thickness was increased to 0.04mm (Table 3). The reason may be the moisture loss may caused rigidity and uniform cell contraction. This was in confirmation with findings of Chen *et al*. (2000) who reported that

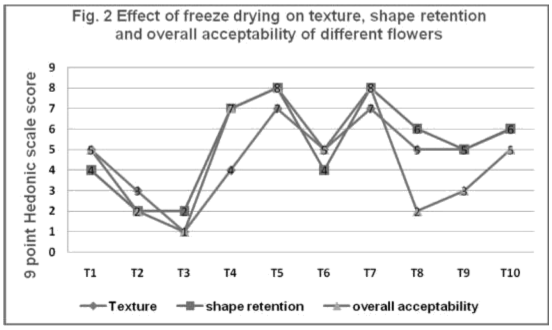

Fig. 2 Effect of freeze drying on texture, shape retention and overall acceptability of different flowers

9- like extremely, 8 - like very much , 7 - like moderately,6- like slightly, 5 – neither like nor dislike , 4 - dislike slightly, 3 - dislike moderately, 2 - dislike very much, 1- dislike extremely

higher drying temperature tended to make the petals stiffer in pink carnation. Hung (1993) reported that both instrumental and sensory scoring methods to evaluate the colour of apples under different storage conditions were highly correlated.

Sensory scoring on quality parameters

Based on the sensory scores given (Fig. 2) pink carnation and jasmine were on par for all quality parameters *viz.,* texture (7.00 and 6.67); Shape retention (7.67 and 8.00); over all acceptability (8.00 and 7.67) respectively. Poor quality scores were obtained in yellow and orange rose for Texture (1.00 and 2.00); Shape retention (1.00 and 3.00); over all acceptability (1.33 and 2.00), respectively.

In this experiment freeze drying effect on different flowers for flower colour, flower physiology, tissue integrity and moisture content with dry flower shape were studied. Over all recommendation is not possible because consistent result is not observed for all flowers for all characters. This is mainly because different flowers showed different performance for different methods of observation. Light colour flowers retained colour value compared to dark flowers. Hence, rose (red) and carnation (red) flowers were rejected. Carnation (white) was rejected in sensory evaluation due to loss of integrity. Flowers which recorded optimum moisture loss provided rigidity and uniform cell contraction with shape retention while higher moisture loss resulted in shriveled flowers. Rose (yellow) and rose (orange) were also rejected due to high shrinkage. In orchids (Dendrobium), orchids (Phaelnopsis) and chrysanthemum (green) clear suggestion was not possible because though flowers recorded lesser change in colour and diameter on moisture loss, petals lost turgidity and drooped (orchids) and shredded (chrysanthemum). Finally on comparing the physiological parameters with sensory evaluation, the pink carnation and jasmine flowers in which the moisture content does not affect the pigment concentration, shape retention with better scores for quality parameters were found suitable for freeze drying and can be used in dry flower industry.

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