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Effect of different drying methods and desiccants on drying quality of annual chrysanthemum and gerbera

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Abstract
The present experiment entitled, "Effect of different drying methods and desiccants on drying quality of annual chrysanthemum and gerbera" was carried out at the laboratory of Floriculture and Landscape Architecture, Department of Horticulture, College of Agriculture, JAU, Junagadh during the year 2019-2020. The experiment was laid out in completely randomized design with factorial concept and two factors *i.e.* drying methods *viz.* sun drying and shade drying and desiccants *viz.* river sand (red), river sand (black), sea sand, silica gel, borax powder and replicated thrice. Significant variation was observed in annual chrysanthemum and gerbera flowers for different drying methods with regard to sensory or quality parameters. Shade drying resulted in better quality parameters such as bright colour, well maintained shape, smooth petal texture, less mechanical damage during drying. Significant variation found among desiccants and sea sand embedding resulted better quality parameters. Along with sea sand another desiccant borax powder resulted in smooth textured flowers with less mechanical damage. Interaction effect was found significant except few days and shade drying with sea sand was found best for all the quality parameters.

Keywords: Drying quality, annual chrysanthemum, gerbera, drying methods, desiccants

Introduction
Flowers are mentioned in the social fabric of our country and every function is said to be incomplete without flowers. Floriculture business has been expanding rapidly throughout the world. Besides home consumption flowers also have tremendous export potential. The shelf life of this cut flower is limited, in spite of using best chemicals for improvement of keeping quality and enhancement of vaselife. Hence they cannot be stored for long duration of time. In order to increase the business potential and other ornamentals to the ultimate extent-alternative use and value addition are the choice of the day. The dried flower industry is growing at an annual growth rate of 10-20 percent. India produces wide varieties of floriculture products, which include flowers and foliage, both fresh and dried flowers such as roses, carnations, chrysanthemums, gladiolus, gerbera, anthurium and orchids and the export basket comprises 71% of dried flowers (Singh *et al.*, 2009) [11].

Dried flower industry was bought to India by the British and prospered in Kolkata because of its proximity to North East where diverse blooms are available in abundance. The dehydrated or dried ornamental plants are generally inexpensive and are sought for their everlasting and attractive appearances (Smith, 1993) [12]. The Annual Chrysanthemum flowers for a long time from the summer through to the first frost of the year towards the end of autumn. They have daisy like flowers of many different colors yellows, reds, whites and pinks; often the petals have two shades of differing colors. The Annual Chrysanthemum varieties range in size from 10 to 90 cm (4 to 36 inches). Some of the common names include Corn Marigold, Snow Daisy, Mini Marguerite, and creeping daisy. Latin names include *Chrysanthemum segetum* and *Chrysanthemum paludosum. Gerbera jamesonii* is a species of flowering plant in the genus Gerbera belongs to family Asteraceae. It is indigenous to South Eastern Africa and commonly known as the Barberton daisy, Transvaal daisy and as Barbertonse madeliefie. The species is perennial and reproduces asexually. This plant produces tall colorful flowers in season. The flowers may be red, yellow, pink, or orange. High quality dry flowers production depends upon the type of flowers chosen for drying, method of drying technique followed, desiccants used for drying and environmental condition during the drying. These factors in turn decide the final quality of dried flowers during drying and also during storage.

In order to study all these aspects the present investigation "Effect of different drying methods and desiccants on drying quality of annual chrysanthemum and gerbera" was carried out with three main aims as to know the effect of drying methods, different desiccants and their interaction effect on drying quality of annual chrysanthemum and gerbera flowers.

Materials and Methods

The present investigation entitled "Effect of different drying methods and desiccants on drying quality of annual chrysanthemum and gerbera" was carried out in at the Floriculture and Landscape Architecture Laboratory, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), during 2020-21, which is situated at altitude of 60m above MSL and 80 kms away from the Arabian Sea coast and 21.5 ^{O}N latitude and 70.5 ^{O}E longitude. The area of Junagadh comes under the sub tropical type of climate. The annual rainfall ranges between 800 to 900 mm in normal years and more than 1000 mm during some years generally the rainfall is uneven, uncertain and erratic with unequal distribution.

The experiment was conducted using Completely randomized design (Factorial) the experiment comprising of two crops annual chrysanthemum cv. Primrose gem and gerbera cv. Intense with twelve treatment combinations *viz.*, S_1M_1(Sun drying without desiccant), S_1M_2 (Sun drying + River sand (Red)), S_1M_3 (Sun drying + River sand (Black)), S_1M_4 (Sun drying+ Sea sand), S_1M_5 (Sun drying + Silica gel), S_1M_6 (Sun drying + Borax powder), S_2M_1(Shade drying without desiccant), S_2M_2 (Shade drying + River sand (Red)), S_2M_3 (Shade drying + River sand (Black)), S_2M_4 (Shade drying + Sea sand), S_2M_5 (Shade drying + Silica gel), S_2M_6 (Shade drying + Borax powder) replicated thrice and number of annual chrysanthemum used per treatment was six and number of gerberas used per treatment was four respectively.

Harvesting was done in the early morning hours and cut ends of harvested flowers were immersed in water. After bringing them to laboratory, flower were sorted out and damaged, disease and pest attacked flowers were removed. Stems with uniform size were selected and trimmed to uniform length gerbera whereas loose flowers of annual chrysanthemum were used and the treatment was imposed immediately. Necessary observations such as flower weight and diameter were recorded before embedding. Among desiccants used sand was washed thoroughly two to three times with tap water properly and then sieved to remove the unwanted particles such as stones, pebbles, gravels and mud. The sand was then dried under sun to remove moisture content from sand and silica gel and borax readily used. The desiccants were filled in the trays uniformly and flowers were placed and then covered with desiccants such a way that each petal completely covered with desiccants and then they were kept in sun and shade conditions in accordance to treatments and all quality parameters observation were taken.

Statistical Analysis

For judging the effect of embedded drying of different treatments, the data of different characters were recorded and statistically analyzed as per the factorial completely randomized design (FCRD). Then analyzed for treatment of comparison 'F" test was further employed to study the effect of different treatments.

Results and Discussion

The findings of the present study as well as relevant discussion have been presented under the following heads:

Flower colour (sign)

Visual examination for flower colour at regular intervals was done and observations were recorded according to the following signs.

= Very bright colour, ## = Bright colour, ### = Dull colour, #### = Very dull colour.

The results regarding flower colour of annual chrysanthemum and gerbera during drying as influenced by different drying methods and desiccants given in Table 1.

Initially the flower colour was excellent and bright but as the drying period increased the colour of the flower decreased gradually and became dull in annual chrysanthemum and gerbera.

Among drying methods not acceptable flower colour found in sun drying in both annual chrysanthemum and gerbera because due to exposure to higher temperature there will be maximum loss of carotenoid pigment in the flower thus causing dull colour of flowers. Whereas, the shade dried flowers maintained acceptable bright flower colour in both flowers during entire process of drying because they were not exposed to higher temperature and hence no loss of caotenoid pigments took place. Similar findings of better colour retainment by shade drying notice by Venugopal and Patil (2000) [14] in *Helichrsum bracteatum*, Nataraj *et al.* (2004) [3] in annual statice.

Among desiccants not acceptable flower colour was found in (M_6) *i.e.* borax powder during drying in both the flowers because of the chemical property of borax powder which has bleaching effect on flowers thus causing colour fading and produces dull coloured flowers which is not seen in sea sand, silica gel and river sand and sea sand was found best. Similar findings with regard to better colour maintenance by sea sand embedding were confirmed by Raju (2001) [5] in china aster, Nataraj *et al.* (2004) [3] in annual statice, Sharma *et al.* (2004) [7] in pot marigold.

Interaction effect reveled that very acceptable colour of flowers was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand and not acceptable colour of flowers was found in (S_1M_6) *i.e.* sun drying with borax powder during 1st, 2nd, 3rd, 4th and 5th day in annual chrysanthemum. Whereas, very acceptable colour of flowers was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand during 1st, 2nd, 3rd and 4th day respectively and not acceptable colour of flowers was found in (S_1M_6) *i.e.* sun drying with borax powder during 4th and 5th day of drying in gerbera respectively. This is because of the fact that during sun drying because of high temperature more loss of carotenoids occurs which causes fading of colour which when combined along with borax powder causes bleaching effect on flowers leading to production of dull and not acceptable flower colour. But, flowers dried under shade with sea sand produced bright coloured flowers with acceptable quality in both the flowers. Similar observations of better colour retainment by shade drying with sea sand were noticed by Nataraja *et al.* (2004) [3] in annual statice, Meman (2006) [2] in miniature roses and gerbera.

Table 1: Effect of different drying methods and desiccants on flower colour in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Flower colour					Flower colour				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
S_1M_1	#	##	##	###	####	#	##	##	###	####
S_1M_2	#	#	##	##	###	#	#	##	##	###
S_1M_3	#	#	##	###	###	#	#	##	###	###
S_1M_4	#	#	#	##	##	#	#	#	##	###
S_1M_5	#	#	##	###	####	#	#	##	###	####
S_1M_6	#	##	###	###	####	#	##	###	####	####
S_2M_1	#	#	##	###	####	#	#	##	###	####
S_2M_2	#	#	#	##	###	#	#	#	##	###
S_2M_3	#	#	#	##	###	#	#	#	##	###
S_2M_4	#	#	#	#	#	#	#	#	#	##
S_2M_5	#	#	#	##	###	#	#	#	##	###
S_2M_6	#	#	##	###	###	#	#	##	###	####

*Where, # = Very acceptable, ## = acceptable, ### = fairly acceptable, #### = not acceptable

Flower shape

The visual observations regarding flower shape was taken at regular intervals with respect to any distortion, lack of firmness, as well as intactness. The observations were recorded according to the following signs.

@ = Very well maintained, @@ = Maintained and @@@ = Destroyed

The results regarding flower shape of annual chrysanthemum and gerbera during drying as influenced by different drying methods and desiccants given in Table 2.

Initially the flower shape was destroyed, but as the drying period increased the flower shape was very well maintained.

Among drying methods shade dried flowers retained better shape in both annual chrysanthemum and gerbera because of less shrinkage and less moisture loss but sundried flower showed unacceptable shape because of more shrinkage. Similar findings of better management of shape in shade dried flowers were noticed by Meman (2006) [2] in miniature rose and gerbera and Swamy *et al.* (2009) [13] in rose var. Gladiator.

Among the desiccants sea sand was found best because sea sand is smooth, heavy and can be easily poured into each and every layer of petals which helps in maintaining the original flower shape but flowers dried in treatment without desiccants caused distorted flower shape because of direct exposure to high temperature causing shrinkage of cells and there was no pressure of desiccants applied on flowers to keep them in shape. Similar findings of better management of shape in flowers dried with sea sand were noticed by Raju (2001) [5] in China aster, Sharma *et al.* (2004) [7] in pot marigold and Ravichandra (2005) [6] in carnation.

Interaction effect showed that highly acceptable shape of flower was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand during 3rd, 4th and 5th of drying and not acceptable shape of flower was found in treatment combination (S_1M_1) *i.e.* sun drying without desiccant during 1st, 2nd, 3rd, 4th and 5th day of drying in annual chrysanthemum. Whereas, highly acceptable shape of flower was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand during 3rd, 4th and 5th day and not acceptable shape of flower was found in treatment combinations (S_1M_1) *i.e.* sun drying without desiccant during 1st, 2nd and 3rd day of drying in gerbera respectively. Similar findings of well maintained flower shape in shade drying with sea sand was reported by Meman (2006) [2] in miniature rose and gerbera.

Table 2: Effect of different drying methods and desiccants on flower shape in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Flower shape					Flower shape				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
S_1M_1	@@@@	@@@@	@@@@	@@@@	@@@@	@@@@	@@@@	@@@@	@@@	@@
S_1M_2	@@@	@@@@	@@@	@@	@	@@@@	@@@@	@@@	@@	@
S_1M_3	@@@	@@@@	@@@	@@	@	@@@@	@@@@	@@@	@@	@
S_1M_4	@@@@	@@@	@@	@@	@	@@@@	@@@@	@@	@@	@
S_1M_5	@@@@	@@@	@@	@@	@	@@@@	@@@@	@@@	@@	@
S_1M_6	@@@@	@@@	@@	@@	@	@@@@	@@@@	@@@	@@	@
S_2M_1	@@@@	@@@@	@@@@	@@@	@@@	@@@@	@@@@	@@@	@@@	@@
S_2M_2	@@@@	@@@	@@@	@@	@	@@@@	@@@@	@@@	@@	@
S_2M_3	@@@@	@@@	@@@	@@	@	@@@@	@@@@	@@@	@@	@
S_2M_4	@@@@	@@	@	@	@	@@@@	@@	@	@	@
S_2M_5	@@@@	@@@	@@	@@	@	@@@@	@@@	@@	@@	@
S_2M_6	@@@@	@@@@	@@	@@	@	@@@@	@@@	@@	@@	@

*Where, @ = Highly acceptable, @@ = acceptable, @@@ = fairly acceptable, @@@@= not acceptable.

Petal texture

The visual examination of dried flowers was done for petal texture and the observations were recorded according to the following signs at regular intervals.

$ = Very Smooth, $$ = Smooth, $$$ = Rough and $$$$ = Very rough

The results regarding petal texture of annual chrysanthemum and gerbera during drying as influenced by different drying methods and desiccants given in Table 3.

Among the drying methods very smooth petal texture was

observed in (S_2) *i.e.* shade drying compared with that of (S_1) *i.e.* sun drying during drying in annual chrysanthemum and gerbera flowers because of fact that during sun drying the drying rate is higher than shade drying which causes unevenness in cell layer due to shrinkage causing roughness in petals and because of even drying without cell shrinkage smooth textured flowers were obtained when flowers dried under shade. These findings of smooth petal texture when shade dried were in accordance with Nataraja *et al.* (2004) [3] in annual statice, Meman (2006) [2] in miniature rose and gerbera.

Among the desiccants used very smooth petal texture was observed in (M_4) *i.e.* sea sand and (M_6) *i.e.* borax powder and very rough petal texture was found in (M_1) *i.e.* without desiccant during drying in both flowers because both sea sand and borax powder are smooth textured which does not cause any damage to petal surface and they are heavier in weight so that equal pressure is applied to all flower parts which causes even moisture loss thus producing smooth textured flowers but flowers dried in treatment without desiccants caused rough petal texture because of direct exposure to high temperature caused shrinkage of cells and damage to petals.Similar findings of smooth petal texture with sea sand were confirmed by Raju (2001) [5] in china aster, Nataraj *et al.* (2004) [3] in annual statice and similar findings of smooth petal texture with borax were confirmed by Shruthi (2010) [8] in Dutch rose and Khyati (2015) [1] in rose, gerbera and gomphrena.

Interaction effect showed that very smooth petal texture was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand during 1st, 2nd, 3rd, 4th and 5th day followed by treatment combinations (S_2M_6) *i.e.* shade drying with borax powder and (S_1M_4) *i.e.* sun drying with sea sand during 1st, 2nd and 3rd day and very rough petal texture was found in treatment combination (S_1M_1) *i.e.* sun drying without desiccant during 2nd, 3rd, 4th and 5th day of drying in annual chrysanthemum. Whereas, very smooth petal texture was found in treatment combination (S_2M_4) *i.e.* shade drying with sea sand during 1st, 2nd, 3rd and 4th day followed by treatment combination (S_2M_6) *i.e.* shade drying with borax powder and (S_1M_4) *i.e.* sun drying with sea sand during 1st, 2nd and 3rd day and very rough petal texture was found in (S_1M_1) *i.e.* sun drying without desiccant during 3rd, 4th and 5th day of drying in gerbera respectively.Similar findings of smooth petal texture maintained under shade drying with sea sand were reported by Meman (2006) [2] in miniature rose and gerbera, Khyati (2015) [1] in rose, gerbera and gomphrena

Table 3: Effect of different drying methods and desiccants on petal texture in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Petal texture					Petal texture				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
S_1M_1	$$$	$$$$	$$$$	$$$$	$$$$	$$	$$$	$$$$	$$$$	$$$$
S_1M_2	$	$$	$$$	$$$$	$$$$	$	$$	$$$	$$$$	$$$$
S_1M_3	$	$$	$$$	$$$$	$$$$	$	$$	$$$	$$$$	$$$$
S_1M_4	$	$	$	$$	$$	$	$	$	$$	$$$
S_1M_5	$	$$	$$$	$$$	$$$$	$	$$	$$$	$$$	$$$$
S_1M_6	$	$	$$	$$	$$$	$	$	$$	$$	$$$
S_2M_1	$$	$$$	$$$$	$$$$	$$$$	$$	$$$	$$$	$$$$	$$$$
S_2M_2	$	$$	$$$	$$$	$$$$	$	$$	$$$	$$$	$$$$
S_2M_3	$	$$	$$$	$$$	$$$$	$	$$	$$$	$$$	$$$$
S_2M_4	$	$	$	$	$	$	$	$	$	$$
S_2M_5	$	$	$$	$$$	$$$	$	$	$$	$$$	$$$
S_2M_6	$	$	$	$$	$$	$	$	$	$$	$$

Where, $ = Very Smooth, $$ = Smooth, $$$ = Rough, $$$$ = Very rough.

Mechanical damage

In certain treatments during the drying process, the shedding of the flowers petals and leaflets, fading of petals was observed, and recorded by using the following grades.

+ = No damage, ++ = 0-15% damage, +++ = 15-30% damage and ++++ = 30-50% damage.

The results regarding mechanical damage of annual chrysanthemum and gerbera during drying as influenced by different drying methods and desiccants given in Table 4.

Among drying methods less mechanical damage was observed in (S_2) *i.e.* shade drying compared with that of (S_1) *i.e.* sun drying during drying in annual chrysanthemum and gerbera because of the fact that due to exposure to high temperature there is increase in level of abscissic acid in flowers which causes dropping of petals from flower and due to higher rate of transipiration and moisture loss petals become brittle and more chances of breakage of petals compared with that of shade drying. Similar findings of less mechanical damage in shade dried flowers were noticed by Meman (2006) [2] in miniature roses and gerbera and Khyati (2015) [1] in rose, gerbera and gomphrena.

Among the desiccants less mechanical damage was observed in (M_4) *i.e.* sea sand and (M_6) *i.e.* borax powder and more mechanical damage was found in (M_1) *i.e.* without desiccant during drying in both the flowers because when flowers are dried without desiccant due to uneven loss of moisture from flowers causes the rupturing of integrity of cells causes breakage and shedding of the petals contributing to more mechanical damage. But, flowers embedded in sea sand and borax due to its smooth texture and even removal of moisture did not reveal much mechanical damage. Similar findings of less mechanical damage from sea sand was reported by Singh and Dhaduk (2005) [10] in sunflower, plumeria and bauhinia flowers and similar findings of less mechanical damage from borax powder were reported by Meman (2006) [2] in miniature rose, gerbera, calendula, gaillardia and marigold.

Interaction effect showed that no mechanical damage was found in treatment combinations (S_2M_4) *i.e.* shade drying with sea sand and (S_2M_6) *i.e.* shade drying with borax powder during 1st, 2nd and 3rd day and maximum mechanical damage of flowers was found in treatment combination (S_1M_1) *i.e.* sun drying without desiccants during 3rd, 4th and 5th day of drying in annual chrysanthemum. Whereas, No mechanical damage was found in treatment combinations (S_2M_4) *i.e.* shade drying

with sea sand and (S_2M_6) *i.e*. shade drying with borax powder during 1st, 2nd, 3rd and 4th day and maximum mechanical damage of flowers was found in (S_1M_1) *i.e.* sun drying without desiccant during 4th and 5th day of drying in gerbera respectively.

Similar findings of less mechanical damage from shade drying with sea sand were noticed by Meman (2006) [2] in miniature rose and gerbera and similar findings of less mechanical damage from shade drying with borax was noticed by Meman (2006) [2] in miniature rose and gerbera and Khyati (2015) [1] in rose, gerbera and gomphrena.

Table 4: Effect of different drying methods and desiccants on mechanical damage in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Mechanical damage					Mechanical damage				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
S_1M_1	+	++	++++	++++	++++	+	++	+++	++++	++++
S_1M_2	+	+	++	++	++++	+	+	++	++	++++
S_1M_3	+	+	++	+++	++++	+	+	++	+++	++++
S_1M_4	+	+	++	++	+++	+	+	+	++	+++
S_1M_5	+	++	+++	++++	++++	+	++	+++	+++	+++
S_1M_6	+	+	++	++	+++	+	+	+	++	+++
S_2M_1	+	++	+++	+++	++++	+	++	++	+++	++++
S_2M_2	+	+	+	++	+++	+	+	+	++	+++
S_2M_3	+	+	+	++	+++	+	+	+	++	+++
S_2M_4	+	+	+	++	++	+	+	+	+	++
S_2M_5	+	+	+++	++++	++++	+	+	++	+++	++++
S_2M_6	+	+	+	++	++	+	+	+	+	++

Where, + = no damage, ++ = 0-15% damage, +++ = 15-30% damage, ++++ = 30-50% damage.

Conclusion

The effect of different drying methods and desiccants was conducted in order to find out the effect of drying method, desiccants and their interaction on drying quality of annual chrysanthemum and gerbera and we found out that shade drying along with sea sand though took little more time for drying flowers resulted in well maintained attractive flower colour, flower shape, smooth petal texture and less mechanical damage in annual chrysanthemum and gerbera. Hence, from present investigation it can be concluded that shade drying with sea sand produced quality dry flowers of annual chrysanthemum and gerbera during drying.

Author contributions

VR hypothesized the experiment; CS carried out the trial and recorded observations under the guidance of VR; CS performed the statistical analysis and wrote the manuscript.

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