www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 105-111

www.thepharmajournal.com
Received: 05-07-2023
Accepted: 12-08-2023

Miter Game
School of Agricultural Science and Rural Development, Nagaland University, Medziphema, Nagaland, India

Dr. Rokolhuii Keditsu
School of Agricultural Science and Rural Development, Nagaland University, Medziphema, Nagaland, India

Phairohlui
School of Agricultural Science and Rural Development, Nagaland University, Medziphema, Nagaland, India

Corresponding Author:
Miter Game
School of Agricultural Science and Rural Development, Nagaland University, Medziphema, Nagaland, India

Tinting process in tuberose (*Polianthes tuberosa* L.) spike using different edible dyes

Miter Game, Dr. Rokolhuii Keditsu and Phairohlui

Abstract
An experiment was conducted to evaluate the effect of different edible dyes on the post-harvest quality of tuberose (*Polianthes tuberosa* L.) spike. The experiment was carried out using two factorial completely randomized design with three replications. Three cut spikes were placed in four different dye solutions (Sunset Yellow, Carmosine, Brilliant Blue and Tartrazine) at three different concentrations (1%, 1.5% and 2%) for 24 hours. The different edible dyes had a significant effect on the sensory characters, fresh weight, water relations, floret opening percentage, days to 1st and 3rd floret wilting and vase life of the tinted spikes. The maximum score for the sensory characters was obtained in Brilliant Blue (D3) with best results in water relation. Brilliant Blue (D3) dye exhibited the highest floret opening percentage of 51.68 and maximum days (5.77 and 6.07) to 1st and 3rd floret wilting and the longest (10 days) vase life. The various concentrations used had a significant effect only on floret opening % and days to 3rd floret wilting of the tinted spike. The maximum floret opening of 50.66% and days (6.18) to 3rd floret wilting was observed in C3 (2%).

Keywords: Edible dyes, concentrations, tuberose spike, vase life

Introduction
Flowers are the wonderful creation of the nature which has an immense importance in human life due to their aesthetic beauty, diverse form, texture, color and fragrance. Tuberose (*Polianthes tuberosa* L.) which is also known as Rajanigandha or Nishigandha is one of the most important and highly valued tropical ornamental bulbous crop under floriculture in India. It is native of Mexico and belongs to the family Amaryllidaceae. Due to its magnificent inflorescence, shape, size and fragrance, it occupies prime position both in domestic and international markets. Due to its aromatic fragrance unlike other ornamental bulbous crops, it has greater potential for cut flower trade and essential oil industry (Sadhu and Bose, 1973) [25]. The flowers of tuberose also lack color in the petals due to absence of carotenoids and anthocyanin in their petals. As tuberose is monotypic in nature, interspecific hybridization to induce color variation is not possible. By treating the tuberose bulbs with fast neutrons and gamma rays several mutants have been obtained but they all showed color variation only on leaves and not in flowers (Sambandamurthy and Appavu, 1980) [28]. Due to the white color of the spikes, most of the growers often face the problem of marketing in the peak season of flowering often leading to spoilage and wastage of flowers. Tinting can be done using synthetic colors or natural food dyes. It enhances the aesthetic beauty of fresh and dry flowers hence, increases its commercial value and marketability. The farmers could readily adopt the tinting technique and double their profits with higher selling rates than the white cut spikes. Keeping these points in mind the present investigation was undertaken to evaluate the effect of different edible dyes with various concentration on the post- harvest quality of tuberose spike.

Materials and Methods
The present investigation to evaluate the effect of different edible dyes on the post- harvest quality of tuberose (*Polianthes tuberosa* L.) spike was carried out in the laboratory, Department of Horticulture, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland during 1st October to 27th November 2018.

Materials
Tuberose spikes were procured from the Horticultural farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema. All the food dyes used in the experiment were of food grade purchased from standard Indian food dye companies.

Treatment details

Fresh weight of the individual spike was recorded and placed in conical flask containing 100 ml of four different dye solutions *i.e*., Sunset Yellow (D1), Carmosine (D2), Brilliant Blue (D3) and Tartrazine (D4) at three different concentrations 1% (C1), 1.5% (C2) and 2% (C3). Dye solutions were prepared by properly mixing dyes in distilled water. The dyes procured were in liquid form with 2.5% dye content. The 1.0 per cent solution of each dye was prepared by dissolving 40 ml of edible dye in 100 ml of distilled water. The 1.5 per cent solution of each dye was prepared by dissolving 60 ml of edible dye in 100 ml of distilled water. And the 2.0 per cent solution of each dye was prepared by dissolving 80 ml of edible dye in 100 ml of distilled water. There is growing awareness for eco consciousness toward the use of organic color (Sankat and Siddique, 2008) [42] as natural dyes are non-toxic in nature and do not cause environmental problems due to its bio-degradable nature. The mouth of the flask was covered with cotton plug securely as to avoid evaporation loss. Tinting process was done for 24 hours and then transferred in a conical flask containing 200 ml of standardized vase solution containing 4% sucrose and 200 ppm Al2SO4 (Aluminum sulphate). The experimental design adopted was CRD with three replications. Observations such as Color, Freshness, Shape/Appearance, Petal retention, Overall acceptability, Fresh weight, Water uptake, Water loss, Water balance, Floret opening percentage, Days to 1st and 3rd floret wilting and Vase life were recorded. Sensory evaluation was carried out with a panel of judges. Panel of judges assessed the different flower quality parameters by scoring on a five-point scale *i.e*., very bad, bad, good, very good and excellent with the weight age of 1, 2, 3, 4, 5 respectively by means of sensory evaluation.

Statistical analysis

Treatments were arranged in a completely randomized design (CRD) with three replications for each treatment. The data on all qualitative and quantitative parameters were subjected to statistical analysis as per the procedure outlined by Gomez and Gomez (2012) [8]. The results have been presented and discussed at a probability level 0.05 or 5 percent probability.

Results and Discussion

Qualitative attributes of tinted tuberose as influenced by different edible dyes

Observations with respect to color, freshness, shape/appearance, petal retention and overall acceptability of the tinted spikes are given in Table 1. Based on the results obtained from the panel of judges for the sensory evaluation, there was a significant effect of edible dyes and insignificant effect of various concentrations on the quality of the tinted spike. The maximum effect of color was found in Brilliant Blue (D3) and the least color effect was found in Carmosine (D2) with a score of 4.22 and 2.80 respectively. Almost all the edible dyes successfully induced color in the cut spikes without affecting their vase life which might be due to the fact that the edible dyes were not toxic to cell metabolism (Safeena *et al*., 2016) [26] except the spike dyed in Carmosine (D2). An uneven distribution of color with much intense shade of the edible dye at the periphery of the petals might be the reason (Dhaduk and Naik, 2003) [6] which has led to least score in Carmosine tinted spikes. The freshness of tinted tuberose spike recorded the maximum score (4.20) in Brilliant Blue (D3) while the minimum score (2.80) was observed in Carmosine (D2). Water absorption in Brilliant Blue (D3) maintains a better water balance which might have attributed to floret freshness. The present study is in accordance to the findings of Waithaka *et al*. (2001) [40] and Salunkhe *et al*., (1990) [27] where they opined that the turgidity in plants and flowers was dependent on the rate of absorption and rate of water loss. A maximum score of 3.66 was observed in Brilliant Blue (D3) which was at par with Tartrazine (D4) with a score of 3.64. The least score was observed in Carmosine (D2) with a score of 2.86. The present study is in line with the findings of Waithaka *et al*. (2001) [40] and Salunkhe *et al*., (1990) [27] where they opined that the turgidity in plants and flowers was dependent on the rate of absorption and rate of water loss. An uneven distribution of color with much intense shade of the edible dye at the periphery of the petals might be the reason (Dhaduk and Naik, 2003) [6] which has led to least score in Carmosine tinted spikes. A maximum score of 4.06 was observed in Brilliant Blue (D3) while the least score (3.04) was observed in Carmosine (D2). This can be attributed to the fact that Brilliant Blue (D3) dye used in the experiment was non-toxic to cell metabolism. As a result, no obstruction was created for movement of water and food materials (Safeena *et al*., 2016) [26]. The present findings are in line with the result of Dhaduk and Naik (2003) [6] where they reported that edible dyes does not create any barrier in the vessels conduction of water and food materials thus do not alter the cell turgidity. A maximum score of 4.13 was observed in Brilliant Blue (D3) while the least score of 2.86 was observed in Carmosine (D2). Almost all the edible dyes successfully induced color in the cut spikes without affecting their vase life which might be due to the fact that the edible dyes were not toxic to cell metabolism (Safeena *et al*., 2016) [26] except the spike dyed in Carmosine (D2). An uneven distribution of color with much intense shade of the edible dye at the periphery of the petals might be the reason (Dhaduk and Naik, 2003) [6] which has led to least score in Carmosine tinted spikes.

Table 1: Effect of different edible dyes and concentrations on the sensory characteristics of tinted spikes

Edible dyes (D)	Color	Freshness	Shape/ Appearance	Petal Retention	Overall acceptability
D1 (Sunset Yellow)	3.86	3.62	3.37	3.75	3.68
D2 (Carmosine)	2.80	2.80	2.86	3.04	2.86
D3 (Brilliant Blue)	4.22	4.20	3.66	4.06	4.13
D4 (Tartrazine)	4.13	4.13	3.64	3.95	4.04
S.Em±	0.06	0.05	0.05	0.03	0.04
CD at 5%	0.17	0.15	0.15	0.09	0.14
Concentrations (C)					
C1 (1%)	3.81	3.71	3.41	3.75	3.73
C2 (1.5%)	3.66	3.75	3.48	3.65	3.75
C3 (2%)	3.78	3.60	3.26	3.71	3.56

S.Em±	0.03	0.04	0.03	0.02	0.03
CD at 5%	NS	NS	NS	NS	NS
Interaction (D×C)					
S.Em±	0.18	0.15	0.15	0.09	0.14
CD at 5%	NS	NS	NS	NS	NS

Quantitative attributes of tinted tuberose as influenced by different edible dyes

Fresh Weight

The maximum gain (8.29 g) in fresh weight was noted in Brilliant Blue (D3) on the 3rd day while the least gain (2.59 g) in fresh weight was observed in Carmosine (D2) on 9^{th} day. Similar results have been recorded by Kumari and Deb (2018) [16] where they observed that the weight of the cut spike increases for 3 days and later decrease during vase life period. The ideal food color for tinting was that, which allows water absorption in flower tissues (Salunkhe *et al.* 1990) [27]. The various concentrations had a non-significant effect on the fresh weight of the tinted spike. However, the highest gain (6.86 g) in fresh weight was recorded in C3 (2%) on the 3rd day which was at par with C2 (1.5%) with 6.75 g gain. while the least (3.97 g) increase in fresh weight was observed in C1 (1%) on 9^{th} day.

Water Uptake

The maximum water uptake (8.59, 6.11 and 5.22 g) was observed in Brilliant Blue (D3) while Carmosine (D2) recorded the least water uptake (3.37, 3.14 and 2.52 g) on all dates of observation. Among all edible food dyes, Brilliant Blue might have been the ideal dye which allows water absorption in flower tissues (Salunkhe *et al*., 1990) [27]. Similarly, Kumar *et al.,* (2015) [14], also stated that the highest mean water uptake was recorded by the spikes treated with blue solution. there was a non-significant effect on water uptake among the various concentrations of dyes. However, the maximum water uptake (6.66, 5.47 and 3.77 g) was recorded in C3 (1%) while C1 (2%) gave a least water uptake (5.75, 3.75 and 2.91 g) on all dates of observation.

Water Loss

The highest water loss (8.74, 8.62 and 8.55g) was recorded in Brilliant Blue (D3) which was at par (8.51, 8.51 and 8.44g) with Sunset Yellow (D1) while the least water loss (6.55, 4.96 and 4.48g) was recorded in Carmosine (D2) on all dates of observation. A higher water loss is co related to the higher water uptake by the cut flower (Debbarma, 2016) [4]. The various concentrations of dyes did not have any significant influence on water loss. However, the highest water loss (8.11 g) was recorded in C3 (2%) on 3^{rd} day while the least (6.05 g) was observed in C1 (1%) on 9^{th} day.

Water Balance

The highest water balance ratio (0.79, 0.64, 0.62 g) was recorded in Brilliant Blue (D3) and least (0.38, 0.34, 0.33 g) in Carmosine (D2) on al dates of observation. A higher water loss is co related to the higher water uptake by the cut flower (Debbarma, 2016) [4]. Among all edible food dyes, Brilliant Blue might have been the ideal dye which allows water absorption in flower tissues (Salunkhe *et al*., 1990) [27] thereby maintains a better water balance (Reddy and Singh, 1996) [24]. The various concentrations had no significant effect on the water balance ratio. The highest water balance ratio (0.89) was observed in C2 (1.5%) on the 3rd day.

A standardized quantity of sucrose and Al_2SO_4 were used in all the treatments during its vase life period. As reported by Varu and Barad (2008) [43] the chemicals like Al_2SO_4 and sucrose might have inhibited vascular blockage and increased absorption of water, ultimately increased the uptake of water in the spike. Similarly, Acock and Nichols (1979) [44] revealed that the lowest water balance ratio might be due to functions of sucrose which supply energy for metabolic processes by preserving moisture and maintaining the water balances through osmotic potential in spike.

Floret Opening Percentage

A maximum floret opening of 51.68% observed in Brilliant Blue (D3) and the least floret opening of 36.65% in Sunset Yellow (D1). The biological activity of edible dyes had renewed following the claims that a red food dye was carcinogenic and that some food additives and colorants in particular might be responsible for producing behavioral changes (Boffey, 1976; Feingold, 1975) [1, 7]. The various dye concentrations revealed a significant effect on the floret opening percentage of the tinted tuberose spikes. The lower concentration (1%) of edible dyes showed the least floret opening while the floret opening percentage increased as the concentration of the dye was enhanced. The maximum floret opening of 50.66% was observed in C3 (2%) while the least floret opening of 36.58% was observed in both C1 (1%). Concentration (2%) allowed more dye to be translocated up to the terminal of the buds of the tuberose flower spike which might have attributed to maximum movement of water and food materials, thus leading to more floret opening (Safeena *et al*., 2016) [26].

Days to 1st Floret Wilting

The maximum days (5.77) to 1st floret wilting was found in Brilliant Blue (D3) and Tartrazine (D4) respectively. While the least days (3.66) taken to 1st floret wilting was found in Carmosine (D2). Floret wilting was mainly due to depleted plant food and inability of the spikes to draw up water which leads to the subsequent color change and flaccidity of the cells (Ichimura *et al*. 2002) [10]. The various concentrations had insignificant effect on the days to 1st floret wilting in tinted tuberose spikes. The maximum days (5.46) to 1st floret wilting was observed in C3 (2%) while the least days (5.05) taken to 1st floret wilting was observed in C1 (1%).

Days to 3^{rd} Floret wilting

The maximum days (6.07) taken for 3rd floret wilting was observed in Brilliant Blue (D3) while the least number of days (4.84) was found in Carmosine (D2). Floret wilting was mainly due to depleted plant food and inability of the spikes to draw up water which leads to the subsequent color change and flaccidity of the cells (Ichimura *et al*. 2002) [10]. The various dye concentrations had a non-significant effect on days to 3^{rd} floret wilting of the tinted tuberose spikes. The maximum days (6.18) taken for 3^{rd} floret wilting was observed in C3 (2%) while the least days (5.27) taken to 3rd floret wilting was observed in C1 (1%).

Vase Life

The maximum vase life (10 days) was recorded in Brilliant Blue (D3) whereas, the minimum vase life of 7.88 days was observed in Carmosine (D2). The result goes in line with Varu and Barad (2008) [43] in tuberose cv. Double and Mekala *et al*. (2012). The reason Carmosine (D2) gave the least vase life could be that when the flowers are detached from the spikes water loss from these continues through transpiration (Salunkhe *et al*., 1990) [27]. The various dye concentrations revealed a significant effect on the vase life of the tinted tuberose spikes. The maximum vase life (9.41days) was observed in C1 (1%) while the least vase life of 9.08 days was observed in both C3 (2%). The result goes in line with the findings of Kumari and Deb (2018) [17], who stated that the flower dropping was found more in higher concentration where the spikes were losing their weight and decreased the vase life of the tinted tuberose spikes.

Table 2: Fresh weight, water uptake and water loss of the spikes after 24 hours of tinting which was taken as initial for further vase life studies

Edible dyes (D)	Fresh weight (g)	Water uptake (g)	Water loss (g)
D1 (Sunset Yellow)	46.55	317.51	364.18
D2 (Carmosine)	41.1	318.66	359.96
D3 (Brilliant Blue	39.77	315.88	355.81
D4 (Tartrazine)	41.33	323.14	364.66
S.Em±	3.05	4.48	6.23
CD at 5%	NS	NS	NS
Concentrations (C)			
C1 (1%)	43.46	321.66	365.52
C2 (1.5%)	37.91	317.08	355.05
C3 (2%)	45.19	317.66	362.88
S.Em±	3.52	3.88	5.4
CD at 5%	NS	NS	NS
Interaction (D×C)			
S.Em±	6.1	7.77	10.8
CD at 5%	NS	NS	NS

Table 3: Fresh weight of tinted spikes as influenced by different edible dyes and concentrations

Edible Dyes (D)	3rd day	6th day	9th day
D1 (Sunset Yellow)	53.44	48.33	43.59
	(6.89)	(-5.14)	(-4.74)
D2 (Carmosine)	45.73	42.70	40.11
	(4.63)	(-3.03)	(-2.59)
D3 (Brilliant Blue)	48.06	41.18	35.67
	(8.29)	(-6.88)	(-5.51)
D4 (Tartrazine)	47.06	41.44	37.55
	(5.73)	(-5.62)	(-3.89)
S.Em±	0.21	0.15	0.13
CD at 5%	0.62	0.46	0.38
Concentrations (C)			
C1 (1%)	50.32	44.96	40.60
	(6.86)	(-5.36)	(-4.36)
C2 (1.5%)	44.66	39.56	35.34
	(6.75)	(-5.1)	(-4.22)
C3 (2%)	50.74	45.69	41.72
	(5.55)	(-5.05)	(-3.97)
S.Em±	0.15	0.11	0.09
CD at 5%	NS	NS	NS
Interaction (D×C)			
S.Em±	0.63	0.47	0.39
CD at 5%	NS	NS	NS

Table 4: Effect of different edible dyes and concentrations on the water uptake of tinted spikes

Edible dyes (D)	3rd day	6th day	9th day
D1 (Sunset Yellow)	6.59	4.85	3.18
D2 (Carmosine)	3.37	3.14	2.52
D3 (Brilliant Blue)	**8.59**	**6.11**	**5.22**
D4 (Tartrazine)	6.07	4.01	2.73
S.Em±	0.25	0.16	0.12
CD at 5%	0.73	0.47	0.35
Concentrations (C)			
C1 (1%)	5.75	5.47	3.77
C2 (1.5%)	6.66	4.36	3.55
C3 (2%)	6.44	3.75	2.91
S.Em±	0.18	0.12	0.09
CD at 5%	NS	NS	NS
Interaction (D×C)			
S.Em±	0.75	0.49	0.36
CD at 5%	NS	NS	NS

Table 5: Water loss by tinted spikes as affected by different edible dyes and concentrations

Edible dyes (D)	3rd day	6th day	9th day
D1 (Sunset Yellow)	8.51	8.51	8.44
D2 (Carmosine)	6.55	4.96	4.48
D3 (Brilliant Blue)	8.74	8.62	8.55
D4 (Tartrazine)	6.59	6.51	4.66
S.Em±	0.16	0.22	0.26
CD at 5%	0.49	0.66	0.78
Concentrations (C)			
C1 (1%)	8.11	7.6	7.02
C2 (1.5%)	6.88	7.13	6.05
C3 (2%)	7.8	6.72	6.52
S.Em±	0.12	0.17	0.2
CD at 5%	NS	NS	NS
Interaction (D×C)			
S.Em±	0.5	0.68	0.8
CD at 5%	NS	NS	NS

Table 6: Effect of different edible dyes and concentrations on the water balance of tinted spike

Edible dyes (D)	3rd day	6th day	9th day
D1 (Sunset Yellow)	0.65	0.6	0.59
D2 (Carmosine)	0.38	0.34	0.33
D3 (Brilliant Blue)	0.79	0.64	0.62
D4 (Tartrazine)	0.51	0.47	0.40
S.Em±	0.02	0.01	0.01
CD at 5%	0.06	0.04	0.03
Concentrations (C)			
C1 (1%)	0.61	0.51	0.46
C2 (1.5%)	0.59	0.54	0.50
C3 (2%)	0.55	0.52	0.50
S.Em±	0.01	0.01	0.009
CD at 5%	NS	NS	NS
Interaction (D×C)			
S.Em±	0.03	0.04	0.03
CD at 5%	NS	NS	NS

Table 7: Floret opening percentage of tinted spikes as effect by different edible dyes and concentrations

Edible dyes (D)	Floret opening percentage
D1 (Sunset Yellow)	36.64
D2 (Carmosine)	42.27
D3 (Brilliant Blue)	51.68
D4 (Tartrazine)	47.19
S.Em±	0.77
CD at 5%	2.252
Concentrations (C)	
C1 (1%)	36.58
C2 (1.5%)	46.08
C3 (2%)	50.66
S.Em±	1.028
CD at 5%	3.003
Interaction (D×C)	
S.Em±	3.086
CD at 5%	NS

Table 8: Effect of different edible dyes and concentrations on days to1st and 3rd floret wilting of tinted spike

Edible Dyes (D)	Days to 1st floret wilting	Days to 3rd floret wilting
D1 (Sunset Yellow)	5.73	5.96
D2 (Carmosine)	3.66	4.84
D3 (Brilliant Blue)	5.77	6.27
D4 (Tartrazine)	5.77	5.88
S.Em±	0.04	0.04
CD at 5%	0.12	0.12
Concentrations (C)		
C1 (1%)	5.05	5.27
C2 (1.5%)	5.19	5.60
C3 (2%)	5.46	6.18
S.Em±	0.05	0.05
CD at 5%	NS	0.16
Interaction (D×C)		
S.Em±	0.17	0.17
CD at 5%	NS	NS

Table 9: Vase life of tinted spikes as effected by different edible dyes and concentrations

Edible dyes (D)	Days
D1 (Sunset Yellow)	9.66
D2 (Carmosine)	7.88
D3 (Brilliant Blue)	10.00
D4 (Tartrazine)	9.33
S.Em±	0.13
CD at 5%	0.40
Concentrations (C)	
C1 (1%)	9.41
C2 (1.5%)	9.16
C3 (2%)	9.08
S.Em±	0.10
CD at 5%	NS
Interaction (D×C)	
S.Em±	0.41
CD at 5%	NS

Plant 1: Tinted tuberose spike with four edible dyes

Plant 2: Floret opening of tinted spike on the 6th day of observation

Conclusion

Among the different edible dyes, Brilliant Blue (D3) exhibited the best result on both qualitative and quantitative parameters. Further studies may be carried out on the present trial for confirmation. Research work on the present study may be repeated with different edible dyes and concentrations. Similar research work may also be carried out for a specific cultivar, at different stages of harvest and different time of immersion.

References

1. Boffey PM. Color additives: botched experiment leads to banning of Red Dye No. 2. Science. 1976;191:450-451.
2. Byun MS, Kim JW, Kim KW. Effect of artificial dyeing on ornamental value and vase life in cut flower of Rosa hybrid cv. Taeinhe, Korean J Hort Sci Technol. 2004;22(1):114-118.
3. De CL, Singh RD. Floriculture industries, opportunities and challenges in Indian Hills. International Journal of Horticulture. 2016;6(13):1-9.
4. Debbarma S. Effect of gibberellic acid on the growth, flowering and vase life on 3(three) cultivars of Gerbera (*Gerbera jamesonii* Bolus). M.Sc. (Ag) Thesis, Nagaland University, School of Agricultural Sciences and Rural Development. Medziphema Campus, India; c2016.
5. DGCIS Annual Report. Website: agrixchange.apeda.gov.in. Accessed on 13th March, 2019.
6. Dhaduk BK, Naik DB. Effect of different edible dyes on flower coloring of tuberose cv. Single Local and Double Local. Symposium of Indian Floriculture in new millennium. 2003;36(2):341-343.
7. Feingold BF. Why your child is Hyperactive (Random House, New York). 1975;8:537-538.
8. Gomez KA, Gomez AA. Statistical procedures for Agricultural Research. 2nd Ed. Ar. Emm. International, Delhi, ISBN: 978-81-265-2395-5; c2012.
9. Gowda JWN, Gowda VN. Effect of calcium, aluminum and sucrose on vase life of gladiolus. Crop Science. 1990;3(1):105-106.
10. Ichimura K, Kawabata Y, Kishimoto M, Goto R, Yamada K. Variation with the cutivar in the vase life of cut flowers. In: National Institute of Floricultural Science. 2002;2:9-20.
11. Park JH, Yoon-Jung H, Bae SH, Lim KB. Optimum Condition of Dyeing Cut Rose 'Denice' by Absorption Method. Current Research on Agriculture and Life Sciences. 2013;31(1):58-62.
12. Ki-Byung L, Shim SI, Yoon-Jung H, Bae SH, Beung-Gu S, Woo-Chung P, *et al*. Artificially Dyeing of cut rose Akito by Absorption method. Flower Research Journal. 2012;20(4).
13. Kumar SB. Studies on standardization of dye concentration, stages of harvest for tinting and postharvest keeping quality of tuberose (cv. Suvasini) and gladiolus (cv. White Prosperity). M.Sc. Thesis, Dr. Y.S.R. Horticultural University. India; c2014.
14. Kumar SB, Kameswari LP, Pratap M, Rao V. Optimization of stage of harvest of spikes of gladiolus cultivar White Prosperity for tinting. Indian Journal of Agricultural Research. 2015;49(1):71-76.
15. Kumar V, Bhattacharjee SK, Ravikumar Mishra RL, Singh KP. Post-harvest life and quality of tuberose spike as affected by coloring agents and storage. J Orna. Hort. 2003;6(2):119-125.
16. Kumari S, Deb P. Effect of tinting on value addition of tuberose (*Polianthes tuberosa* L.) cv. Prajwal. International Journal of Bio-resource and Stress Management. 2018;9(3):314-322.
17. Kumari S, Deepika Raghupati B, Sarika K, Deb P. Value addition of tuberose (*Polianthes tuberosa* L.) cv. Calcutta Double cut flowers by colouring with edible dyes. Chemical Science Reviews and Letters. 2018;7(25):158-164.
18. Mekala P, Ganga M, Jawaharlal M. Artificial coloring of tuberose flowers for value addition. South Indian Horticulture. 2012;60:216-223.
19. National Horticulture Board. Website: www.nhb.com. Accessed on 2019 April 21st.
20. Pathak HC, Rao GS, Saiyed LH, Parmar MR, Ardeshna RB, Patel SY, *et al*. Research Accomplishments and Recommendations, Navsari Agricultural University, Navsari; c2008. p. 396-450.
21. Patil SD, Dhaduk BK. Value addition of Candytuft (*Iberis umbellate* L.) cut flowers by coloring with edible dyes. In: National Seminar on Crop Productivity and Quality Improvements through Physiological Interventions, Navsari, Gujarat; c2005. p. 23-25.
22. Patil SD, Patil. Value addition of candytuft (*Iberis umbellate* L.) cut flowers colored with edible dyes, Asian Journal of Bio-Science. 2008;3(1):163-167.
23. Ranchana P, Ganga M, Jawaharlal M, Kannan M. Standardization of tinting techniques in China aster cv. Local White. International Journal of Current Microbiology and Applied Sciences. 2017;6(9):27-31.
24. Reddy BS, Singh K. Effect of aluminum sulphate and sucrose on vase life of tuberose. Journal Maharashtra Agriculture University. 1996;21(2):201-203.
25. Sadhu MR, Bose TK. Tuberose for most artistic garlands. Indian Horticulture. 1973;18(3):17-20.
26. Safeena SA, Thangam M, Singh NP. Value addition of tuberose (*Polianthes tuberosa* L.) spikes by tinting with different edible dyes. Asian Journal of Research in Biological and Pharmaceutical Sciences. 2016;4(3):89-98.
27. Salunkhe DK, Bhat NR, Desai BB. Postharvest biotechnology of flowers and ornamental plants. Springer-Verlag, Berlin; c1990. p. 192.
28. Sambandhamurty S, Appavu K. Effect of the chemicals on coloring of tuberose (*Polianthes tuberosa* L.), National Seminar on Production Technology for Commercial Flower Crops, TNAU. 1980;9(1):73-75.
29. Sangama. Tinting technique for value addition of tuberose, National Symposium on Indian Floriculture in the New Millennium, Bangalore. 2002;3(3):18-23.
30. Sowmeya S, Kumaresan S, Priya SL. Effect of multi colors in tinting techniques in cut flowers (Rose and Carnation). Chemical Science Review and Letters. 2017;6(24):2250-2253.
31. Kumar SB, Kameswari L, Pratap M, Rao VP. Optimization of stage of harvest of spikes of gladiolus cv. white prosperity. Agri. Science Digest. 2014;35(2):89-94.
32. Sudha Patil, Dhaduk BK. Effect of chemical preservatives and coloring solutions on vase life of candytuft cut flowers (*Iberis umbellate* L.) The Asian Journal of Horticulture. 2007;2(2):55-63.
33. Sudha D, Patil, Dhaduk BK. Value addition of Lady's Lace (*Pimpinella monoica*) cut flower by coloring with edible dyes. Journal of Ornamental Horticulture. 2008;11(1):32-36.
34. Chougala S, Naik B, Mathapati HM, Savita S, Shivakumar KH. Effect of tinting on florets drop of cut tuberose spikes. International Journal of Current Research. 2016;8(3):27206-27208.
35. Vahoniya D, Panigrahy SR, Patel D, Patel J. Status of Floriculture in India: With special focus to Marketing, Int. J Pure App. Biosci. 2018;6(2):1434-1438.
36. Varu DK, Barad AV. Effect of stem length and stage of harvest on vase-life of cut flowers of tuberose (*Polianthes*

tuberosa L.) cv. Double. Journal of Horticultural Sciences. 2010;5(1):42-47.
37. Varu DK, Barad AV. Effect of floral preservatives on quality and vase life of cut flowers (*Polianthes tuberosa* L.) cv. Double. Asian J Hort. 2007;3(1):169-172.
38. Kumar V, Bhattacharjee SK. Influence of coloring agents on postharvest life and quality of tuberose cut spikes. Scientific Horticulture. 2004;9:187-191.
39. Viradia RR, Bajad A, Polara ND. Value addition through use of Dye Chemicals and Floral Preservatives in Tuberose (*Polianthes tuberosa* L.) cv. Double, International Journal of Forestry and Horticulture. 2015;1(1):1-4.
40. Waithaka K, Reid MS, Dodge LL. Cold storage and flower keeping quality of cut tuberose (*Polianthes tuberosa* L.). Journal of Horticultural Science and Biotechnology. 2001;76:271-275.
41. Yamini R, Thamaraiselvi PS, Kannan M. Standardization of tinting techniques for tuberose (*Polianthes tuberosa* L.) flowers. Advances in Floriculture and Urban Horticulture; c2018. p. 353-356.
42. Sankat D, Siddique N. Studies on environment friendly dyes obtained from plants. J Environ. Res. Develop. 2008 Jan;2(3):562-569.
43. Varu DK, Barad AV. Effect of different packing methods on vase life and quality of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. Asian journal of bio science. 2008;3(1):159-162.
44. Acock B, Nichols R. Effects of sucrose on water relations of cut, senescing, carnation flowers. Annals of Botany. 1979 Aug 1;44(2):221-30.