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Evaluation of tinting induced changes in post harvest quality attributes of tuberose

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ABSTRACT

Tuberose is an ornamental bulbous plant having fragrant waxy white flowers. It has a great economic potential for flower trade but its limited genetic variability for flower colour reduces its market value. In order to add variability in white coloured flowers, spikes can be tinted with food dye. The spikes of tuberose cv. Prajwal were tinted with food dyes namely Lemon yellow, Kesar yellow, Apple green, Raspberry red, Classic blue, Orange red and Rose pink @ 1% alone and supplemented with sucrose (2%) and citric acid (300ppm) for 1 and 2 hrs. Tinting had no adverse effect on vase life and days to opening of basal floret although other quality parameters were affected. Increase in immersion time increased the dye solution uptake, weight of spike, time taken by flowers to loose colour and floret size. Water uptake, transpirational loss, per cent loss in physiological weight declined with increase in immersion time. Based on ratio of water loss to uptake, number of floret drop/spike, time taken to loose colour and per cent of floret opening, the spikes tinted with Apple green and Classic blue dye solution supplemented with sucrose and citric acid were found to have more acceptability than those tinted with Rose pink and Orange red.The value addition in terms of rupees/spike was 2.61 for spikes tinted with Apple green and Classic Blue solution alone and 2.44 in solution supplemented with sucrose and citric acid whereas corresponding values for Orange red and Rose pink tinted spikes were respectively 1.96 and 1.84.Thus, tinted spikes will not only add to the variability of colour but will also serve as a value added product to add incentives to farmer's income.

Key words: *Polianthes tuberose*, vase life, colouring with food dyes.

INTRODUCTION

Tuberose (*Polianthes tuberose* L.) is an important ornamental bulbous flowering plant. It is commonly known as Rajanigandha or Nishigandha which means 'The Fragrance of the Night'. It has magnificent inflorescence with pleasant fragrance, shape, size and keeping quality. The elongated spikes produce cluster of fragrant waxy white flowers. The long spikes of tuberose cut flower are used for vase decoration and bouquet preparation while loose flowers are used for making floral ornaments, garlands and button holes. Tuberose has a great economic potential for flower trade but its limited genetic variability for flower colour reduces its market value. Due to monotypic nature it is not possible to induce colour variation through breeding (Huang *et al*., 4) as till today only white flowers are available for commercial cultivation. So, tinting with food colours in tuberose could serve the purpose of adding variability in its white coloured flowers (Mekala *et al*.,7).

The scenario of floriculture products is expanding at a rapid rate and holds very good prospect as the most successful component of diversified horticultural industry. The consumption basket of floriculture industry is getting diversified towards value-added floral products and therefore it is important for production to respond to these shifts in consumption. Value addition in floriculture means to increase the cash return of a small-scale floricultural enterprise through changes in genetics, processing or diversification. The value-addition for marketing flowers includes adoption of post-harvest technology and improved logistics. Marketing of value-added product e.g., tinted flowers or dehydrated foliage rather than the raw material can help to generate substantial revenue.

Tinting is one of the most important value addition technologies to impart desired shades of colours to flowers. Tinting enhances aesthetic beauty of fresh and dry flowers as single colour limits the flower acceptability and reduces the market value (Chougala *et al*., 2). At the post harvest stage tinting is outstanding method by which we can change the colour according to our wish and desire (Sowmeya *et al*., 11). Colouring inflorescences with food dyes intensify the visual appearance of these flowers and increase their economic value but at the same time tinting with food dyes interferes with the post harvest keeping quality of tuberose spikes (Patil and Patil,

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9). Several studies have been conducted for tinting tuberose spikes but the detailed insight into the effect of concentration of food dye and immersion time on keeping quality parameters of spikes is meager. Keeping in view the demand of diversification of floral products, colour variability in tuberose and increasing incentives to farmers, the present investigations were undertaken to evaluate the effect of different food colours and duration of immersion on post harvest keeping quality of tuberose spikes.

MATERIALS AND METHODS

The plants of tuberose cultivar, Prajwal were raised in the Research Farms of the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana. The laboratory experiments were performed in the Department of Floriculture and Landscaping and the Department of Botany, Punjab Agricultural University, Ludhiana. The spikes were harvested at tight bud stage (when 1-2 basal florets showed colour) and subjected to pulsing treatments. The treatments were given by dipping the basal 5-7 cm portion of the spikes in the respective dye solutions namely Lemon yellow, Kesar yellow, Apple green, Raspberry red, Classic blue, Orange red and Rose pink @ 1% alone or supplemented with sucrose (2%) and citric acid (300ppm) for 1 hour and 2 hours. After the treatment, the post-harvest keeping quality of the spikes was evaluated by placing them in distilled water under ambient conditions. The observations recorded were increase in weight after tinting, dye solution uptake, change in colour after immersion, days for opening of basal floret, per cent opening of floret, floret size, vase life, number of florets drop/spike, time taken by petals to lose the colour retention at the end of vase life, water uptake (Venkatarayappa *et al*., 13), transpirational loss of water, ratio of water loss to water uptake, loss in physiological weight, value addition in terms of rupees/spike.

$$\text{Value addition} = \frac{\text{Total benefit obtained by tinted spikes (Rs.)}}{\text{Total cost involved in tinting (Rs.)}}$$

The experiment was carried out in factorial completely randomized design (CRD). Data was subjected to statistical analysis (ANOVA) using SAS software (Version 9.2, SAS Institute Inc., Cary, NC, USA). Mean comparison to calculate significant difference between treatments were performed using CD at 0.05 level of probability.

RESULTS AND DISCUSSION

Vase life of cut spikes is the most important parameter of cut flowers. Tinting of tuberose spikes with different dyes as well as time of immersion had no significant effect on the vase life (Fig. 1). The vase life of non tinted spikes (T_{16}) was recorded to be 5.00 days which was at par with all the other treatments. This might be due to fact that dyes do not interfere with cell metabolism and thus the vase life remains unaffected (Dhaduk and Naik, 3; Kumar *et al*., 6). The unaffected vase life of spikes after tinting is a very good sign that enables the growers to not only add colour to white flowers of tuberose but also to add incentives to their incomes. But at the same time the effect of type of dye and time of immersion on other quality parameters especially floret opening, visual

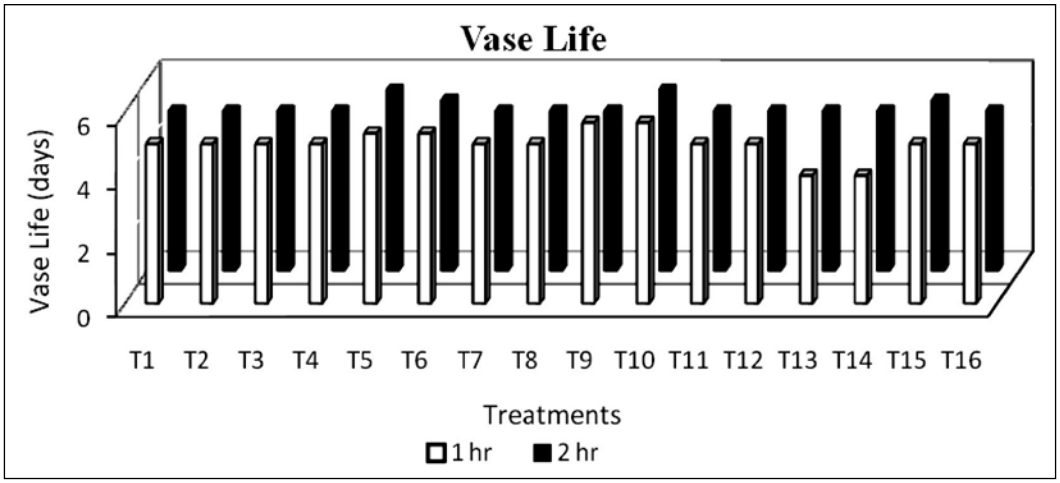

Fig. 1. Effect of food dyes and immersion time on time taken by florets of Tuberose spikes (cv. Prajwal) to lose colour.

*T1- Lemon yellow T2- Lemon yellow + sucrose (2%) +citric acid (300ppm) T3- Kesar yellow T4- Kesar yellow + sucrose (2%) + citric acid (300ppm) T5- Apple green T6- Apple green + sucrose (2%) + citric acid (300ppm) T7- Raspberry red T8- Raspberry red + sucrose (2%) + citric acid (300ppm) T9- Classic blue T10- Classic blue + sucrose (2%) + citric acid (300ppm) T11- Orange red T12- Orange red + sucrose (2%) + citric acid (300ppm) T13- Rose pink T14- Rose pink + sucrose (2%) + citric acid (300 ppm)

appearance of colour as well as floret drop needs to be evaluated for good quality spikes.

The spikes immersed for 2 hrs in dye solution with sucrose and citric acid absorbed more dye than 1hr (Table 1). The spikes tinted with supplemented Lemon yellow solution (T_2) for 2hrs resulted in maximum uptake of dye (3.36ml) in comparison to Rose pink ($T_{13,}$ T_{14}) and Kesar yellow (T_3) tinted spikes for 1hr.

Table 1: Effect of food dyes and immersion time on dye solution uptake (ml) and per cent increase in weight by Tuberose spikes (cv. Prajwal).

Treatment (T)	Dye solution uptake (ml)			Per cent increase in weight		
	Immersion time(I_1)	Immersion time (I_2)	Mean	Immersion time (I_1)	Immersion time (I_2)	Mean
T_1-1% Lemon yellow	1.82^{H}	2.16^{E}	1.99^{f}	3.01^{K} (9.99)	3.39^{H} (10.61)	3.20^{f} (10.30)
T_2-1% Lemon yellow+2% Sucrose+300ppm Citric acid	2.50^{C}	3.36^{A}	2.93^{a}	2.75^{N} (9.54)	2.89^{L} (9.79)	2.82^{h} (9.66)
T_3-1% Kesar yellow	1.36^{Q}	1.73^{JK}	1.54^{j}	3.56^{E} (10.88)	4.21^{A} (11.83)	3.89^{a} (11.36)
T_4-1% Kesar yellow+2% Sucrose+300ppm Citric acid	1.76^{IJ}	2.90^{B}	2.33^{b}	3.80^{C} (11.24)	3.48^{FG} (10.75)	3.64^{b} (10.99)
T_5-1% Apple green	1.63^{M}	2.00^{G}	1.81^{h}	2.41^{P} (8.93)	3.25^{I} (10.39)	2.83^{h} (9.66)
T_6-1% Apple green+2% Sucrose+300ppm Citric acid	1.43^{P}	2.86^{B}	2.14^{d}	2.89^{L} (9.79)	3.04^{K} (10.04)	2.97^{g} (9.92)
T_7-1% Raspberry red	1.80^{HI}	2.23^{D}	2.01^{ef}	3.22^{I} (10.34)	3.64^{D} (10.99)	3.43^{c} (10.67)
T_8-1% Raspberry red+2% Sucrose+300ppm Citric acid	1.56^{N}	2.50^{C}	2.03^{e}	2.54^{O} (9.17)	3.79^{C} (11.23)	3.17^{f} (10.20)
T_9-1% Classic blue	1.53^{NO}	2.00^{G}	1.76^{i}	2.93^{L} (9.85)	2.41^{P} (8.93)	2.67^{j} (9.39)
T_{10}-1% Classic blue+2% Sucrose+300ppm Citric acid	1.66^{LM}	1.96^{G}	1.81^{h}	2.70^{N} (9.45)	3.74^{C} (11.15)	3.22^{f} (10.30)
T_{11}-1% Orange red	1.50^{O}	2.10^{F}	1.80^{h}	3.43^{GH} (10.66)	3.91^{B} (11.40)	3.67^{b} (11.03)
T_{12}-1% Orange red+2% Sucrose+300ppm Citric acid	1.80^{HI}	2.10^{F}	1.95^{g}	3.11^{J} (10.16)	3.54^{EF} (10.84)	3.33^{de} (10.50)
T_{13}-1% Rose pink	1.36^{Q}	1.53^{NO}	1.44^{l}	2.12^{Q} (8.37)	3.24^{I} (10.37)	2.68^{j} (9.37)
T_{14}-1% Rose pink +2% Sucrose+300ppm Citric acid	1.33^{Q}	1.63^{M}	1.48^{k}	2.83^{M} (9.67)	2.71^{N} (9.47)	2.77^{i} (9.57)
T_{15}-2% Sucrose+300ppm Citric acid	1.70^{KL}	2.26^{D}	1.98^{fg}	3.04^{K} (10.04)	3.52^{EF} (10.81)	3.28^{e} (10.43)
T_{16}-Water (Control)	2.13^{EF}	2.46^{C}	2.29^{c}	3.01^{K} (9.89)	3.66^{D} (11.03)	3.34^{d} (10.51)
Mean	1.68^{b}	2.24^{a}		2.96^{b} (9.88)	3.40^{a} (10.60)	
CD	I = 0.01 T = 0.03 I× T = 0.05			I = 0.02 T = 0.05 I × T = 0.08		

*Different lower case letters horizontally indicate statistically significant difference between immersion times and vertically indicate statistically significant difference between dye treatments. Different upper case letters indicate statistically significant difference between type of dye and immersion time.

*Figures in parenthesis are arc sine transformed values

This might be due to role of sucrose and citric acid in preventing vascular blockage leading to more translocation of the dye (Varu and Barad, 12).

Both the type of dye and immersion time significantly influenced the weight of spikes (Table 1). The spikes tinted with Kesar yellow (T_3) for 2hrs showed maximum (4.21 per cent) increase in weight whereas minimum increase of 2.12 per cent was in Rose pink (T_{13}) for 1 hr. The spikes immersed for 2hrs showed significantly higher per cent increase in weight (3.40) than the spikes immersed for 1hr (2.96) irrespective of type of dye used as with time the amount of dye solution uptake also increased (Kumar, 5). Irrespective of immersion time maximum per cent increase in weight (3.89) was recorded in spikes treated with Kesar yellow (T_3).

Days taken for opening of basal floret is an important post harvest quality parameter and tinting didn't show any significant effect on the number of days taken for opening of basal floret (Table 2).This indicated that tinted tuberose spikes (with different food dyes for different duration) took same number of days to open basal floret as taken by non tinted spikes (T_{15} and T_{16}).The immersion time significantly increased the per cent opening of florets (Table 3). The spikes tinted for 2hrs showed significantly higher per cent of floret opening (40.89) than the spikes treated for 1hr (37.34) irrespective of type of dye used. Among all the treatments, the tinted spike with supplemented Kesar yellow (T_4) for 2hrs showed maximum per cent of floret opening of 57.4 and minimum of 21.03 in Orange red (T_{11}) for 1 hr. This

Table 2: Effect of food dyes and immersion time on days of opening of florets and floret size of Tuberose spikes (cv. Prajwal)

Treatment (T)	Days for opening of floret			Floret size (cm)		
	Immersion time(I_1)	Immersion time (I_2)	Mean	Immersion time (I_1)	Immersion time (I_2)	Mean
T_1-1% Lemon yellow	1.33	1.00	**1.17**	3.86^{HI}	3.83^{I}	**3.85**
T_2-1% Lemon yellow+2% Sucrose+300ppm Citric acid	1.33	1.00	**1.17**	4.00^{C}	4.00^{C}	**4.00**
T_3-1% Kesar yellow	1.00	1.00	**1.00**	3.66^{M}	4.10^{B}	**3.88**
T_4-1% Kesar yellow+2% Sucrose+300ppm Citric acid	1.33	1.33	**1.33**	3.72^{K}	4.10^{B}	**3.91**
T_5-1% Apple green	1.33	1.00	**1.17**	3.83^{I}	4.23^{A}	**4.03**
T_6-1% Apple green+2% Sucrose+300ppm Citric acid	1.00	1.33	**1.17**	3.83^{I}	4.03^{C}	**3.93**
T_7-1% Raspberry red	1.33	1.00	**1.17**	3.76^{J}	4.00^{D}	**3.88**
T_8-1% Raspberry red+2% Sucrose+300ppm Citric acid	1.00	1.00	**1.00**	3.66^{M}	4.07^{B}	3.86
T_9-1% Classic blue	1.00	1.00	**1.00**	3.93^{EF}	3.97^{D}	**3.95**
T_{10}-1% Classic blue+2% Sucrose+300ppm Citric acid	1.00	1.00	**1.00**	3.86^{HI}	4.23^{A}	**4.05**
T_{11}-1% Orange red	1.00	1.00	**1.00**	3.80^{HI}	3.67^{LM}	**3.73**
T_{12}-1% Orange red+2% Sucrose+300ppm Citric acid	1.00	1.00	**1.00**	4.00^{C}	3.83^{I}	**3.92**
T_{13}-1% Rose pink	1.00	1.00	**1.00**	3.90^{FG}	3.87^{GH}	**3.88**
T_{14}-1% Rose pink +2% Sucrose+300ppm Citric acid	1.00	1.00	**1.00**	3.70^{KL}	3.67^{LM}	**3.68**
T_{15}-2% Sucrose+300ppm Citric acid	1.00	1.00	**1.00**	3.96^{DE}	3.87^{GH}	**3.91**
T_{16}-Water (Control)	1.33	1.00	**1.17**	3.83^{I}	3.83^{I}	**3.83**
Mean	1.12	1.04		3.83^{b}	3.96^{a}	
CD	I= NS T = NS I× T = NS			I= 0.08 T = NS I×T = 0.03		

*Different upper case letters indicate statistically significant difference between type of dye and immersion time.

Table 3: Effect of food dyes and immersion time on per cent opening and number of floret drop/spike of Tuberose spikes (cv. Prajwal)

Treatment (T)	Per cent opening of floret			No. of florets drop/spike		
	Immersion time(I_1)	Immersion time (I_2)	Mean	Immersion time (I_1)	Immersion time (I_2)	Mean
T_1-1% Lemon yellow	30.27^{QR} (33.37)	37.57^{K} (37.78)	33.92^{I} (35.58)	10.67^{O}	16.67^{D}	13.67^{g}
T_2-1% Lemon yellow+2% Sucrose+300ppm Citric acid	29.67^{RS} (32.99)	42.73^{I} (40.80)	36.20^{i} (36.90)	10.33^{P}	8.67^{R}	9.50^{k}
T_3-1% Kesar yellow	33.57^{P} (35.40)	35.73^{MN} (36.69)	34.65^{k} (36.04)	10.33^{P}	16.36^{E}	13.34^{h}
T_4-1% Kesar yellow+2% Sucrose+300ppm Citric acid	35.90^{LMN} (36.80)	57.43^{A} (49.25)	46.67^{c} (43.03)	10.67^{O}	11.67^{M}	11.17^{j}
T_5-1% Apple green	43.83^{GHI} (41.44)	36.73^{KLM} (37.29)	40.28^{f} (39.36)	13.33^{I}	14.00^{G}	14.17^{f}
T_6-1% Apple green+2% Sucrose+300ppm Citric acid	50.85^{CD} (45.47)	53.40^{B} (46.93)	52.12^{a} (46.20)	7.00^{T}	8.33^{S}	7.67^{m}
T_7-1% Raspberry red	44.40^{GH} (41.77)	49.57^{DE} (44.73)	46.98^{b} (43.25)	12.00^{L}	12.67^{K}	12.34^{i}
T_8-1% Raspberry red+2% Sucrose+300ppm Citric acid	51.06^{C} (45.59)	37.30^{K} (37.63)	44.18^{d} (41.61)	11.67^{M}	6.67^{U}	9.17^{l}
T_9-1% Classic blue	43.47^{HI} (41.23)	31.27^{Q} (33.99)	37.37^{g} (37.61)	15.67^{F}	13.00^{J}	14.34^{e}
T_{10}-1% Classic blue+2% Sucrose+300ppm Citric acid	34.93^{NO} (36.21)	37.13^{KL} (37.52)	36.03^{j} (36.87)	11.00^{N}	15.67^{F}	13.34^{h}
T_{11}-1% Orange red	21.03^{U} (27.28)	41.13^{J} (39.88)	31.08^{m} (33.58)	13.67^{H}	18.67^{A}	16.17^{b}
T_{12}-1% Orange red+2% Sucrose+300ppm Citric acid	26.13^{T} (30.73)	47.23^{F} (43.40)	36.68^{h} (37.06)	13.33^{I}	9.00^{Q}	11.16^{j}
T_{13}-1% Rose pink	45.00^{G} (42.11)	48.53^{EF} (44.14)	46.77^{b} (43.13)	18.33^{B}	18.67^{A}	18.50^{a}
T_{14}-1% Rose pink +2% Sucrose+300ppm Citric acid	47.70^{F} (43.67)	34.83^{NOP} (36.15)	41.26^{e} (39.91)	12.00^{L}	17.33^{C}	14.67^{c}
T_{15}-2% Sucrose+300ppm Citric acid	34.17^{OP} (35.76)	34.83^{NOP} (36.15)	34.50^{k} (35.96)	3.00^{V}	3.00^{V}	3.00^{n}
T_{16}-Water (Control)	25.37^{T} (30.23)	28.93^{S} (32.52)	27.15^{n} (31.38)	11.67^{M}	17.33^{C}	14.50^{d}
Mean	37.34^{b} (37.50)	40.89^{a} (39.68)		11.73^{b}	12.98^{a}	
CD	I = 0.10 T = 0.27 I × T = 0.38			I = 0.01 T = 0.03 I × T = 0.05		

*Different lower case letters horizontally indicate statistically significant difference between immersion times and vertically indicate statistically significant difference between dye treatments. Different upper case letters indicate statistically significant difference between type of dye and immersion time.

*Figures in parenthesis are arc sine transformed values

might be due to availability of considerable quantity of respiratory substrate (sucrose) that ensures opening of immature florets and further with increase in immersion time more solutes could be trans located through xylem (Singh *et al*., 10).

Likewise the per cent opening of florets, the floret size of tinted spikes also showed significant increase with increase in immersion time (Table 2).The floret size was maximum in spikes tinted for 2 hours (27.29) as compared to spikes tinted for 1

hour (26.81). This might be due to more availability of water and respiratory substrate (sucrose) with time (Bhramankar *et al*., 1). Although slight change in floret size was recorded with dye used but it was not significant. This might be due to fact that dyes did not impose any adverse effect to the cell metabolism up to that immersion times (Dhaduk and Naik, 3).

Floret drop is a major concern affecting post harvest life of tuberose spikes. The spikes kept in water showed 11.67 after 1 hr and 17.33 floret drops after 2 hrs that reduced to 3 when water was supplemented with sucrose and citric acid. The addition of sucrose and citric acid in dye solution supplemented the spikes due to which the number of floret drop was less in tinted spikes (Fig. 2). This might be due to availability of considerable quantity of respiratory substrate (sucrose) that ensures opening of immature florets (Singh *et al*., 10) and hence corresponds to less floret drop.

The immersion of spikes in food dye for 1 and 2 hr increased the floret drop as compared to non tinted spikes but it was comparable with control (water) when dye solution was supplemented with sucrose and citric acid (Table 3). Further immersion of spikes in dye solution for 2 hrs led to higher floret drop than 1 hr which could be accounted for higher dye uptake after 2 hrs. This higher dye uptake might interfere with the osmotic pressure of the cells that altered cell turgidity or led to blockage of vascular vessels during translocation (Chougala *et al*.,2). The spikes tinted with Orange red and Rose pink resulted in higher floret drop even than control but with other dyes especially Apple green and Classic blue it was less or at par with control.

The immersion time significantly declined the water uptake (Table 4).The amount of water uptake was significantly more in spikes tinted for 1 hour (49.22 g/spike) as compared to spikes tinted for 2 hours (43.16 g/spike). More dye uptake in spikes immersed in dye solution for 2 hours during tinting accounts for the reduction in amount of water uptake by spikes tinted for 2 hours. Rose pink (T_{14}) tinted spikes absorbed 61.43g of water per spike from the vase solution in comparison to 12.40 g of water per non tinted spike (T_{16}). This might be due to significant effect of type of dye on the osmotic pressure of the cell thus altering the cell turgidity that resulted in significant variation in amount of water absorbed (Chougala *et al*., 2).Transpirational loss was significantly influenced by the type of dye as well as immersion time (Table 4). The spikes immersed in dye solution for 1hr lost more water 54.12g/spike in comparison to 2hrs (51.22g/spike).Among all the treatments, non tinted spikes (T_{16}) lost least water per spike (13.53 g/spike) for 1hr in comparison to non tinted spikes supplemented with sucrose and citric acid (T_{15}). Further the amount of water lost was more in all tinted spikes supplemented with sucrose and citric acid as compared to tinted spikes without supplemented with sucrose and citric acid indicating that high rate of water absorption led to high rate of transpiration.

The ratio of water loss to water uptake was significantly more in spikes immersed for 2hrs (1.19) in comparison to spikes immersed for 1hr

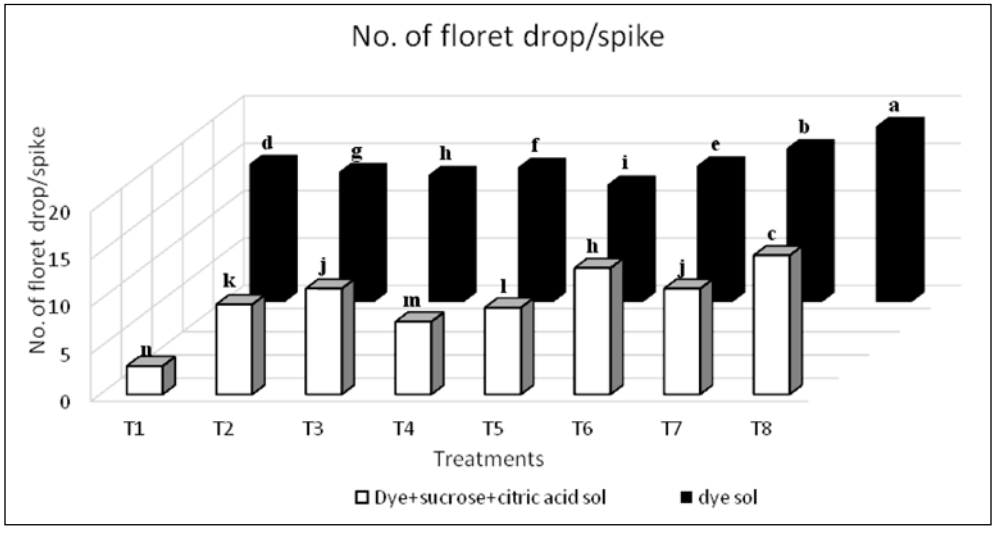

Fig. 2. Effect of food dye solutions on number of floret drop/spike in Tuberose

*T1- Control T2- Lemon yellow T3- Kesar yellow T4- Apple green T5- Raspberry red T6- Classic blue T7- Orange red T8- Rose pink
**Different lower case letters indicate statistically significant difference between dye treatments.

Table 4: Effect of food dyes and immersion time on uptake of water and transpirational loss of water by Tuberose spikes (cv. Prajwal)

Treatment (T)	Water uptake (g/spike)			Transpirational loss (g/spike)		
	Immersion time(I_1)	Immersion time (I_2)	Mean	Immersion time (I_1)	Immersion time (I_2)	Mean
T_1-1% Lemon yellow	35.53^{R}	40.53^{O}	38.03^{k}	39.10^{S}	44.67^{Q}	41.88^{k}
T_2-1% Lemon yellow+2% Sucrose+300ppm Citric acid	53.23^{EF}	43.23^{MN}	48.23^{g}	63.10^{EF}	51.10^{L}	57.10^{f}
T_3-1% Kesar yellow	59.77^{C}	40.23^{O}	50.00^{f}	61.90^{FG}	46.73^{OP}	54.31^{g}
T_4-1% Kesar yellow+2% Sucrose+300ppm Citric acid	60.97^{B}	45.27^{JK}	53.12^{d}	64.53^{CDE}	55.10^{IJ}	59.81^{d}
T_5-1% Apple green	46.27^{IJ}	46.77^{I}	46.52^{h}	51.90^{KL}	53.43^{JK}	52.67^{h}
T_6-1% Apple green+2% Sucrose+300ppm Citric acid	56.77^{C}	52.63^{FG}	54.70^{c}	63.90^{DE}	66.23^{C}	65.07^{b}
T_7-1% Raspberry red	32.23^{S}	39.63^{O}	35.93^{l}	40.03^{S}	42.43^{R}	41.23^{k}
T_8-1% Raspberry red+2% Sucrose+300ppm Citric acid	42.43^{N}	60.27^{B}	51.35^{e}	49.23^{MN}	66.00^{C}	57.62^{f}
T_9-1% Classic blue	54.10^{E}	48.43^{H}	51.27^{e}	48.03^{NO}	59.37^{H}	53.70^{g}
T_{10}-1% Classic blue+2% Sucrose+300ppm Citric acid	69.43^{A}	51.77^{G}	60.60^{b}	66.23^{C}	59.63^{H}	62.93^{c}
T_{11}-1% Orange red	36.53^{QR}	36.63^{Q}	36.58^{j}	45.90^{PQ}	42.23^{R}	44.06^{j}
T_{12}-1% Orange red+2% Sucrose+300ppm Citric acid	44.77^{KL}	38.23^{P}	41.50^{j}	50.27^{LM}	48.00^{NO}	49.13^{i}
T_{13}-1% Rose pink	44.10^{LM}	44.77^{KL}	44.43^{i}	60.53^{GH}	55.63^{I}	58.08^{e}
T_{14}-1% Rose pink +2% Sucrose+300ppm Citric acid	69.23^{A}	53.63^{EF}	61.43^{a}	70.23^{B}	65.53^{CD}	67.88^{a}
T_{15}-2% Sucrose+300ppm Citric acid	70.23^{A}	35.63^{QR}	52.93^{d}	77.43^{A}	46.37^{OPQ}	61.90^{c}
T_{16}-Water (Control)	11.90^{T}	12.90^{T}	12.40^{m}	13.53^{U}	17.10^{T}	15.32^{l}
Mean	49.22^{a}	43.16^{b}		54.12^{a}	51.22^{b}	
CD	I = 0.26 T = 0.73 I × T = 1.03			I = 0.29 T = 0.83 I × T = 1.17		

*Different lower case letters horizontally indicate statistically significant difference between immersion times and vertically indicate statistically significant difference between dye treatments. Different upper case letters indicate statistically significant difference between type of dye and immersion time.

(Table 5). The spikes tinted with Rose pink (T_{13}) recorded maximum ratio of loss to uptake (1.30) as compared to spikes tinted with Classic blue (1.02). Among all the treatments, the tinted spikes with Rose pink (T_{13}) showed maximum loss to uptake ratio (1.37) in comparison to Classic blue (T_9) which showed 0.89 loss to water uptake ratio . This ratio is in accordance with our sensory evaluation of better quality of spikes tinted with Classic blue in comparison to Rose pink.

The colour of tuberose flowers is creamy white. The sensory evaluation for colour using RHS colour chart was done after tinting spikes with different food dyes for different durations. The colour of spikes in control T_{15} and T_{16} was recorded as White group 155C. Depending upon the colour of food dye used, the change in colour was noticed. As the time of immersion increased from 1 to 2hrs, the intensity of colour of food dye increased as recorded through RHS scale (Viradia *et al*., 14). This may be due to more absorption of dye to the petals through the vasculatory system along with water or dye uptake. The colour retained at the end of vase life by the flowers in all dyes revealed that fading of colour took place in all treatments at the end of vase life. The spikes immersed for 1hr in dyes viz., Lemon yellow, Kesar yellow, Apple green, Raspberry red, Classic blue, Orange red and Rose pink imparted shades of Yellow, Green, Red purple, Blue green, Orange red and Purple with colour codes 6C, 6B, 140B, 63B, 117C, 30C and 75C that changed to 6D, 6C, 140C, 65D, 117D, 30D and 75D at the end of vase life. The corresponding change in colour after 2hrs was noticed with colour codes 6B, 6A, 140A, 63A, 117B, 30B and 75B that changed to 6C, 6B, 140B, 65C, 117C, 30C and 75C respectively at the end of vase life. Hence, it is clear that as the number of days in the vase increased there is a decrease in colour intensity (Patil and Dhaduk, 8).

The spikes tinted for 2 hours took significantly more days (4.78) to lose colour than the spikes tinted for 1 hour (4.22 days). This corresponds to more dye uptake by spikes tinted for 2hrs than 1 hr (Fig 3). The Apple green (T_5, T_6) and Classic blue (T_9, T_{10}) tinted spikes took maximum time 6.75 days while Rose pink (T_{13}) tinted spikes took least time taken to

Table 5: Effect of food dyes and immersion time on ratio of water loss to uptake and per cent loss in physiological weight by Tuberose spikes (cv. Prajwal).

Treatment (T)	Water uptake (g/spike)			Transpirational loss (g/spike)		
	Immersion time(I_1)	Immersion time (I_2)	Mean	Immersion time (I_1)	Immersion time (I_2)	Mean
T_1-1% Lemon yellow	1.10^{KL}	1.10^{KL}	1.10^{fg}	29.90^{H} (33.13)	23.83^{I} (29.21)	26.87^{g} (31.17)
T_2-1% Lemon yellow+2% Sucrose +300ppm Citric acid	1.19^{FGH}	1.18^{GHI}	1.18^{cd}	11.00^{LM} (19.31)	12.83^{L} (20.98)	11.92^{k} (20.14)
T_3-1% Kesar yellow	1.04^{MN}	1.22^{EFG}	1.13^{ef}	6.23^{O} (14.45)	29.23^{H} (32.72)	17.73^{hi} (23.58)
T_4-1% Kesar yellow+2% Sucrose +300ppm Citric acid	1.06^{LM}	1.16^{HIJ}	1.11^{fg}	10.63^{M} (19.03)	17.87^{K} (24.99)	14.25^{j} (22.01)
T_5-1% Apple green	1.12^{JK}	1.14^{IJK}	1.13^{ef}	49.00^{C} (44.41)	35.53^{F} (36.57)	42.27^{d} (40.49)
T_6-1% Apple green+2% Sucrose +300ppm Citric acid	1.13^{JK}	1.26^{CDE}	1.19^{cd}	3.10^{P} (10.13)	32.23^{G} (34.58)	17.67^{hi} (22.36)
T_7-1% Raspberry red	1.24^{DE}	1.07^{LM}	1.16^{de}	20.43^{J} (26.86)	17.23^{K} (24.52)	18.83^{h} (25.69)
T_8-1% Raspberry red+2% Sucrose +300ppm Citric acid	1.16^{HIJ}	1.10^{KL}	1.13^{ef}	20.43^{J} (26.86)	8.53^{N} (16.97)	14.48^{j} (21.92)
T_9-1% Classic blue	0.89^{P}	1.15^{HIJ}	1.02^{h}	36.23^{F} (36.99)	54.53^{B} (47.58)	45.38^{c} (42.29)
T_{10}-1% Classic blue+2% Sucrose +300ppm Citric acid	0.95^{O}	1.23^{DEF}	1.09^{g}	40.63^{D} (39.58)	38.36^{E} (38.26)	39.50^{e} (38.92)
T_{11}-1% Orange red	1.26^{CDE}	1.15^{HIJ}	1.20^{bc}	16.27^{K} (23.77)	16.87^{K} (24.24)	16.57^{i} (24.01)
T_{12}-1% Orange red+2% Sucrose +300ppm Citric acid	1.12^{JK}	1.27^{CD}	1.19^{cd}	28.27^{H} (32.10)	29.27^{H} (32.74)	28.77^{f} (32.42)
T_{13}-1% Rose pink	1.37^{A}	1.22^{EFG}	1.30^{a}	77.43^{A} (61.61)	35.00^{F} (36.26)	56.22^{a} (48.93)
T_{14}-1% Rose pink +2% Sucrose +300ppm Citric acid	1.01^{N}	1.24^{DE}	1.13^{ef}	52.70^{B} (46.53)	40.67^{D} (39.60)	46.68^{b} (43.17)
T_{15}-2% Sucrose+300ppm Citric acid	1.10^{KL}	1.30^{BC}	1.20^{bc}	5.00^{OP} (12.91)	12.63^{L} (20.81)	8.82^{l} (16.86)
T_{16}-Water (Control)	1.14^{IJK}	1.33^{AB}	1.23^{b}	21.77^{J} (27.80)	32.00^{G} (34.44)	26.88^{g} (31.12)
Mean	1.12^{b}	1.20^{a}		26.81^{b} (29.72)	27.29^{a} (30.90)	
CD	I = 0.01 T = 0.03 I × T = 0.04			I = 0.21 T = 0.59 I × T = 0.83		

*Different lower case letters horizontally indicate statistically significant difference between immersion times and vertically indicate statistically significant difference between dye treatments. Different upper case letters indicate statistically significant difference between type of dye and immersion time.

lose colour. Although by the end of vase life all the tinted spikes retained tinge of colour but that was not acceptable.

The per cent weight loss by the spikes showed increase with increase in the immersion time (Table 5).The spikes tinted for 2 hours showed significantly higher per cent of loss in weight (27.29) than the spikes tinted for 1 hour (26.81) irrespective of type of dye used. Both the type of dye and immersion time significantly influenced the per cent loss in weight. The spikes tinted with Rose pink (T_{13}) for 1 hour showed maximum per cent loss of 77.43 and minimum of 3.10 in Apple green (T_6). Irrespective of immersion time, maximum loss was 56.22% with Rose pink (T_{13}) tinted spikes and the least per cent loss was recorded in non tinted spikes (T_{15}).

The cost of coloured spike is generally higher than white coloured spike in the market. The benefit cost ratio can be obtained by dividing total benefit obtained by tinted spikes (Rs.) with total cost involved in tinting (Rs.). So the benefit cost ratio of tinted spikes (T_1, T_7, T_5, T_9, T_{11} and T_{13}) was 2.29, 2.61 and 1.96 respectively in comparison to spikes tinted with respective dye solutions with sucrose and citric acid (T_2, T_8, T_6, T_{10}, T_{12} and T_{14}) which has benefit cost ratio of 2.15, 2.44 and 1.84 (Table 6). Thus on an average one rupee spend in tinting, one can earn a profit of 1.21 paisa indicating that tinting the spikes of tuberose cv. Prajwal with food dyes is a good remunerative value addition technique especially when the coloured spikes are not available or when a spike of particular colour is required for decorative schemes.

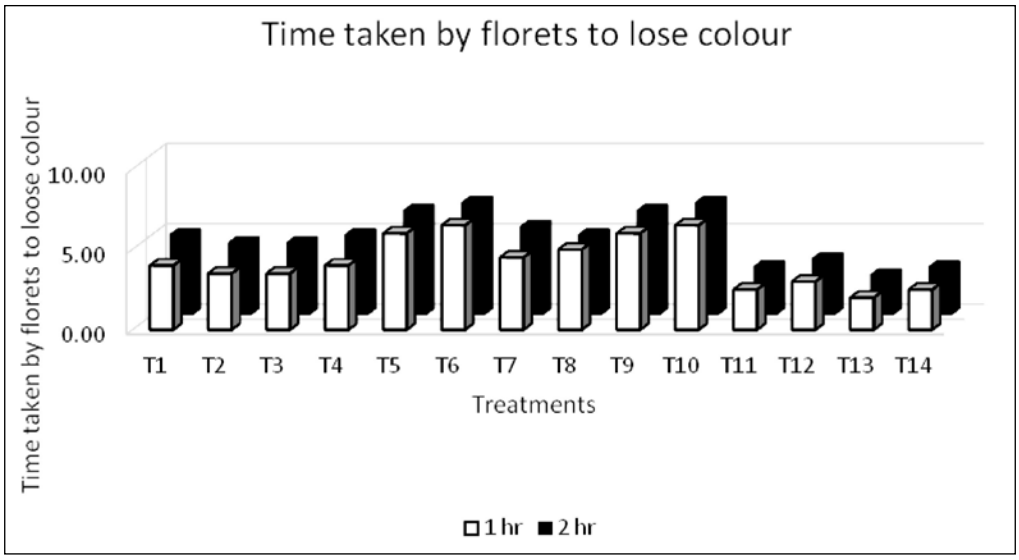

Fig. 3. Effect of food dyes and immersion time on time taken by florets of Tuberose spikes (cv. Prajwal) to lose colour.

*T1- Lemon yellow T2- Lemon yellow + sucrose (2%) +citric acid (300ppm) T3- Kesar yellow T4- Kesar yellow + sucrose (2%) + citric acid (300ppm) T5- Apple green T6- Apple green + sucrose (2%) + citric acid (300ppm) T7- Raspberry red T8- Raspberry red + sucrose (2%) + citric acid (300ppm) T9- Classic blue T10- Classic blue + sucrose (2%) + citric acid (300ppm) T11- Orange red T12- Orange red + sucrose (2%) + citric acid (300ppm) T13- Rose pink T14- Rose pink + sucrose (2%) + citric acid (300ppm)

Table 6: Effect of food dyes and immersion time on value addition in terms of rupees/Tuberose spikes (cv. Prajwal).

Treatment (T)	Value addition in terms of rupees/spike
T_1-1% Lemon yellow	2.29
T_2-1% Lemon yellow+2% Sucrose+300ppm Citric acid	2.15
T_3-1% Kesar yellow	2.28
T_4-1% Kesar yellow+2% Sucrose+300ppm Citric acid	2.14
T_5-1% Apple green	2.61
T_6-1% Apple green+2% Sucrose+300ppm Citric acid	2.44
T_7-1% Raspberry red	2.29
T_8-1% Raspberry red+2% Sucrose+300ppm Citric acid	2.15
T_9-1% Classic blue	2.61
T_{10}-1% Classic blue+2% Sucrose+300ppm Citric acid	2.44
T_{11}-1% Orange red	1.96
T_{12}-1% Orange red+2% Sucrose+300ppm Citric acid	1.84
T_{13}-1% Rose pink	1.96
T_{14}-1% Rose pink +2% Sucrose+300ppm Citric acid	1.84
T_{15}-2% Sucrose+300ppm Citric acid	0.00
T_{16}-Water (Control)	0.00

CONCLUSION

Thus the results revealed that tinting of spikes with different food dyes and for different immersion times did not significantly affect the vase life and days to opening of florets. Based on different quality parameters especially floret drop/spike, ratio of loss to uptake, time taken to loose colour etc. the tinting of spikes with Apple green and Classic blue with or without supplemented with sucrose and citric acid was found to give better results than other dyes. The spikes tinted with Rose pink and Orange red were found to perform at par or below the non tinted spikes in terms of quality parameters.

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