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Effect of food colour tinting on the aesthetic value and longevity of tuberose flower (*Polianthes tuberosa* L.)

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Abstract
Tuberose (*Polianthes tuberosa* L.) is a widely cultivated cut flower valued for its pure white, fragrant blooms. However, its popularity is often limited due to the lack of colour variation. To enhance its aesthetic appeal and marketability, artificial tinting using food dyes offers a promising value addition technique. With this objective, an experiment was conducted on tuberose to determine the most suitable food dyes, their concentrations, and the appropriate bud stage for tinting, so as to improve consumer acceptance and extend vase life. Harvested spikes were immersed in solutions of different food dyes, namely Blue, Apple Green, Tomato Red, each tested at concentrations of 4%, 5%, 6% and 7% The findings indicated that spikes tinted at the 7% concentration with Blue dye were most preferred by consumers. Although higher concentrations (6%) ensured better colour absorption and intensity, the lower concentration (4%) was more effective in maintaining prolonged vase life, thereby balancing both visual appeal and longevity.

Keywords: *Polianthes tuberose*, colouring with food dye, vase life

Introduction
Tuberose (*Polianthes tuberose* L.) is an ornamental bulbus flowering plants. Belong to family Amaryllidaceae has originated from Mexico. It is commonly known as Rajanigandha or Nishi Gandha which means "The Fragrance of the Night". Due to varied climate and soil, tuberose is an important ornamental and commercial cut as well as loose flower crop of India. Tuberose stands fifth in the international trade after rose, carnation, chrysanthemum, and gladiolus. Because its magnificent inflorescence, shape, size, and keeping quality it occupies prime position both in domestic and international market. Flower of tuberose also lack colour due to absence of carotenoids and anthocyanins (Huang *et al*., 2002) [5]. Growers of tuberose often face problem of marketing during the peak flowering season, where coloured spikes might have fetched better prices (Anonymous, 2019) [1]. Due to monotypic in nature it is not possible to induce colour variation through breeding (Huang *et al*., 2002) [5] as till today only white flower are available for commercial cultivation. So, tinting with food colours, in tuberose could serve the purpose of adding variability in its white coloured flowers (Mekal *et al*., 2012) [9]. Tinting is one of the important value addition technique which could be adopted in flower crops where pigment is either absence or not prominent. It enhance the aesthetic beauty of fresh and dry flowers (Sowmeya *et al*., 2017) [13] artificial colouring of spikes is fetching a more price in the market as compared to white ones. The technique of value addition like colouring of white flowers can add value up to 5 to 10 times (Mekala *et al*., 2012) [9]. Such type of artificial colouring is done by using food colours. Certified synthetic food colour are less expensive and lead to minimum health hazards by imparting an intense and uniform colour. Spikes treated with plain water or left untreated demonstrated a longer vase life compared to those dyed with colorants. While tuberose spikes with tinted florets in green, red or yellow are visually more appealing and enhance the attractiveness of bouquets and floral arrangements, their vase life is comparatively shorter. Although tinted flowers add charm and decorative value, their reduced longevity makes them more suitable forshort-term display purposes (Ranchana *et al*., 2017) [12].

Material and Methods
The study was conducted at college of horticulture and research station Station Sankra, Patan, Durg (C.G.). flower where harvested in the morning between 7.00-8.00 am, from

farmer field with 2-4 open flower in each spike. To prepare colour solution of 4%,5%,6% and 7% of blue, apple green and tomato red colour were mixed with 100ml of filtrated water. Uniform tuberose spikes, each 65 cm in length with 2-4 florets open, were selected, and one spikes were placed in cylinder shaped bottle containing 100 ml of edible dye solutions. After six hours of tinting, the spikes were transferred immediately to vase solutions. For vase preparation, a 3% sugar solution was made by dissolving 30 g of sugar in 100ml of water, and citric acid solution of 350 mg was dissolved in 100mlof water. Each vase solution was prepared in 1000ml cylinder bottle using 100 ml of filtered water. The experiment comprised 13 treatments with 3 replications: Control, T_1 = 4% Blue, T_2 = 5% Blue, T_3 = 6% Blue, T_4 = 7%blue, T_5 = 4% tomato red, T_6 = 5% tomato red, T_7 = 6%tomato red, T_8 = 7%tomato red, T_9 = 4% apple green, T_{10} = 5% apple green, T_{11} = 6% apple green, T_{12} = 7% apple green, Observations recorded included colour uptake, water absorption during tinting, effect on spike weight, flower diameter, number of florets opened, and number of florets dropped. The diameter of the 3^{rd} pair of florets from the base was measured daily using a vernier calliper. Colour expression and retention were evaluated using the RHS colour chart. The vase life was determined based on wilting of 50% of florets per spike. Data were analyzed under a Completely Randomized Design (CRD) using ANOVA, and treatment differences were considered significant at $P \leq 0.001$.

Result and Discussion

About colour shade obtained

Dye solution uptake

The dye solution uptake by spikes after 2 hours of immersion was recorded and summarized in Table. A significant variation in dye uptake was observed at each 2-hour interval among the treatments. The uptake ranged from 1.96 to 1.10 g/spike, with an average of 1.66 g/spike. The highest uptake (1.96 g/spike) was noted in 7% blue (T4), which was at par with 7% tomato red (T8) (1.85 g/spike), 7% apple green (T12) (1.85g/spike. The lowest uptake (1.10 g/spike) was recorded in 4% apple green (T9). After four hours of immersion, the dye solution uptake by tuberose spikes was recorded and is presented in Table 4.1.2. The uptake ranged from 3.67 to 1.68 g/spike, with an average of 2.90 g/spike. The highest uptake (3.67 g/spike) was observed in 7% blue (T4), which was at par with 7% tomato red (T8) (3.53 g/spike), while the lowest uptake (1.68 g/spike) was recorded in 4% apple green (T9). At the end of six hours, the dye uptake ranged from 3.20 to 4.95 g/spike, with a mean value of 3.75 g/spike. The maximum uptake (4.95 g/spike) was again recorded in 7% blue (T4), which was at par with 7% tomato red (T8) (4.85 g/spike), 7% apple green (T12) (4.84 g/spike). The minimum uptake (3.20g/spike) was observed in 4% apple green (T9). Sambandhamurthy and Appavu (1980) [17] say that increase in colour shade intensity with increase in concentration of colours.

Floret size (cm)

The data presented in Table 4.1.3. clearly indicate that floret size varied significantly, ranging from 3.75cm to 2.42 cm with a mean value of 3.06 cm. The maximum floret diameter (3.75cm) was observed in 7% blue (T4), while the minimum (2.36 cm) was recorded in 4% control (T0). Floret size is also influenced by bulb diameter, and variations may be attributed to higher water uptake (Seyfeena *et al*., 2012). Spikes harvested at the tight bud stage (1-2 basal florets showing color) likely had sufficient sucrose availability, which may have supported enhanced respiration necessary for cell division, cell expansion, and the supply of carbon skeletons for tissue development. This ultimately contributed to greater floret expansion and increased size through the formation of cell constituents (Singh *et al*., 2005) [16]. Comparable findings have also been reported by Mahesh *et al*. (2011) [10] and Kumar *et al*. (2015) [7] in gladiolus.

Initial weight of the spike (g)

The analyzed data on the initial weight of spikes across different dyes are presented in Table 1.3. Significant variations were observed, ranging from 22.09g to 40.80 g, with an average of 30.77g. The highest initial spike weight (40.80 g) was recorded in 7% blue (T4), after that 7% tomato red (T8) (36.53g) and 7% apple green (T12) (36.53g). The lowest spike weight (22.09 g) was observed in the control (T0). The variation in spike weight may be attributed to factors such as the number of spikes produced per plant, the number and size of leaves, as well as environmental conditions like average temperature and photoperiod prevailing during spike development. Similar findings on initial spike weight in tuberose have been reported by Gaurav *et al*. (2005) [4], Mahawer *et al*. (2008, 2013) [8, 11], and Sarita *et al*. (2017) [14].

Percent increase in fresh weight after tinting

The data on percent increase in fresh weight after tinting, presented in Table 1.4. revealed significant variation among different dyes. The values ranged from 0.96% to 2.9%, with an average of 1.95%. The highest increase in fresh weight was observed in 7% blue (2.9%), after that 7% tomato red (T8) (2.8%) and 7% apple green (T12) (2.6%). In contrast, the lowest increase was noted in 4% apple green (T5) (1.0%). Probable reason for variation in the percent of increase in fresh weight might be due to increase in uptake of dye solution with a time of immersion. (Kumar *et al*. 2015) [7].

Vase life parameters

Days for opening of florets (25%,50%,75%)

The number of days taken for opening of 25% florets was recorded (Table 4.2.1.). A significant variation was observed, ranging from 1.50 to 4.07 days with a mean of 2.78 days. The earliest opening of 25% florets (1.50 days) occurred in the control, while the maximum duration (4.07 days) was recorded in 7% apple green. This was statistically at par with 7% blue and 6% apple green (3.85 days), 6% Blue (3.62 days), 7% tomato red (3.46 days), 4% blue (3.30 day). Similarly, significant differences were also recorded for the opening of 50% florets (Table 4.2.1.). The days required for 50% floret opening ranged from 4.70 to 5.70 days, with a mean of 5.2 days. Among the treatments, 4% blue showed the earliest 50% floret opening (4.00days), while the maximum delay was observed in 7% Apple Green (5.60 days). Similarly, significant differences were also recorded for the opening of 75% florets (Table 4.2.1.). The days required for 75% floret opening ranged from 4.14 to 5.56 days, with a mean of 4.85 days. Among the treatments, 6% blue showed the earliest 75% floret opening (4.14 days), while the maximum delay was observed in 7% Apple Green (5.56 days). The variation in the percentage of bud opening can be attributed to the physiological maturity of the spikes and their substantial carbohydrate requirement (Awadhesh and Bhagawan, 2013) [2]. This trend may be explained by the fact that florets were already in the process of opening at the time of harvest, and the progression continued without interruption as the required carbohydrates were already mobilized and utilized. Similar findings were reported by Bakhsh *et al*. (1999) [3] in tuberose.

Vase life (days)

The data on the average vase life of tinted tuberose spikes are presented in Table 4.10. A detailed examination of the results revealed significant variation among the edible dyes. The vase life ranged from 5.45 to 8.87 days, with an average of 7.16 days. The longest vase life (8.87 days) was recorded in the control (T0), which was statistically at par with 4% apple green (T9) (8.76 days), 4% tomato red (T5) (7.64 days), and 4% blue (T2) (7.45%). In contrast, the shortest vase life (5.45 days) was observed in 7% blue (T4), 7% tomato red (T8) (5.92) and 7% apple green (T12) (5.97). An increase in dye concentration led to a reduction in vase life of tinted flowers. This decline in vase life may be attributed to accelerated ion leakage (Singh *et al*., 2005) [16].

Water uptake

The amount of water absorbed by the spikes at the end of vase life was documented in Table. It varied from 37.77 to 87.50 g/spike, with an average of 62.63 g/spike. The maximum uptake (87.50 g/spike) was observed in the 7%blue. The lowest uptake (37.77g/spike) was recorded in control. When flowers are detached from the plant, they continue to lose water through transpiration. The most effective flower preservative is one that facilitates water absorption into the flower tissues (Salunkhe *et al*., 1990) [18]. Absorption of water from the preservative solution helps maintain proper water balance, keeps the flowers fresh and delays early wilting, thereby extending vase life. According to Waithaka *et al*. (2001) [19], turgidity in plants and flowers depends on the balance between water absorption and water loss. In cut flowers, water loss from tissues is influenced by environmental conditions, and immediately after cutting, stomatal closure causes a sharp reduction in water loss. Floret wilting occurs mainly due to depletion of stored food and the inability of the flower to uptake sufficient water, which eventually results in colour fading and cell flaccidity (Ichimura *et al*., 2002) [6].

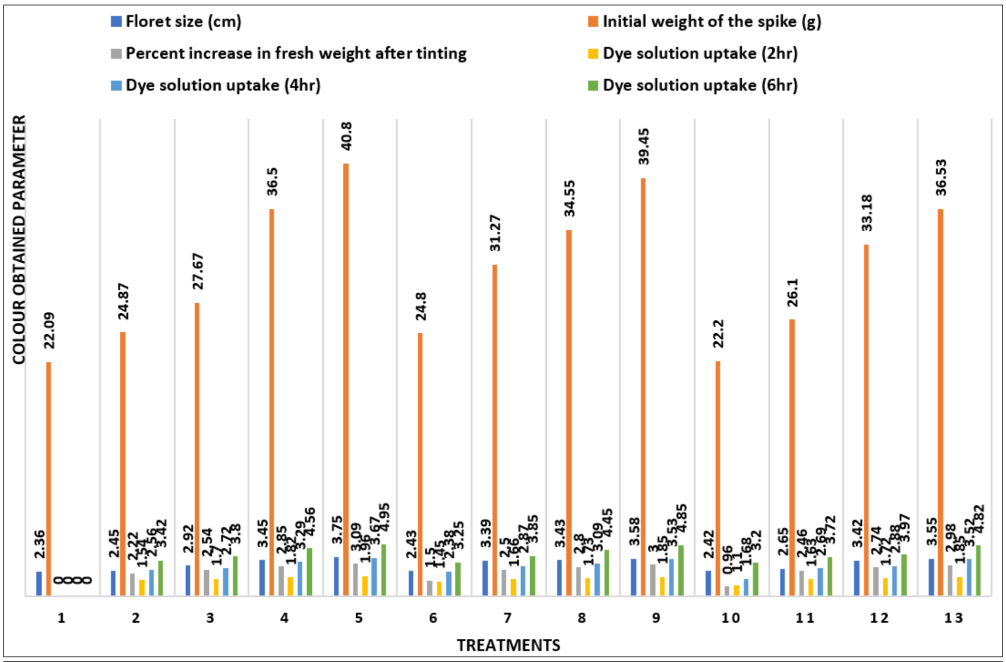
Transpiration loss of water (g/spike)

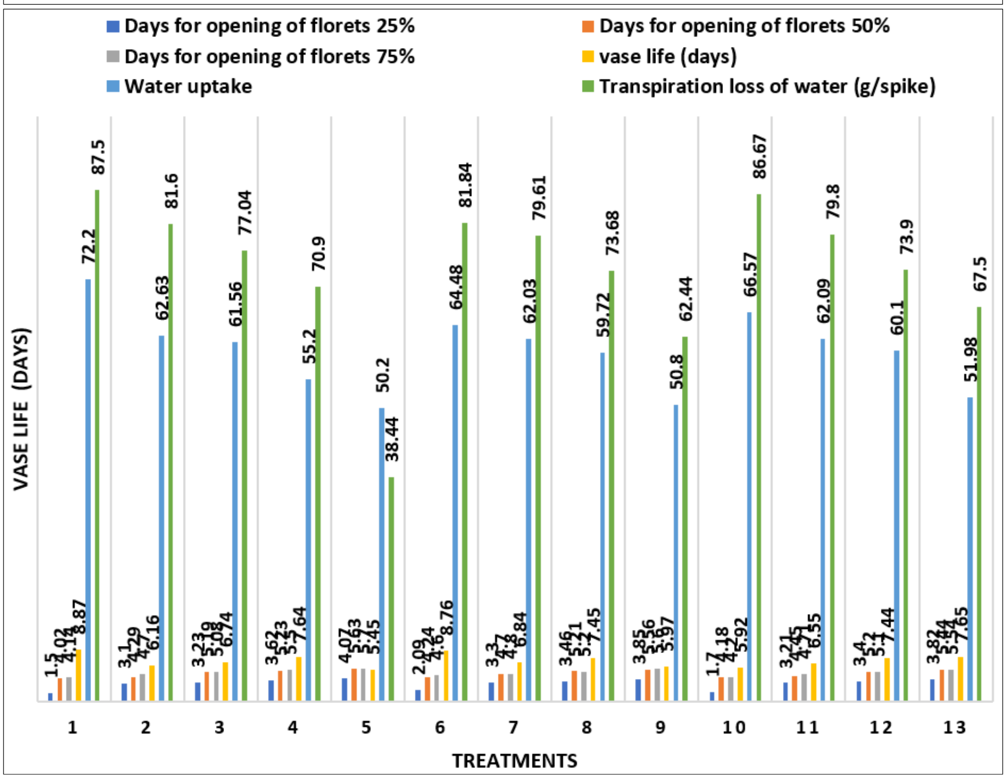
The analyzed data on transpiration loss of water are presented in Table 4.2.5. A significant variation in water loss through transpiration was observed across different dyes, ranging from 38.44 to 87.5 g/spike, with an average of 73.91 g/spike. Among the treatments, the minimum transpiration loss (38.44 g/spike) was recorded in the 7% blue, followed by 62.44 g/spike in spikes with 4% apple green edible dye. The maximum transpiration loss (87.5 g/spike) was observed in spikes treated with 5% Tomato Red dye solution, which was statistically at par with 86.67 g/spike recorded in spikes treated with 5% apple green dye. This variation in transpiration loss could be attributed to the fact that a major portion of the absorbed water is utilized by the spike to maintain cell turgidity, thereby prolonging vase life. These findings are in agreement with the results reported by Kumar *et al*. (2005) in tuberose.

Colour obtained parameter						
Treatment	Floret size (cm)	Initial weight of the spike (g)	Percent increase in fresh weight after tinting	Dye solution uptake		
				Dye solution uptake (2hr)	Dye solution uptake (4hr)	Dye solution uptake (6hr)
T0	2.36	22.09	00	00	00	00
T1	2.45	24.87	2.22	1.54	2.56	3.42
T2	2.92	27.67	2.54	1.70	2.72	3.80
T3	3.45	36.50	2.85	1.82	3.29	4.56
T4	3.75	40.80	3.09	1.96	3.67	4.95
T5	2.43	24.8	1.50	1.45	2.38	3.25
T6	3.39	31.27	2.50	1.66	2.87	3.85
T7	3.43	34.55	2.80	1.73	3.09	4.45
T8	3.58	39.45	3.00	1.85	3.53	4.85
T9	2.42	22.2	0.96	1.10	1.68	3.20
T10	2.65	26.10	2.46	1.63	2.69	3.72
T11	3.42	33.18	2.74	1.72	2.88	3.97
T12	3.55	36.53	2.98	1.85	3.52	4.82
SEm	0.03	0.04	0.04	0.046	0.05	0.083
CD	0.11	0.13	0.13	0.06	0.16	0.243

Vase life (days) parameter						
Treatment	Days for opening of florets (25%, 50%, 75%)			Vase life (days)	Water uptake	Transpiration loss of water (g/spike)
	Days for opening of florets 25%	Days for opening of florets 50%	Days for opening of florets 75%			
T0	1.50	4.02	4.14	8.87	72.20	87.50
T1	3.10	4.29	4.70	6.16	62.63	81.60
T2	3.23	5.19	5.08	6.74	61.56	77.04
T3	3.62	5.23	5.50	7.64	55.20	70.90

T4	4.07	5.63	5.70	5.45	50.20	38.44
T5	2.09	4.24	4.60	8.76	64.48	81.84
T6	3.30	4.70	4.80	6.84	62.03	79.61
T7	3.46	5.21	5.20	7.45	59.72	73.68
T8	3.85	5.56	5.60	5.97	50.80	62.44
T9	1.70	4.18	4.20	5.92	66.57	86.67
T10	3.21	4.45	4.71	6.55	62.09	79.80
T11	3.40	5.20	5.10	7.44	6010	73.90
T12	3.82	5.44	5.54	7.65	51.98	67.50
SEm	0.048	0.037	0.042	0.17	1.41	1.58
CD	0.141	0.107	0.121	0.51	4.13	4.63





Conclusion

The study indicated that spikes tinted at the 2-4 bud flowering stage with the food dye Blue were most preferred by consumers. While the 7% dye showed superior colour absorption and intensity compared to the 4% dye, the 4% concentration was found to be more effective in extending vase life.

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