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Effect of modified atmosphere packaging and storage duration on keeping quality of gladiolus spikes

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ABSTRACT

Gladiolus has elegant spikes with bright florets and good keeping quality. The storage of spikes during production period will be beneficial for the farmers during low production period. Thus, the present study was planned to investigate the effect of long term modified atmosphere storage on gladiolus spikes. The spikes of gladiolus cv. Alexander the Great, harvested at tight bud stage, were treated with sucrose (20%) + aluminum sulphate (300 ppm) for 20 h followed by sealing in LDPE and PP sleeves (25 µm) with and without perforations and stored vertically at 3-4°C for 0, 6, 12 and 18 days. After storage, vase-life was evaluated. The basal florets opened in all sleeves after 18 days of storage. Increase in storage duration hastened the opening of basal florets, whereas packaging did not affect significantly. Vase-life, opening of florets (%), floret diameter and physiological weight declined with increase in storage duration.

Key words: Gladiolus, modified atmosphere packaging, storage life, vase-life.

INTRODUCTION

Commercial floriculture is an emerging profitable agro industry in the world (Ezilmathi *et al.*, 2). The cut flowers like gladiolus, tuberose, chrysanthemum, rose *etc*. have a great demand in both local and international markets. However, the constraints faced by the growers are decrease in cut flowers' quality from harvesting to marketing and short vase-life. The storage and packaging systems play a pivotal role not only in preservation of keeping quality of flowers but also in regulation of supply of flowers in the markets for better remunerative prices. At lower temperatures, flowers have low respiration rate and other metabolic activities that provide time for proper handling, packaging and marketing (Farazi *et al.*, 3). Dry refrigerated storage or modified atmosphere (MA) storage in which flowers are packed in water retentive plastic films and stored at low temperature, holds most promising post harvest management device for transportation and long duration storage of flowers (Zelter *et al.*, 14). The key to successful passive MAP of fresh flowers is to use film of suitable permeability to gases like CO_2, O_2, water vapour *etc.* so as to ensure and establish the optimal equilibrium Modified Atmosphere (EMA) at low temperature during storage (Day, 1).

Gladiolus is known as the 'Queen of bulbous flowers' due to its spikes with florets of massive form, brilliant colours, attractive shapes, varying size and excellent shelf-life. An appropriate storage technique for gladiolus spikes is required during the periods of over production to sustain the supply of spikes during decline in production. It is immensely important to determine the optimum storage duration of cut flowers that keeps the quality and potential vase-life at its best. The research work done on storage of gladiolus is meagre. However, some reports on the technique of MAP at low temperature contributing to good flower quality during storage (Grover *et al.*, 4) and shipment (Zelter *et al.*, 14) have been documented.

Thus, keeping in view constraints in cut flower marketing and importance of gladiolus among different cut flowers, the present experiment was conducted.

MATERIALS AND METHODS

The plants of gladiolus cultivar, *viz.*, Alexander the Great were raised in the field area of the Department of Floriculture and Landscaping, PAU, Ludhiana from the uniform-sized corms (3.5-4.0 cm dia) following all recommended agronomical practices to raise the healthy crop. The spikes were harvested at tight bud stage (when 1-2 basal florets showed colour) to study the effect of long term modified atmosphere storage on post harvest quality of gladiolus spikes. The harvested spikes were pre-cooled at 4°C for 6 h and subjected to pre-storage treatments with sucrose (20%) + aluminum sulphate (300 ppm) for 20 h. After pre-storage treatment, the spikes were sealed in Low Density Polyethylene (LDPE) and Polypropylene (PP) sleeves of 25 µ thickness with and without perforations and stored vertically in cold room at 3-4°C temperature for 0, 6, 12 and 18 days. The freshly-harvested spikes served as control. Thus,

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there were 5 packaging treatments that included PP (with perforations), PP (without perforations), LDPE ((with perforations), LDPE (without perforations) and unsealed/ unwrapped spikes; and four storage treatments that included 0, 6, 12 and 18 days. After storage, the stems were placed in plain water for evaluation of keeping quality. The observations recorded were number and days to the opening of basal floret, vase-life, opening of florets (%), floret size, loss in weight (%) and membrane stability index (Grover *et al.*, 6).

Data were subjected to statistical analysis to calculate critical difference by using analysis of variance (ANOVA) for completely randomised block design (Khaderand and Saltveit, 7).

RESULTS AND DISCUSSION

The results pertaining to number of florets opened during storage revealed that after 6 days of storage, no floret showed opening, whereas 1-2 florets were half and fully opened, respectively, after 12 and 18 days of storage in all packaging treatments (Table 1). The freshly harvested spikes (without storage) took 3.22 days to opening of basal florets whereas increase in storage duration from 6 to 12 to 18 days declined the days to opening of basal florets respectively from 1.78 to 1.07 to 0.65 days. The days taken to opening of basal florets were at par in different packaging treatments (Table 1). The florets exhibited decreased metabolic activity during MA storage, which did not enable the florets to expand (Sharma *et al.*, 8). The delayed floret opening during MA storage is advantageous because spikes with unopened florets can be easily transported as such buds are less prone to damage during transport.

The vase-life of freshly harvested spikes was found to be highest (8 days), whereas vase-life declined in all other treatments (Table 2). The decline in vase-life was 14% after 6 days of storage whereas the corresponding values were 29 and 35% respectively after 12 and 18 days of storage in comparison to control. The mean vase-life of spikes stored without packaging was 5.31 days which was at par with packaging in LDPE {(with perforations) mean vase life of 5.57 days}. The significant difference was observed between mean vase-life of control and LDPE (without perforations) and PP packaging. The mean vase-life of spikes packed in PP with perforations and without perforations was at *par*. The precise mechanism for storage-induced decline in vase-life is not yet fully understood but increased sensitivity to ethylene and loss of membrane permeability after storage could be some of the causes, which have been reported to shorten post-storage vase-life of flowers (Singh *et al.*, 9).

The storage duration significantly declined the per cent opening of florets in all packaging treatments (Fig. 1). The mean per cent of florets that opened declined from 76.5 to 66.32 to 60.48 to 46.82, respectively, when storage duration increased from 0 to 6 to 12 to 18 days. This might be due to the fact that the spikes of gladiolus cut at tight bud stage contain high starch content but low levels of soluble sugars and hence, the upper florets fail to expand which lead to low percentage of floret opening (Singh *et al.*, 10). Physiological processes involved in reduction in floral bud opening might be due to increase in respiration rate during storage, decline in content of soluble sugars, increased sensitivity to ethylene and production of toxic metabolites during storage that contribute to poor post storage opening of the buds

Table 1. Effect of storage and packaging on number of florets open during storage and days to opening of basal floret of gladiolus spikes.

Packaging material (B)	No. of florets open in storage			Days to opening of basal floret			
	Storage duration (days, A)			Storage duration (days)			
	6	12	18	6	12	18	Mean
LDPE (with perforations)	No floret show opening	Basal floret half open	1-2 florets fully open	1.78	1.22	0.56	1.19
LDPE (without perforations)	-do-	-do-	-do-	2.00	0.89	0.44	1.11
PP (with perforations)	-do-	-do-	-do-	1.67	1.11	0.67	1.15
PP (without perforations)	-do-	-do-	-do-	1.44	1.00	0.67	1.04
Control	-do-	-do-	-do-	2.00	1.11	0.89	1.33
Mean	-	-	-	1.78	1.07	0.65	
	-	-	-	Control (0 day storage) = 3.22			
$CD_{0.05}$				CD (5%) A = 0.31; B = NS; A × B = NS			

Table 2. Effect of storage and packaging on vase-life (days) and floret size (cm) of gladiolus spikes.

Packaging material (B)	Vase-life (days)				Diameter of second floret (cm)			
	Storage duration (days, A)				Storage duration (days)			
	6	12	18	Mean	6	12	18	Mean
LDPE (with perforations)	6.31	5.53	4.86	5.57	8.47	7.67	6.91	7.68
LDPE (without perforations)	6.97	5.42	5.30	5.90	8.67	7.81	7.94	8.14
PP (with perforations)	7.19	6.19	5.64	6.34	8.37	7.61	6.87	7.62
PP (without perforations)	7.53	5.97	5.54	6.35	7.94	7.71	7.71	7.79
Control	6.08	5.19	4.64	5.31	8.04	7.61	6.54	7.40
Mean	6.82	5.66	5.20		8.30	7.68	7.19	
	Control (0 day storage) = 8.00				Control (0 day storage) = 8.98			
$CD_{0.05}$	A = 0.34; B = 0.44; A × B = NS				A = 0.25; B = NS; A × B = NS			

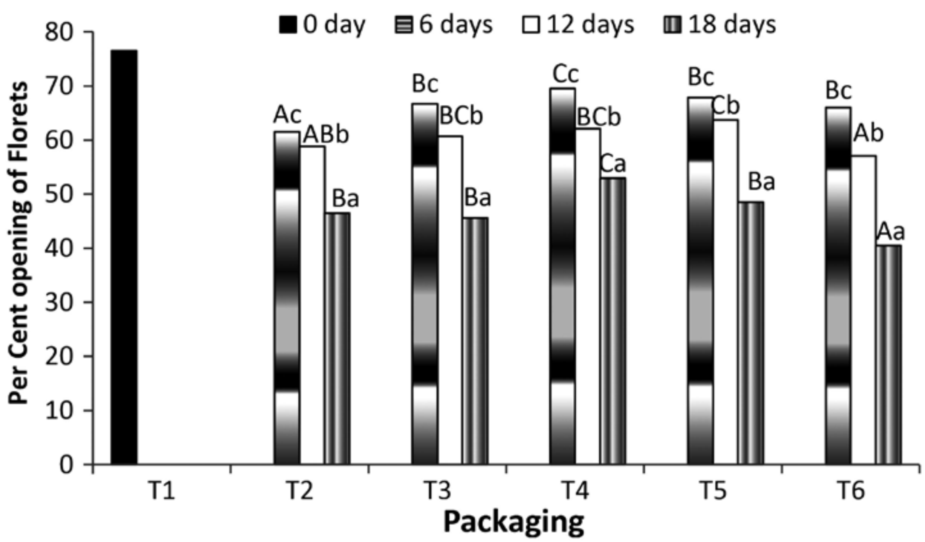

Fig. 1. Effect of storage and packaging on per cent opening of florets of gladiolus spikes. T1 = without packaging and storage; T2 = LDPE (with perforations); T3 = LDPE (without perforations); T4 = PP (with perforations); T5 = PP (without perforations); T6 = stored without packaging. **Different lower case letters indicate statistically significant differences between storage durations for the same packaging treatment, whereas different upper case letters indicate significant differences between packaging treatments for the same storage duration.

(Singh *et al.*, 11). The packaging material significantly influenced the per cent opening of florets. The both PP packaging have significantly higher per cent of opened florets in comparison to LDPE packaging and unpacked spikes. The higher number of floret opening in packed spikes could be attributed to turgidity of the spikes on account of higher water uptake and optimum cell metabolism with sustainable levels of carbohydrates in florets (Singh *et al.*, 12).

Floret size showed significant decrease with increase in storage duration (Table 2). The highest diameter of floret was recorded for freshly harvested spike (8.98 cm), which decreased by 8 per cent after 6 day storage, 14 and 20 per cent, respectively as storage duration increased to 12 and 18 days. The floret size of unpacked spikes was least in all storage treatments but the effect of packaging in all polymeric sleeves was found to be non significant.

The per cent weight loss by the spikes showed increase with increase in the storage duration (Fig. 2). The weight loss was least after 6 day of storage and reached the maximum value after 18 day of storage. Among the packaging treatments, the weight lost after storage by unpacked spikes was highest (7.95%). The packaging treatments significantly improved the retention of weight of spikes during storage as indicated by decreased per cent of weight loss in all packaging treatments. The longer the periods

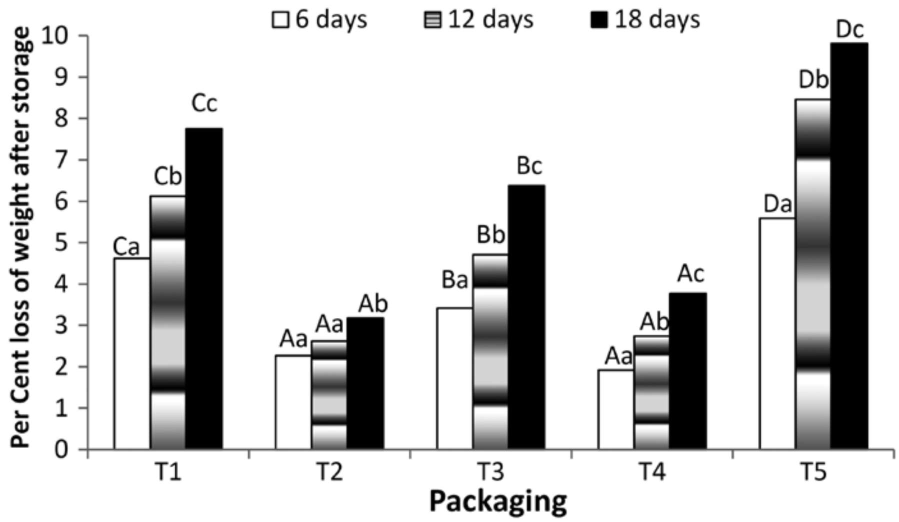

Fig. 2. Effect of storage and packaging on per cent loss of weight after storage of gladiolus spikes.

*T1 = LDPE (with perforations); T2 = LDPE (without perforations); T3 = PP (with perforations); T4 = PP(without perforations); T5 = stored without packaging
**Different lower case letters indicate statistically significant differences between storage durations for the same packaging treatment whereas different upper case letters indicate significant differences between packaging treatments for the same storage duration.

of storage of spikes more is the depletion of stored water and food. Hence, cut stems stored for longer periods with reduced amount of energy resulted in loss of weight and florets of smaller diameter and shorter vase-life as compared to those stored for short durations. Both polymeric sleeves (LDPE & PP without perforations) significantly retained higher weight after storage than other treatments. The reduced loss of weight of spikes packed in sleeves (Fig. 2) might be due to the reason that packaging prevented the water loss and maintained high relative humidity, which helped in reducing weight loss from cut stem 3).

Tepals excised from florets of freshly harvested spikes exhibited higher MSI (80.54). MSI decreased with increase in the storage duration and was 69.43, 60.72 and 45.85 after 6, 12 and 18 days of storage, respectively (Table 3). The loss of membrane integrity during storage could further explain the decrease in the ability of florets to open, decreased vase-life and loss of floret opening after storage. MSI of tepals of unpacked spikes after all storage durations exhibited significantly higher decline in comparison to packaging in polymeric sleeves, but different packaging treatments were at par in terms of maintaining membrane integrity. The maintained MSI of tepals stored under MA using PP and LDPE was a result of minimal damage during cold storage as attributed from per cent weight loss (Fig. 2). This further supports our findings of improved vase life of spikes packed in different sleeves. The membrane

Table 3. Effect of storage and packaging on Membrane Stability Index (MSI) on tepals of gladiolus spikes.

Packaging material (B)	Storage duration (days)			
	6	12	18	Mean
LDPE (with perforations)	72.24	68.43	45.52	62.06
LDPE (without perforations)	75.78	66.21	46.81	62.93
PP (with perforations)	68.37	58.22	48.05	58.21
PP (without perforations)	70.98	59.34	49.23	59.85
Control	59.78	51.42	39.63	50.28
Mean	69.43	60.72	45.85	
	Control (0 day storage) = 80.54			
$CD_{0.05}$	A = 4.86; B = NS; A × B = NS			

deterioration in unpacked spikes during storage as revealed by lower value of MSI (Table 2) could be explained by lipid peroxidation in cut flowers (Zeltzer *et al.*, 14).

The spikes packed in PP sleeves exhibited longer vase life followed by LDPE sleeves as compared to unwrapped ones (Table 2). This might be due to the fact that this wrapping material modifies internal atmosphere with high CO_2, low O_2 and high relative humidity within the package as a consequence of product's respiration and low permeability of films to gas, which further minimizes the respirational loss of carbohydrates as well as transpirational loss of water and helps in retaining its fresh weight. This condition in turn reduces depletion of stored food and helped to supply adequate energy to the florets for successful opening and to be larger in diameter (Zencirkiranm and Menguc, 15). This is in concomitant with our findings where florets packed in sleeves have higher diameter than unpacked spikes (Table 2).

The differential behaviour of different sleeves as depicted by different parameters, *viz.* number of florets opening, days to basal floret opening, vase life, per cent opening of florets, loss in weight, MSI etc. could be explained on the basis of differential permeability of sleeves to different gases and storage temperature that influence the processes of respiration and transpiration and ultimately quality in gladiolus (Singh *et al.*, 10; Tripathi and Tuteja, 13; Zencirkiranm and Menguc, 15).

Thus, the gladiolus spikes stored for 18 days after MAP exhibited good post-harvest keeping quality and indicated that through packaging some loss of spikes during peak flowering seasons could be reduced.

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