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EFFECT OF PASSIVE HYPOBARIC PRESSURE ON STORAGE OF GLADIOLUS SPIKES

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SUMMARY

The spikes of gladiolus cv. White Prosperity were stored under sub atmospheric pressure (368.3 mm of Hg) in two polymeric film packages viz. High Density Polyethylene (HDPE) and Polypropylene (PP) of 100 gauge (25 μ) thickness. PP film maintained high levels of CO_2 and low levels of O_2 inside the packages throughout the storage period. The accumulation of CO_2 in the HDPE packages was very low. HDPE packages also accumulated very high percentage of O_2 i.e. near the atmospheric level. PP film packages retarded per cent loss of weight of the spikes and opening of florets in storage but increased post storage floret opening and vase life of the spikes. Florets in PP film packages also retained high starch and low soluble sugar contents in the tepals

***Key words*: CO_2, gladiolus, O_2, storage, sub atmospheric pressure**

INTRODUCTION

Storage of cut flowers is an important component of their post harvest handling. It not only aids in regulating marketing during periods of overproduction but can also be useful for long term shipment of flowers (Goszczynska and Rudnicki 1988). Storage conditions of flowers vary with the species (Goszczynska and Rudnicki 1988, Nowak and Rudnicki 1990, Singh *et al.* 2001). Prolonged storage of flowers under dry refrigerated conditions can be useful over the wet storage because in the former case, flowers show very low metabolic rate (Hardenburg *et al*. 1969, Goszczynska and Rudnicki 1988) and occupy less space during storage as well as in transport. Grover (2001) reported that post storage life of flowers depends upon the gaseous permeability properties of the polymeric film packages in which the flowers have been previously dry-stored. The films which tend to maintain elevated levels of CO_2 and low levels of O_2 inside the packages, are considered suitable for modified atmosphere storage of flowers (Halevy and Mayak 1981, Goszczynska and Rudnicki 1988, Grover 2001).

Some previous workers have suggested the utility of low pressure storage of cut flowers (Burg 1973, Halevy and Mayak 1981, Nowak and Rudnicki 1990, Singh *et al.* 2001). However, the maintenance of suitable low pressure conditions for storage requires considerable infrastructure and is also cost intensive. The present investigations were undertaken with an objective to evaluate the effect of polymeric film sleeves on storage of gladiolus spikes under initial low pressure and to study the passive modification of the storage atmosphere with respect to CO_2 and O_2 concentrations inside the packages.

MATERIALS AND METHODS

Ninety cm long spikes of gladiolus cv. White Prosperity were harvested from the field-grown crop, at tight bud stage (when basal 1-2 florets had shown colour). The spikes were immediately put in buckets containing

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water, pre-cooled at 4±0.5^{O}C for 6 hours and cut to a uniform length of 75 cm. The spikes were then grouped into bundles of 3 each, loosely tied at the base with rubber band and inserted in two polymeric film sleeves viz., High Density Polyethylene (HDPE), and Polypropylene (PP) of 100 gauge (25 μ) thickness. The film sleeves were hermetically sealed from both the sides using electronic polythene-sealing machine. The packages of all the films had an identical size of 80 x 10 cm^2 with an effective area of 1600 cm^2 for gaseous diffusion and water vapour transmission. The void volume inside the packages was measured by placing three uniformly selected spikes in the package and then filling the same with water. Volume of water was referred to as void volume and was kept constant i.e. 2320±20 cc (an average of 10 packages). The air inside the package was removed to a partial pressure of 368.3 mm of Hg using vacuum pump. The packages were stored in vertical position in a cool chamber (4±0.5^{O}C; 90-95 % R.H.) for 3, 6, 9, 12, 15 and 18 days. The spikes were weighed both before and after the storage for determining per cent decrease in fresh weight. The concentrations of CO_2 and O_2 inside the polymeric film packages were measured after 3, 6, 9, 12, 15 and 18 days of storage using Nucon 7500 gas chromatograph (GC) equipped with thermal conductivity detector. The GC column equipped with molecular sieve-5A was used for measuring O_2 concentration whereas that packed with Porapak-Q was used for measuring CO_2 concentration. Argon was used as a carrier gas. The retention time and area of each constituent gas was determined with the help of a computer equipped with software in oracle and compared with the reference standards. Atmospheric levels of CO_2 and O_2 were also measured in the laboratory and have been referred to as control.

After storage, basal 2 cm portions of the spikes were recut under water to remove surface blockages. The spikes were put in cylindrical vases of glass containing distilled water and placed in an air-conditioned laboratory at 23±2^{O}C temperature, 60-70% R.H and 16 h illumination (1000 lux intensity) provided by 40 W white fluorescent tubes. Observations were recorded for number of florets that opened during storage as well as per cent opening of florets on the spike when these were placed in vases after storage. Freshly harvested spikes served as control.

Starch and total soluble sugar contents in the tepals were analyzed after 6, 12 and 18 days of storage in the polymeric film packages, according to the methods of McCredy *et al.* (1950) and Dubois *et al.* (1956), respectively. The contents were also analyzed in the tepals of freshly-harvested spikes and served as control. The data presented are a mean of there replications each representing three spikes. The data were analysed by the least significant differences test (LSD) using complete randomized design.

RESULTS AND DISCUSSION

Change in CO_2 and O_2 levels: Table 1 shows that CO_2 concentration was higher in PP film packages (6.48 per cent) than in HDPE packages (1.41 per cent). The levels of CO_2 also remained higher in PP film packages than in the HDPE packages throughout the duration of storage. Higher levels of CO_2 in PP packages were apparently due to its release during respiration where as low levels in the HDPE film packages could be ascribed to its higher efflux into the outer atmosphere. Both HDPE and PP films are reported to vary in permeability for CO_2 and O_2 The permeability of HDPE for CO_2 and O_2 is reported to be 2300 and 390-1750 $\mu m/m^2/KPa$, respectively, where as for PP film the values are 2100 and 622, respectively (Kenneth 1998)

PP film packages also showed accumulation of the low concentration of O_2 (5.59 per cent) as compared to HDPE packages (19.17 per cent). In the latter packages, the concentration of O_2 remained near the atmospheric level throughout the storage duration. In contrast, in PP film packages, the level remained very low. Low O_2 levels in this film package were apparently due to its low influx from the outer atmosphere. The content remained statistically the same after 3, 6, 9 and 12 days of storage but showed further decrease after 15 and 18 days in storage. It may be mentioned that the florets exhibited expansion between 12 to 18 days of storage. The decrease in levels of O_2 in PP packages after 15 and 18 days of storage, hence, could be ascribed to increase in respiratory activity, required for expansion of florets. High CO_2 and low O_2 levels have been considered suitable for storage of flowers as these conditions decrease the rate of respiration and destructive oxidative processes and also alleviate damaging effects

Table 1. CO_2 and O_2 concentrations (%) in packages of different polymeric films during storage of gladiolus spikes

Storage Duration (days)	CO_2 concentration			O_2 concentration		
	HDPE	PP	Mean	HDPE	PP	Mean
3	1.41	6.18	3.80	16.78	5.43	11.11
6	1.97	6.89	4.43	18.76	5.22	11.99
9	2.24	7.32	4.78	19.02	8.75	13.89
12	1.11	6.42	3.77	19.94	8.27	14.11
15	1.18	6.34	3.76	19.89	2.98	11.44
18	0.57	5.75	3.16	20.62	2.89	11.76
Mean	1.41	6.48		19.17	5.59	
Control	0.03±0.001 (±SE mean of three replications)			20.99±0.01 (±SE mean of three replications)		
LSD (P=0.05)	Polymeric films (A)=0.25; Storage duration (B)=0.43; AxB=NS			Polymeric films (A)=0.47; Storage duration (B)=0.82; A x B = 1.16		

of ethylene (Halevy and Mayak 1981, Goszczynska and Rudnicki 1988, Singh *et .al.* 2001).

Per cent decrease in fresh weight of spikes and number of florets opening in storage: Per cent decrease in fresh weight of spikes remained very low throughout the duration of storage in both the polymeric film packages (Table 2). It, however, continued to increase with increase in storage duration and was maximum (1.25 per cent) after 18 days of storage. The increase in loss of weight during storage could mainly be due to loss of water through transpiration and depletion of substrates during respiration. Interestingly, per cent weight loss was high (0.95) in HDPE packages and was low in PP packages (0.55). HDPE film packages, which exhibited more loss of weight of spikes, also retained higher levels of O_2 and the lower levels of CO_2 than PP packages. High levels of CO_2 are also known to favour stomatal opening and hence, stimulate water loss (Srivastava and Kumar 1995).

The florets on the spikes exhibited opening only after 12 days of storage (Table 2). Less number of florets was observed to open during storage in PP packages (0.24)

Table 2. Per cent decrease in fresh weight of spikes and number of florets opened in different polymeric film packages during storage of gladiolus spikes

Storage Duration (days)	Per cent decrease in fresh weight			Number of florets opened in storage		
	HDPE	PP	Mean	HDPE	PP	Mean
3	0.31	0.22	0.27	0.00	0.00	0.00
6	0.73	0.47	0.60	0.00	0.00	0.00
9	0.92	0.51	0.72	0.00	0.00	0.00
12	1.03	0.53	0.78	0.56	0.33	0.45
15	1.16	0.64	0.90	1.22	0.45	0.84
18	1.55	0.95	1.25	2.56	0.67	1.62
Mean	0.95	0.55		0.72	0.24	0.48
LSD (P=0.05)	Polymeric films (A)=0.84; Storage duration (B)=0.15; A x B = 0.21			Polymeric films (A)=0.23; Storage duration (B)=0.40; AxB=0.56		

than in HDPE packages (0.72). The increase in the extent of floret opening in HDPE film packages was apparently due to high levels of O_2 and low level of CO_2 in these packages, which favoured high respiratory activity of the spikes (Halevy and Mayak 1981, Goszczynska and Rudnicki 1988, Singh *et al*. 2001). Opening of florets inside the packages during storage is, however, not desired because open florets are highly prone to damage during post storage handling, especially during transport. Therefore, PP film packages which showed less expansion of florets during storage, are more suitable for the storage of spikes.

Per cent opening of florets after storage: The post storage per cent opening of florets was significantly higher in case of spikes stored in PP packages (44.03) than those stored in HDPE packages (33.59) (Table 3). The tendency of florets to open also showed continuous decline with increase in storage duration and was minimum after 18 days of storage (27.15). The decline in the ability of flower buds to open after storage has also been reported earlier (Goszczynska and Rudnicki 1988, Nowak and Rudnicki 1990, Grover 2001) and has been ascribed to the loss of membrane phospholipids and increase in membrane microviscosity leading to loss of membrane permeability, increased sensitivity to ethylene, decline in content of soluble proteins, accumulation of toxic metabolites such as acetaldehyde, ethanol and ammonia in the flower tissue and other unknown physiological factors (Paulin 1973, Shinitzky and Henkart 1979, Halevy and Mayak 1981, Quinn 1981, Faragher *et al*.1984, 1986, Paulin *et al*. 1985).

Table 3. Per cent opening of florets of gladiolus spikes after storage in different polymeric films packages

Storage duration (days)	Per cent florets opened after storage		
	HDPE	PP	Mean
3	54.06	55.93	55.00
6	40.23	50.57	45.40
9	31.70	45.32	38.51
12	28.68	42.71	35.70
15	25.38	36.81	31.10
18	21.47	32.83	27.15
Mean	33.59	44.03	
Control	61.10±3.15 (±SE mean of three replications)		
LSD (P=0.05)	Polymeric films (A)=1.18; Storage duration (B)=2.04; AxB=2.88		

Starch and soluble sugar contents: Table 4 presents changes in starch and soluble sugar content of tepals after different durations of storage in both the polymeric films. Freshly harvested spikes showed maximum starch content in the tepals, which decreased with increase in the duration of storage. Among the two polymeric films, higher starch content (32.43 mg g^{-1} dry weight) was observed in PP film packages, than in HDPE film sleeves (26.28 mg g^{-1} dry weight). The higher content of starch in tepals in PP film packages indicates its slow hydrolysis into soluble sugars, apparently facilitated by high CO_2 and low O_2 concentrations inside these packages. Starch content, however, continued to decrease in both the film packages, with increase in the storage duration.

Total soluble sugar content of tepals was also less in spikes stored in PP film packages than those stored in HDPE packages. Such high levels of soluble sugars in HDPE film packages indicate rapid hydrolysis of starch in this film package. It may also be mentioned that HDPE packages retained very high O_2 and low CO_2 concentrations, the conditions which are favorable for high metabolic activity, thereby, leading to hydrolysis of stored starch and expansion of florets during storage.

Increase in soluble sugars during storage indicates that the conversion of starch into sugars continued under refrigerated conditions though the rate varied with the nature of the film package. The HDPE packages in which O_2 levels tended to come in equilibrium with the outer atmosphere exhibited higher soluble sugar contents in the tepals than the PP packages. It may, however, be mentioned that in spite of high levels of soluble sugars in the HDPE packages throughout the entire duration of the storage, the florets continued to lose the ability to open after storage and the spikes in these packages showed less post storage opening of florets than those stored in PP packages.

Table 4. Starch and total soluble sugar contents (mg g^{-1} dw) in florets of gladiolus spikes after storage in different polymeric film packages

Storage Duration (days)	Starch content			Soluble sugar content		
	HDPE	PP	Mean	HDPE	PP	Mean
6	31.55	35.67	33.61	223.03	192.76	207.90
12	24.73	31.37	28.05	248.03	245.36	246.70
18	22.57	30.25	26.41	326.75	265.62	296.19
Mean	26.28	32.43		265.94	234.58	
Control	39.28±2.40 (±SE mean of three replications)			212.55±5.37 (±SE mean of three replications)		
LSD (P=0.05)	Polymeric films (A)=0.89; Storage duration (B)=1.09; AxB=1.55			Polymeric films (A)=1.40; Storage duration (B)=1.71; AxB= 2.42		

In conclusion, the present studies indicate that polypropylene film packages (100 gauge thick) are suitable for passive hypobaric storage of gladiolus spikes. These packagers maintained high CO_2 and low O_2 levels throughout the storage duration.

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