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Influence of packaging material along with wet refrigerated storage conditions on post-harvest life of cut chrysanthemum cv. Reagan White

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ABSTRACT

An experiment was carried out to investigate the effect of different packaging films comprising of LDPE (100 and 200 gauge), polypropylene, polyethylene, micro-perforated polyethylene and cellophane bags on low temperature storage of cut chrysanthemum flowers cv. Reagan White. The results obtained showed that the LDPE was most effective film in enhancing the vase-life and quality under both refrigerated wet storage and normal ambient conditions. The LDPE 100 gauge packed flower stems resulted in enhanced vase-life compared to other treatments by maintaining flower and leaf membrane stability index coupled with lower physiological loss in weight. The percent decline in total soluble sugars and reducing sugar contents in leaf and ray floret tissues was less in LDPE packaged flowers as compared to other treatments and control. The wrapped flowers stems in refrigerated wet storage after 15 days at 4°C were held in vase at ambient conditions. The maximum vase-life (12.67 days) was found with LDPE 100 gauge packaged flower stems. The higher CO_2 and lower O_2 concentrations were recorded in LDPE packed flower stems, which were attributed to prevention of oxidative stress. There was marked favourable biochemical changes in the cut flower tissue, *viz.* total soluble sugars, reducing sugar, leaf chlorophyll content, MDA content, and superoxide dismutase activity in vase under ambient conditions.

Key words: Chrysanthemum, biochemical changes, packaging materials, refrigerated wet storage, vase-life.

INTRODUCTION

Floriculture is an emerging and fast expanding market in India. In 2013-14, flowers are grown in area of 2.55 lakh ha, producing 17.54 lakh tonnes of loose flowers and 5.42 lakh tonnes of cut flowers. This large production of flowers at the same time brings glut in market, as flower is highly perishable commodity. Farmers are not getting even the actual cost of production. Sometimes, it becomes unacceptable by consumers due to its rapid deterioration in quality causing huge losses to growers. These losses to farmers or retailer can be avoided by using effective use of either of preservatives, packaging materials, storage at low temperature *etc*. The vase-life of cut flowers is highly related with the turgidity of petals and stem cells. The turgidity of flowers is dependent on the balance between continuous water utilization and its supply. Total soluble sugars and reducing sugar maintain turgidity of flowers as they are the source of carbohydrate that improves quality and facilitates of slow opening of buds. Chrysanthemum occupies the third rank in term of production after rose and marigold. Spray chrysanthemums are more popular and traded than standard. These cut flowers are normally packaged in different wrapping materials and transported. Packaging of produce in polyfilms at low temperature creates modified atmospheric conditions having high CO_2 and less O_2. Storage of chrysanthemum cut stems in different packaging materials showed increase in vase-life, limited fresh weight loss, increased carotenoids content and slow increase in malondialdehyde content and others super radicals (Datta *et al*., 3). The use of refrigerated wet storage of flowers reduces water loss, decreases in the metabolic activity of stems and bacterial growth in vase, thus improves the shelf-life for longer duration (Nowak and Rudnick, 9). The present investigation was undertaken to standardize the best packaging materials suited for refrigerated wet storage of chrysanthemum to manage glut situations.

MATERIALS AND METHODS

Experiments were carried out in the Research Farm of the Directorate of Floricultural Research, IARI, New Delhi, during 2013-2014. Chrysanthemum cv. Reagan White flowers were harvested at maturity and with stem length of 50 cm. The cut spray were packaged in different packaging materials, *i.e*. T_1 = LDPE 200 gauge, T_2 = LDPE 100 gauge, T_3 = Polypropylene, T_4 = Polyethylene, T_5 = Microperforated polyethylene, and T_6 = Cellophane. The flowers without packaging were taken as control (T_0). The five flower stems were wrapped in above mentioned materials and control were transferred in flask containing double-distilled water (500 ml) and kept at 4°C. The day of transferring

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flower stem in double-distilled water, wrapped with respective packaging materials was considered as zero day. Five stems in three replications for seven different treatments were conducted. The experiment was conducted at temp 4°-6°C and relative humidity of 65%, PPF 16/8 h of 350-400 µmol $m^{-2}s^{-1}$. A separate set of treatment combinations were kept for destructive sample analysis. Observations were recorded on 3rd, 15th, 27th, 39th upto 51st days.

In another experiment, effort was made to examine the vase-life by transferring the wrapped flowers after 15 days of storing at 4°C from refrigerator to normal ambient conditions. Here 15th day was considered as zero day. Flower stem weight was calculated on percentage basis by taking initial minus fresh weight. The water uptake by cut stem was recorded. Membrane stability index of leaf and ray florets was estimated according to Bailey *et al.* (1). The chlorophyll content of leaves were measured by DMSO method (Hiscox and Israelstam, 6), tissue total soluble solids (TSS) and reducing sugar of floret and leaf were estimated by Nelson's arsenomolydate method. Superoxide dismutase activity was estimated by monitoring the inhibition of photochemical reduction of nitro-blue tetrazolium as described by Bayer and Fridovich (2). Lipid peroxidation was determined by the thiobarbituric acid reaction as described by Heath and Packer (7). The termination of vase-life was determined as that time when pollens busted from outer part of disc florets or flower showing. The oxygen and carbon dioxide concentration in packaging material was measured using gas sensor till the symptoms of floret wilting appeared. The experiment was conducted in factorial randomized block design having seven treatments including control with single flower stem as one unit and three replications using statistical analysis system software.

RESULTS AND DISCUSSION

It was evident that all the six packaging materials extended the vase-life of chrysanthemum flower stems as compared to control. The effect of different packaging materials on membrane stability of ray floret and leaf tissue significantly differed as compared to control in refrigerated storage conditions. Amongst the treatment T_2 (71.04) recorded the maximum MSI of ray florets followed significantly by T_1 (64.70) and T_6 (55.16) but treatments T_3, T_4 and T_5 did not differ significantly differed as compared to control. MSI of leaf was also non-significantly differed in T_1 (67.83) and T_2 (69.23) but significantly differed with other treatments and control. The MSI of leaf was lower to ray-florets. Among the duration, the maximum MSI was recorded at initials days of storage and afterward it was declined slowly during storage but significantly differed with other treatments (Table 1).

There was a significant slight increase in physiological fresh weight of flower stems in all treatments and control with respect to days of increasing storage period. Among the treatments, there was 20 and 13.81% change in fresh weight in T_1 and T_2 as compared to control. There was continuous increase in the fresh weight in T_2 and T_1 upto 39 days, in T3, T4, T5 and T6 upto 27 days; and control upto

Table 1. Effect of packaging materials on the membrane stability index of ray florets and leaf tissues during wet refrigerated storage of chrysanthemum cut-flowers.

Treatment\ Day	Ray floret						Leaf					
	3	15	27	39	51	Mean	3	15	27	39	51	Mean
T_0	84.49	65.54	44.50	29.46	17.76	48.35	84.73	58.25	35.19	25.06	15.63	43.77
T_1	83.74	74.11	63.85	57.36	44.42	64.70	84.21	77.92	70.13	60.66	46.23	67.83
T_2	84.77	81.55	67.36	60.94	60.56	71.04	83.16	74.06	68.22	63.36	57.36	69.23
T_3	73.32	65.19	51.33	46.25	25.07	52.23	74.87	70.65	55.88	41.23	23.7	53.26
T_4	72.02	64.70	53.98	46.47	27.97	53.03	72.85	50.00	35.27	30.32	24.67	42.62
T_5	77.25	68.06	56.27	45.98	21.36	53.79	75.73	42.18	35.32	30.38	23.87	41.49
T_6	76.29	68.72	60.50	49.81	20.50	55.16	76.19	51.87	37.51	30.26	24.70	44.11
Mean	78.84	69.70	56.83	48.04	31.09		78.82	60.71	48.22	40.18	30.89	
CD at 5%												
Treat. (T)						5.23						5.78
Dur. (D)						7.58						7.60
T × D						8.98						9.12

D = Days after treatment

15 days of refrigerated wet storage. Maximum fresh weight was found at 27 days of storage, which declined significantly thereafter (Table 4). Lower reduction in fresh weight could be attributed to low respiration rate at low temperature and packaging materials that maintain high humidity inside it (Varu *et al*., 12).

Our results showed that there was continuous decline in water uptake in all treatments, but maximum uptake was recorded at initial days, which were non-significantly differed among the treatments as well as durations of storage. The leaf total soluble sugars (TSS) were maximum in leaf tissue in T_2, which was significantly different from T_5, T_6 and control but was non-significantly different with other treatments. Among the duration leaf TSS was non-significantly differ upto 15 days of storage afterwards it was significantly differed at 27, 39 and 51 days of storage. Findings showed leaf RS was at par with leaf TSS in all treatments. Whereas, leaf RS was found to significant upto 15 days of refrigerated wet storage afterwards it was non-significantly at respective durations. Sugars (TSS & RS) were found maximum in initial day of storage, which declined progressively. While reducing sugars in leaf was maximum in T_3 that was highly significantly compared to control, but was non-significantly different with other treatments (Table 2). It was evident that the TSS and reducing sugar contents in leaf declined with increment of duration. In ray florets, the maximum TSS was estimated in T_2 (31.49 mg/g FW) followed by T_4 (31.05 mg/g FW), which was non-significantly different with other treatments but significantly differed with control (22.40 mg/g FW). Among the sampling interval in vase, the maximum TSS was observed at 3 day (40.89 mg/g FW) that was significantly higher compared to 27, 39 and 51 days. While maximum reducing sugar was found in T_2 (31.49 mg/g FW) followed by T_4 (31.05 mg/g FW), which was non-significantly different with control. The results showed among the treatment has not much significant differed in TSS and RS of leaf and ray florets but highly significantly differed with control (Table 3). However, amongst the packaging material, LDPE was found to be having good performances.

In the sub-experiment, some packs flowers wrapped with packaging materials were transferred from refrigerator to normal ambient conditions after 15 days of storage, and the different parameters were recorded. The maximum vase-life (12.67 days) was observed in flowers wrapped with T_2 non-significantly followed by T_1 (11.23 days) but significantly followed by other treatments as well as control. The maximum water uptake was observed 73.49 ml in T_2 LPDE significantly followed by 65.40 ml in T_1 LDPE (200 gauge) and 61.16 ml in polypropylene. While, minimum water uptake 19.33 ml was recorded in control with minimum vase-life of 4.24 days. The minimum percentage loss in fresh wt. (5.52%) was recorded in T_2 LPDE (100 gauge) significantly followed with other treatments. This is highly correlated with water uptake (Table 5). Similar findings were reported by Roychowdhury (11) in tuberose spikes wrapped with polyethylene (PE), which exhibited least loss in fresh weight (0.69%). The CO_2 concentration was found higher inside the packaging and differed significantly with control. The O_2 concentration was found lower inside the packaging. The balance of gaseous concentration

Table 2. Effect of packaging materials on leaf total soluble sugars and reducing sugar contents in chrysanthemum cut flowers under refrigerated wet storage.

Treatment\ Day	TSS (mg/ g FW)						RS (mg/ g FW)					
	3	15	27	39	51	Mean	3	15	27	39	51	Mean
T_0	40.22	36.56	23.56	17.67	11.67	25.94	23.41	17.72	13.67	11.62	8.34	14.96
T_1	41.48	38.67	30.12	26.67	18.34	31.06	22.45	19.21	16.42	14.23	12.23	16.91
T_2	40.54	39.54	32.76	29.12	22.51	32.89	21.37	19.68	17.31	16.11	14.44	17.79
T_3	41.67	38.12	31.23	25.72	16.54	30.66	23.56	19.21	16.11	14.32	12.11	17.06
T_4	42.32	37.87	30.36	24.84	17.74	30.63	22.71	18.72	16.56	14.62	12.78	17.08
T_5	40.11	37.54	26.12	19.72	12.56	27.21	21.65	18.11	14.45	12.51	10.32	15.41
T_6	41.46	37.41	27.56	20.67	14.86	28.39	22.54	19.04	14.76	12.72	11.42	16.09
Mean	41.12	37.96	28.82	23.48	16.32		22.53	18.82	15.61	13.73	11.66	
CD at 5%												
Treat. (T)						2.89						1.85
Dur. (D)						5.46						3.62
T × D						6.07						4.28

Table 3. Effect of refrigerated wet storage and packaging materials on ray florets total soluble solids and reducing sugar contents in chrysanthemum.

Treatment\ Day	Total soluble sugars (mg/g FW)						Reducing sugar (mg/g FW)					
	3	15	27	39	51	Mean	3	15	27	39	51	Mean
T_0	39.05	34.78	18.87	10.56	8.76	22.40	27.14	20.54	18.45	11.65	7.86	17.13
T_1	41.65	37.87	31.67	25.65	18.43	31.05	26.74	23.52	22.45	18.56	15.87	21.43
T_2	39.67	37.87	31.75	27.84	20.34	31.49	27.34	23.58	21.67	20.67	17.42	22.14
T_3	40.56	36.87	28.90	22.64	16.70	29.13	25.70	21.62	18.43	14.87	10.43	18.21
T_4	38.75	35.34	30.70	21.60	17.57	28.79	27.45	26.48	22.65	15.67	13.78	21.21
T_5	42.67	39.65	28.76	16.34	13.21	28.12	26.73	22.85	17.56	12.56	9.56	17.85
T_6	43.89	38.50	30.50	20.33	14.36	29.51	26.43	24.76	20.75	13.78	11.50	19.44
Mean	40.89	37.26	28.74	20.71	15.62		26.79	23.34	20.28	15.39	12.35	
CD at 5%												
Treat. (T)						3.31						2.46
Dur. (D)						5.52						4.17
T × Dur.						6.51						4.86

Table 4. Effect of refrigerated wet storage and packaging materials on stem fresh weight and water uptake in chrysanthemum cv. Reagen White.

Treatment\ Day	Stem FW (g)						Water uptake (ml/ day)					
	3	15	27	39	51	Mean	3	15	27	39	51	Mean
T_0	23.63	25.05	24.67	17.47	13.03	20.77	25.13	15.53	11.34	8.54	4.49	13.01
T_1	21.35	24.44	25.24	25.59	21.60	23.64	27.00	20.2	16.2	13.14	9.60	17.23
T_2	23.33	26.33	26.56	27.10	21.53	24.97	27.86	21.13	16.27	14.54	10.66	18.09
T_3	21.58	24.36	25.04	25.09	17.20	22.65	27.06	20.00	16.73	11.00	8.47	16.65
T_4	22.30	24.49	25.13	21.90	14.67	21.69	27.82	19.93	15.45	16.11	7.34	17.33
T_5	24.64	26.48	26.65	22.40	15.13	23.06	28.46	18.94	13.74	9.20	7.60	15.58
T_6	21.80	24.51	25.28	24.83	18.13	22.91	26.74	17.94	12.87	7.74	5.87	14.23
Mean	22.66	25.09	25.51	23.48	17.33		27.15	19.09	14.65	11.45	7.72	
CD at 5%												
Treat. (T)						2.25						2.48
Dur. (D)						3.14						4.84
T × Dur.						4.12						5.42

inside the packaging depends on permeation of packing materials. High concentration of CO_2 (5-10%) has been reported to retard senescence, due to its ethylene inhibitory activity and through its effect in maintaining high levels of polyamines in tissues (Philosoph-Hadas *et al*., 10). This CO_2-senescence retarding effect on vegetative organs may also affect, in turn, florets' opening, since green leaves and bracts may serve as possible sources for assimilate import to the floret sink during opening after storage (Meir *et al*., 8).

Having higher chlorophyll content of wrapped flowers and control was observed at 0 days, degradation of chlorophyll content was observed in wrapped and open sets with the advancement of senescence. Here slowest degradation of chlorophyll was noticed in LPDE (100 gauge) and LDPE (200 gauge) and it differed significantly differed with other treatments and control for all durations (Fig. 1). The leaf and ray floret total soluble sugars were found continuously decreasing as senescence of flower stem proceeded. The leaf and ray florets, sugar levels differed significantly among the durations (Fig. 2).

Different components of antioxidant enzyme activities were measured at 0, 4, 8 and 12 day interval. The activity of the SOD enzyme was found continuously increasing as senescence proceeds. The

Table 5. Effect of packaging materials after 15 days of removal from refrigeration in chrysanthemum cv. Reagan White.

Treatment\ Day	Vase-life (days)	Total water uptake (ml)	% loss in cut flower FW (g)	Floret tissue CO_2 conc. (%)	Floret tissue O_2 conc. (%)
T_0	$4.24^{e} \pm 0.58$	$19.33^{e} \pm 1.45$	$37.45^{a} \pm 1.39$	$0.33^{d} \pm 0.003$	$78^{a} \pm 0.030$
T_1	$11.37^{ab} \pm 0.67$	$65.40^{b} \pm 1.66$	$7.95^{b} \pm 0.46$	$5.45^{a} \pm 0.145$	$13.46^{f} \pm 0.392$
T_2	$12.67^{a} \pm 0.34$	$73.49^{a} \pm 2.68$	$5.52^{c} \pm 0.184$	$5.83^{a} \pm 0.050$	$12.11^{f} \pm 0.322$
T_3	$10.33^{b} \pm 0.38$	$61.16^{b} \pm 1.51$	$10.67^{c} \pm 1.02$	$4.12^{b} \pm 0.308$	$15.63^{d} \pm 0.119$
T_4	$9.27^{c} \pm 0.42$	$49.19^{c} \pm 1.89$	$14.21^{d} \pm 0.92$	$3.45^{c} \pm 0.160$	$14.32^{d} \pm 0.103$
T_5	$7.00^{d} \pm 0.54$	$41.35^{d} \pm 1.44$	$22.29^{e} \pm 0.88$	$4.56^{b} \pm 0.081$	$17.24^{b} \pm 0.154$
T_6	$8.43^{c} \pm 0.57$	$52.62^{c} \pm 2.32$	$13.43^{e} \pm 0.60$	$3.12^{c} \pm 0.132$	$16.31^{c} \pm 0.201$

maximum SOD enzyme activity was found in control as compared to wrapped flowers stem, which may be due to the accumulation of superoxide radicals in the floret tissue, caused by storage stress and disturbances in antioxidant balance. The MDA content was found significantly lower in packaged flower stems as compared to control. As day proceeded, the MDA content was found to increase significantly. MDA is a decomposition product of polyunsaturated fatty acid that may be probably due to oxidative stress. Here, a positive relation was found between open and packaged materials in terms of SOD activity and MDA contents (Fig. 3). Earlier, Ezhilmathi *et al*. (4) also reported petal senescence to be associated with increase in hydrolytic enzymes, degradation of macromolecules and an increase in respiratory activity.

The low density polyethylene and other packaging materials had modified the O_2 and CO_2 levels within the package atmosphere due to its permeation. That resulted in increased CO_2 concentration, humidity and slowing down of transpiration. This lead to slow down in respiration rate leading to slow conversion of sugar, which maintains higher turgidity and freshness of flowers and leaf, thus improving the quality of flower

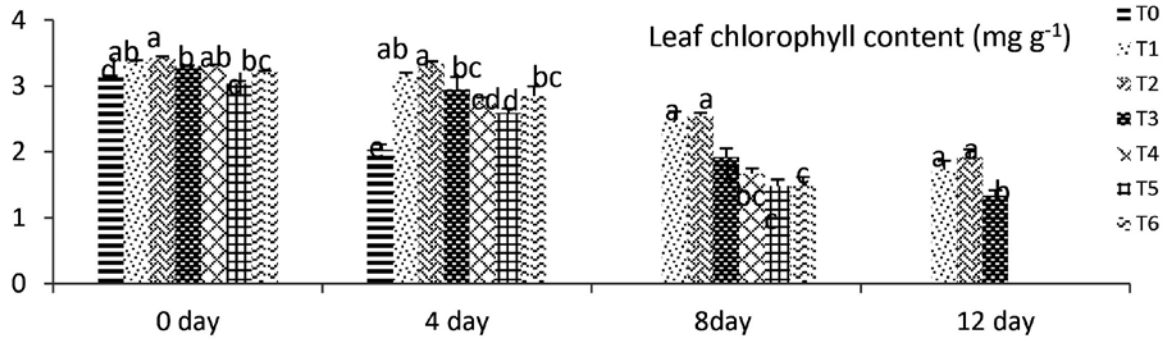

Fig. 1. Leaf chlorophyll content in vase after 15 day wet stored cut chrysanthemum flowers.

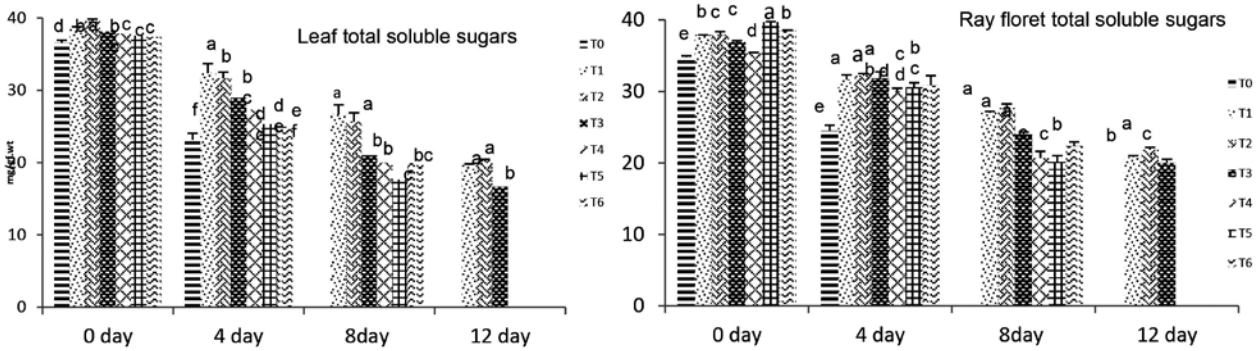

Fig. 2. Leaf and ray floret total soluble sugars of the wet refrigerated cut chrysanthemum flowers in vase.

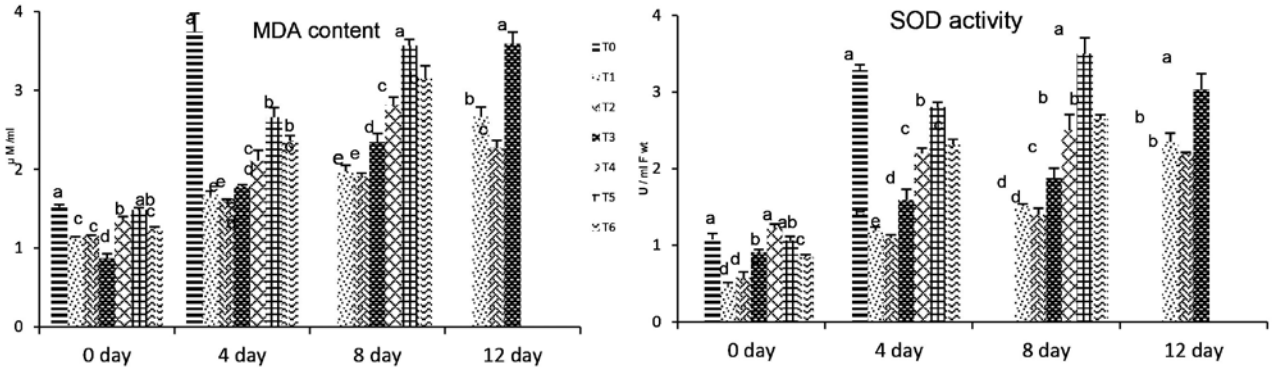

Fig. 3. Changes in MDA content and SOD activity of the wet refrigerated cut chrysanthemum flowers in vase.

stems. The polyethylene packaging reduced the permeability to moisture and air, thereby reducing the weight loss probably due to a reduction in moisture loss, respiration and cell division processes. From the study it was concluded that use of LDPE (100 gauge) packaging for chrysanthemum cut flowers in refrigerated wet storage conditions or normal ambient conditions was most effective in prolonging the vase-life and also improving the quality.

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REFERENCES

1. Bailley, C.A., Banamae, Corbineare, F. and Come, D. 1996. Changes in superoxide dismutase, catalase and glutathione reductase activities as related to seed deterioration during accelerated aging of sunflower seeds. *Physiol. Plant.* **97**: 104-10.

2. Bayer, W.F. and Fridovich, I. 1987. Assaying for superoxide dismutase activity: some large consequences of minor changes in conditions. *Annal. Biochem*. **161**: 559-66.

3. Dutta, S.K., Chakrabarty, D., Gupta, V.N. and Verma, A.K. 2013. Changes in antioxidant activities in chrysanthemum cut sprays during storage and packaging. *Sci. Cult.* **79**:183-86.

4. Ezhilmathi, K., Singh, V.P., Arora, A. and Sairam, R.K. 2007. Effect of 5-sulfosalicylic acid on antioxidant activity in relation to vase-life of *Gladiolus* cut flowers. *Pl. Growth Reg.* **51**: 99-108.

5. Halevy, A. and Mayak, S. 1981. Senescence and postharvest physiology of cut flowers. *Hort. Rev*. **3**: 59-143.

6. Hiscox, J.D. and Israelstam, G.F. 1979. A method for the extraction of chlorophyll from leaf tissue without maceration using dimethyl sulphoxide. *Canadian J. Bot.* **57**: 1332-34.

7. Heath, R.L. and Packer, L. 1968. Photoperoxidation in isolated chloroplasts. I. Kinetic and stoichiometry of fatty acid peroxidation. *Arch. Biochem. Biophys*. **125**: 189-98.

8. Meir, S., Philosoph-Hadas, S., Michaeli, R., Davidson, H., Fogelman, M. and Shaffer, A. 1995. Improvement of the keeping quality of mini-gladiolus spikes during prolonged storage by sucrose pulsing and modified atmosphere packaging. *Acta Hort.* **405**: 335-42.

9. Nowak, J. and Rudnicki, R.M. 1990. *Postharvest Handling and Storage of Cut Flower, Florist, Greens and Potted Plants*, Timber Press, Portland, Oregon, USA, pp. 39-43.

10. Philosoph-Hadas, S., Meir, S., Rosenberger, I. and Halevy, A.H. 1995. Control and regulation of the gravitropic response of cut flowering stems during storage and horizontal transport. *Acta Hort*. **405**: 343-50.

11. Roychowdhury, N., Chakrabarty, S. and Munsi, P. 2011. Influence of packaging material, storage condition and storage duration on vase life of tuberose 'Calcutta Double'. *Acta Hort*. **886**: 359-64.

12. Varu, D.K. and Barad, A.V. 2008. Effect of different packing methods on vase-life and quality of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. *Asian J. Biol. Sci.* **3**: 159-62.

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