Indian Journal of Agricultural Sciences **86** (11): 1489–94, November 2016/Article
https://doi.org/10.56093/ijas.v86i11.62937

Efficacy of floral preservatives stored at different temperatures and time periods on lushness retention and vaselife of chrysanthemum (*Dendranthema* × *grandiflora*) cv. Thai Chen Queen

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Received: 9 January 2016; Accepted: 30 May 2016

ABSTRACT

Different floral preservative treatments consisting of citric acid, 8HQ, sucrose and their combinations stored at different temperatures and duration (time periods) were used to reduce the foliage discoloration and to enhance the vase life of chrysanthemum (*Dendranthema* × *grandiflora* Ramat.) cv. Thai Chen Queen, at ICAR-IARI, New Delhi during 2012-14. Experiment was laid out in completely randomized block design with sixteen treatments and three replications. It was observed that all the preservative treatments significantly reduced foliage discoloration and increased the vase life over control (Distilled water). The preservative solution containing 400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at low temperature (T_{14}) resulted in maximum vase life (36.56 days), maximum chlorophyll content with zero wilting and leaf yellowing and reduced leaf browning. Minimum weight loss (9.48%) was recorded in 400ppm 8HQ+400ppm citric acid +3 month old storage at low temperature (T_5). However, maximum volume of solution consumed (104.72 ml) was recorded in 400 ppm 8HQ+400 ppm citric acid+3% sucrose+6 month old storage at low temperature (T_{10}), whereas maximum flower diameter (12.37cm) was recorded in 400ppm 8HQ+400 ppm citric acid+3% sucrose+3 month old storage at low temperature (T_6).

Key words: Cut flowers, Chrysanthemum, Floral preservatives, Foliage discoloration, Vase life, Thai Chen Queen

Chrysanthemum (*Dandranthema* × *grandiflora* Ramat.) belongs to the family Asteraceae and ranks second in world cut flower trade. In India, chrysanthemum is gaining popularity as cut flower in the urban floriculture trade. It is highly suitable for beds, pots and for floral arrangement. Flowers of standard varieties are produced on long, sturdy stems and have a good keeping quality but the foliage tends to loose its greenness. Among various cut flower varieties used Thai Chen Queen is more popular. Due to high perishability, flower and foliage parts are vulnerable to large postharvest losses. Leaves of cut chrysanthemum frequently become yellow, spontaneously, sometimes prior to the onset of flower senescence making the flowers unattractive, reduces their quality and shortens vase life (Doi *et al.* 2003, 2004). Yellowing of foliage is cultivar specific and is caused by poor production, excessive or improper storage and preservative solutions used at higher than recommended concentrations. To preserve the best quality of flowers after harvest and to make them tolerant to fluctuations in environmental conditions treatment with floral preservatives is recommended. Influence of different holding solutions on chrysanthemum has been reported (Kofranek and Halevy 1972, Talukdar *et al.* 2004) but information on controlling leaf discoloration is not available. Since the problem is varietal specific, an investigation was carried out to study the effect of various floral preservatives on improving the postharvest quality of chrysanthemum cut flower cv. Thai Chen Queen.

MATERIALS AND METHODS

The present study was carried out in the Division of Floriculture and Landscaping ICAR-IARI, New Delhi during 2012-14. The experiment was laid out in completely randomized design, with sixteen treatments replicated thrice with three stems per replication. Preservative formulations were prepared by mixing 8HQ and citric acid each of 400 mg together with or without 30g sucrose and were stored either at room temperature or in refrigerator (10-12°C) for three months, six months and one year, respectively. At the time of experiment, these stored preservative formulations were dissolved in distilled water to make final volume one litre and were compared with distilled water (control); a commercial formulation "Proflora" and freshly prepared solution of the hybrid mix of 400 ppm8 HQ, citric

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acid with or without 3% sucrose.

Flowers of cv. Thai Chen Queen were harvested from research farm of the Division of Floriculture and Landscaping during morning hours and were immediately placed in bucket containing water and thereafter, brought to the laboratory. Stems were cut to a uniform length of 30 cm and were dressed by removing lower 1/3rd leaves. The cut stems were then placed in various combinations of preservative solutions, viz.

Treatments	Preservative solutions
T_1	400ppm 8HQ+400ppm citric acid+ storage Fresh
T_2	400ppm 8HQ+400ppm citric acid+3 % sucrose+ storage Fresh
T_3	400ppm 8HQ+400ppm citric acid +3 months old storage at room temperature
T_4	400ppm 8HQ+400ppm citric acid+3 % sucrose+3 months old storage at room temperature
T_5	400ppm 8HQ+400ppm citric acid +3 months old storage at low temperature
T_6	400ppm 8HQ+400ppm citric acid+3 % sucrose+3 months old storage at low temperature
T_7	400ppm 8HQ+400ppm citric acid +6 month old storage at room temperature
T_8	400ppm 8HQ+400ppm citric acid+ 3% sucrose +6 months old storage at room temperature
T_9	400ppm 8HQ+400ppm citric acid +6 months old storage at low temperature
T_{10}	400ppm 8HQ+400ppm citric acid+3 % sucrose+6 months old storage at low temperature
T_{11}	400ppm 8HQ+400ppm citric acid +one year old storage at room temp
T_{12}	400ppm 8HQ+400ppm citric acid+ 3% sucrose +one year old storage at room temp
T_{13}	400ppm 8HQ+400ppm citric acid +one year old storage at low temperature
T_{14}	400ppm 8HQ+400ppm citric acid+ 3% sucrose +one year old storage at low temperature
T_{15}	Pro Flora, Commercial formulation @ 1.5 ml/lit.
T_{16}	Distilled Water

Flower stems were kept in test tubes containing 50 ml of prepared holding solutions with different combinations as per the treatment schedule. Mouths of the test tubes were then covered with non-absorbent cotton to minimize evaporation loss and prevent contamination. The measured volume of preservative solution was topped up in the test tubes as and when needed. Observations on vase life, physiological weight loss, flower diameter, solution uptake (ml), leaf yellowing (%), leaf wilting (%) and leaf browning (%) were recorded and the data were subjected to analysis of variance (Panse and Sukhatme 1967). Pigments (chlorophyll a, chlorophyll b, total chlorophyll and carotenoids) were extracted from the leaves of chrysanthemum by dimethyl sulfoxide (DMSO) method (Hiscox and Isrealstam 1979) and the concentrations of the extracted pigments were calculated based on the absorbance values at 664 nm, 648 nm, and 470 nm respectively (Lichtenthaler 1987).

RESULTS AND DISCUSSION

The results related to postharvest traits and foliage discoloration, wilting as well as chlorophyll and carotenoid pigments have been presented in Table 1 and 2.

Physiological weight loss/weight gain

Data presented in Table 1 showed that among various preservative combinations used, maximum weight gain (59.55%) was recorded when flowers were held in a preservative solution containing 400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +6 months old storage at room temperature (T_8) and it was at par with T_2, T_{10}, T_{12}, and T_{14}. Minimum weight gain (9.48%) was recorded when flowers were held in a preservative solution containing 400 ppm 8HQ+400 ppm citric acid +3 months old storage at low temperature (T_5) and it was at par with T_1, T_3, T_6, T_7, T_9, T_{11}, T_{13}, and T_{16}.However, maximum weight loss (-32.57%) was recorded when flowers were held in 1.5 ppm solution of Pro Flora (a Commercial formulation) (T_{15}). The possible reason for minimum weight loss might be low transpirational losses. The presence of 8 HQC in vase solution resulted in partial closure of stomata and hence, reduced transpiration loss of water. Similarly, Jain *et al.* (2009) reported that holding the cut flowers of chrysanthemum cv. Shyamal in 300 ppm citric acid +500 ppm $Al_2 (SO_4)_3$ +2% sucrose solution resulted in minimum weight loss. The significant increase in fresh weight of cut stems could be attributed to strong antimicrobial activities of 8-HQ that restricted the growth of micro organisms in vase solution (Rogers 1973).

Flower diameter

Data presented in Table 1 depicts that cut flowers of cv. Thai Chen Queen when held in solution containing 400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months storage at low temperature (T_6) resulted in maximum per cent increase in flower diameter (35.08%) and it was at par with T_1, T_2, T_3, T_8, T_9, T_{10}, T_{12}, and T_{14} while keeping the flowers in pro flora (T_{15}) showed negative effect on flower diameter and the flower diameter decreased by 13.81%. Since quinoline esters are acidic in solution and 8-HQC inhibits stem plugging by reducing pH of vase solution, thereby, increasing the conductivity of stems and hence increased diameter (Marousky 1972). The 8 HQ also improves the diameter and opening of flower due to its germicidal activity and anti ethylene effect (Halevy and Mayak 1981). Similarly, Jain *et al.* (2009) reported increase in flower diameter in var. Kanchil in 150 ppm citric acid +1000 ppm aluminium sulphate + 2% sucrose.

Solution uptake

Holding the flowers in a preservative solution containing 400 ppm 8HQ+400 ppm citric acid+3% sucrose+6 months storage at low temperature (T_{10}) resulted in maximum solution uptake (104.72 ml) and the minimum solution uptake (18.34 ml) was observed in treatment T_{16}

and was statistically at par with T_2, T_4, T_6 and T_{14} (Table 1). The 8-HQ serves as good surfactant solution with its strong antimicrobial properties and also helps in elimination of physiological stem blockage in sterile tissue to encourage free flow of water uptake (Marousky 1972). Jain *et al.* (2014a) also reported similar results in chrysanthemum with 400 ppm 8-HQC and 1.5% sucrose. The addition of sucrose to vase solution decrease the water potential in tissues thereby, improving the water uptake by cut stems (Kofranek and Halevy 1976). The flowers fed with sucrose solution have increased opening as the addition of sucrose allows the flower to develop fully which is not possible with water. Jowkar *et al*. (2012) also reported that aluminum sulfate and 8HQC was an efficient treatment for different aspects of biocide application, i.e. microbial control, solution uptake, relative fresh weight, flower longevity, and appearance etc.

Vase life

It is evident from Table 1 that maximum vase life (36.56 days) was recorded with 400 ppm 8HQ+400 ppm citric acid + 3% sucrose + one year old storage at low temperature (T_{14}) which was statistically at par with all the treatments except treatment T_{15} (ProFlora) with minimum vase life (14.67 days). It means the preservative formulation can be stored easily for ready use up to one year under refrigerated conditions. The increase in vase life might be due to better water relations, delay in protein degradation, maintenance of membrane integrity and thereby, delaying senescence. The effect of 8 HQ component in enhancing vase life of cut flowers might be due to the fact that 8-HQC reduced physiological stem blockage in sterile tissues. It was suggested that this effect was related to chelating properties of quinoline esters which may chelate metal ions of enzyme activity in chelating stem blockage (Marousky 1972). Holding the flowers in citric acid+ sucrose enhance cut flower longevity by increasing water uptake, improved water balance, maintaining normal levels of transpirational loss of water (Vijayalaxmi *et al.* 2011). Yuniarti *et al*. (2007) and Jain *et al.* (2014b) also reported similar results in chrysanthemum. Our results further corroborates with the of Jain *et al*. (2009) and Wiraatmaja *et al.* (2007).

Leaf wilting, yellowing and browning

It is evident from the Table 2 that no leaf wilting (0.00%) was observed when cut flowers were kept in preservative solution treated with T_8, T_{12} and T_{13}, however, maximum leaf wilting (28.76%) was recorded in 400 ppm 8HQ+400 ppm citric acid +3 months old storage at low temperature (T_5). Jain *et al*. (2014b) also reported no leaf wilting when cut flowers were kept in preservative solution containing aluminium sulphate, citric acid and sucrose. The presence of citric acid in the preservative solution helps in reducing the transpirational losses and preventing foliage wilting. No leaf yellowing was recorded when the flowers were held in a preservative solution containing 400 ppm 8HQ+400 ppm citric acid + 3% sucrose + 6 months old storage at room temperature (T_8) and 400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at room temp (T_{12}), while maximum leaf yellowing (81.11 %) was recorded in Pro Flora, Commercial formulation @ 1.5 ml/lit. (T_{15}). Jain *et al*. (2014b) reported that no leaf yellowing when the flowers were held in a preservative solution containing 150 ppm citric acid+500 ppm aluminium sulphate+2% sucrose (T_2) and 300 ppm citric acid+500ppm aluminium sulphate+2% sucrose. This might be due to the fact that exogenous application of sucrose during postharvest handling may preserve chlorophyll loss and hence, prevented yellowing. It was also reported that carbohydrate deprivation commonly occurs in higher plants during senescence (Peoples and Dalling 1988), in darkness (Elmarani *et al.* 1994) and under postharvest conditions (King *et al.* 1990). No leaf browning was recorded when the flowers were held in a preservative solution of treatment T_1, T_5, T_6, T_7, T_9, T_{11}, T_{12} and T_{13} and it was significantly different from all the treatments (Table 2) while maximum leaf browning (4.09%) was recorded in distilled water or control (T_{16}). Similarly, minimum leaf discoloration (17.09%) was recorded in a solution containing 400 ppm 8-HQC +1.5 % sucrose (Jain *et al.* 2014a).

Chlorophyll content

The data presented in Table 2 revealed that maximum chlorophyll a (4.73 µg/ml), chlorophyll b (1.92 µg/ml) and total chlorophyll content (6.65 µg/ml) was recorded with 400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months old storage at low temperature (T_6). however, minimum total chlorophyll content (2.93 µg/ml) and chlorophyll b (0.57µg/ml) was recorded in distilled water. Minimum chlorophyll a content (2.08µg/ml) was recorded when flowers were kept in preservative solution containing 400ppm 8HQ+400ppm citric acid+ storage Fresh (T_1) and was statistically at par with T_3, T_5, T_7, T_9 and T_{11}. Jain *et al.* (2014b) also reported that maximum chlorophyll b (8.59 µg/ml) and total chlorophyll (13.14 µg/ ml) content was recorded in preservative solution containing 300 ppm citric acid+500 ppm aluminium sulphate+2% sucrose. Retention of maximum chlorophyll content in the leaves of flowers held in a solution containing citric acid and sucrose is the possible reason of the reduction of foliage yellowing as exogenous supply of sucrose helps in the maintenance of the membrane permeability, increasing chlorophyll content and known to maintain freshness of flowers and leaves.

Carotenoid content

Maximum carotenoid content (0.64 µg/ml) was recorded in distilled water (T_{16}) and was at par with all the treatments except T_1, T_2 and T_3, however, minimum carotenoid content (0.16 µg/ml) was recorded in 400 ppm 8HQ+400 ppm citric acid+3 % sucrose (T_2). Jain *et al*. (2014b) reported that maximum carotenoid content in150 ppm citric acid+500 ppm aluminium sulphate+2% sucrose as well as in distilled water.

Table 1 Effect of floral preservatives on post harvest handling of chrysanthemum cv. Thai Chen Queen

Treatment	Initial flower weight (gm)	Final flower weight (gm)	Percent flower weight (gain/loss)	Initial flower diameter (cm)	Final flower diameter(cm)	% increased flower diameter (cm)	Solution uptake (ml)	Vase life (days)
400 ppm 8HQ+400 ppm citric acid+ storage Fresh (T_1)	20.48	23.20	13.55 (21.42)	9.27	12.26	32.33 (34.62)	77.28	21.78
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+ storage Fresh (T_2)	20.13	29.15	45.92 (42.61)	9.31	12.11	30.16 (33.23)	104.00	36.44
400 ppm 8HQ+400 ppm citric acid +3 months old storage at room temperature (T_3)	21.96	25.45	15.85 (23.44)	9.46	12.22	29.26 (32.70)	87.28	22.78
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months old storage at room temperature (T_4)	18.75	26.78	43.08 (40.99)	9.12	10.67	16.91(24.22)	92.17	26.00
400 ppm 8HQ+400 ppm citric acid +3 months old storage at low temperature (T_5)	19.66	21.58	9.48 (17.68)	9.19	11.56	25.81 (30.49)	74.05	21.89
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months old storage at low temperature (T_6)	22.83	28.29	23.49 (28.47)	9.16	12.37	35.08 (36.27)	99.56	27.89
400 ppm 8HQ+400 ppm citric acid +6 month old storage at room temperature (T_7)	14.82	16.59	11.66 (19.31)	8.51	10.33	21.32 (27.41)	49.17	21.44
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +6 months old storage at room temperature (T_8)	15.79	25.14	59.55 (50.50)	8.30	10.50	26.53 (30.98)	84.89	33.22
400 ppm 8HQ+400 ppm citric acid +6 months old storage at low temperature (T_9)	14.17	15.92	12.45 (20.46)	7.96	10.24	28.68 (32.37)	48.39	19.44
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+6 months old storage at low temperature (T_{10})	19.22	28.78	49.78 (44.86)	8.05	10.29	27.55(30.86)	104.72	31.89
400 ppm 8HQ+400 ppm citric acid +one year old storage at room temp (T_{11})	15.00	18.31	22.45 (28.08)	8.47	10.23	20.75 (27.07)	68.84	24.56
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at room temp (T_{12})	14.60	21.82	48.78 (44.18)	8.56	10.80	26.34 (30.82)	78.28	27.56
400 ppm 8HQ+400 ppm citric acid +one year old storage at low temperature (T_{13})	18.01	19.72	9.82 (17.76)	8.80	10.66	21.26 (27.33)	67.78	23.89
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at low temperature (T_{14})	18.09	27.18	50.23 (45.11)	8.49	11.10	30.83 (33.71)	99.56	36.56
Pro Flora, commercial formulation @ 1.5 ml/lit. (T_{15})	15.14	10.20	-32.57 (34.78)	8.57	7.39	-13.81 (21.80)	18.34	14.67
Distilled water (T_{16})	17.77	19.92	12.47 (20.63)	8.86	10.85	22.37 (28.14)	60.75	23.06
CD (P=0.05)	2.77	3.96	14.56 (9.52)	0.47	0.88	8.75 (5.97)	15.26	3.93
SE (m)	0.96	1.37	5.03 (3.29)	0.16	0.31	3.02 (2.06)	5.28	1.36
SE (d)	1.35	1.93	7.12 (4.65)	0.23	0.43	4.27 (2.92)	7.46	1.92
CV	9.25	10.58	35.22 (18.22)	3.18	4.86	21.96(11.85)	12.03	9.10

Figures in parentheses are transformed values

Table 2 Effect of different floral preservatives on leaf discolouration and biochemical constituents of chrysanthemum cv. Thai Chen Queen

Treatment	% leaf wilting (after 10 days)	% leaf yellowing (after 10 days)	% leaf browning (after 10 days)	Chlorophyll a (µg/ml)	Chlorophyll b (µg/ml)	Total chlorophyll (µg/ml)	Carotenoids (µg/ml)
400 ppm 8HQ+400 ppm citric acid+ storage Fresh (T_1)	14.90 (21.12)	27.81 (31.42)	0.00(1.00)	2.08	1.18	3.25	0.24
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+ storage Fresh ($_{T2}$)	1.11 (3.50)	6.55 (14.33)	1.85(1.52)	3.19	1.46	4.64	0.16
400 ppm 8HQ+400 ppm citric acid +3 months old storage at room temperature (T_3)	16.36 (19.74)	8.70 (13.90)	2.34(1.75)	2.77	1.06	3.83	0.28
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months old storage at room temperature (T_4)	3.63 (10.96)	9.98 (17.76)	1.2(1.39)	3.75	1.31	5.06	0.61
400 ppm 8HQ+400 ppm citric acid +3 months old storage at low temperature (T_5)	28.76 (32.16)	17.99 (24.62)	0.00(1.00)	2.40	0.96	3.36	0.58
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+3 months old storage at low temperature (T_6)	5.43 (10.72)	13.45 (20.27)	0.00(1.00)	4.73	1.92	6.65	0.33
400 ppm 8HQ+400 ppm citric acid +6 months old storage at room temperature (T_7)	3.17 (5.99)	17.04 (23.73)	0.00(1.00)	2.47	0.92	3.38	0.43
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +6 months old storage at room temperature (T_8)	0.00 (1.00)	0.00(1.00)	1.85(1.52)	3.21	1.40	4.61	0.21
400 ppm 8HQ+400 ppm citric acid +6 months old storage at low temperature (T_9)	5.40 (10.98)	20.25(26.60)	0.00(1.00)	2.84	1.23	4.07	0.32
400 ppm 8HQ+400 ppm citric acid+3 % sucrose+6 months old storage at low temperature (T_{10})	4.94(10.18)	4.48(9.83)	2.62(1.81)	3.13	0.86	3.99	0.62
400 ppm 8HQ+400 ppm citric acid +one year old storage at room temp (T_{11})	3.70(8.96)	33.42(35.16)	0.00(1.00)	3.18	2.06	5.24	0.31
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at room temp (T_{12})	0.00(1.00)	0.00(1.00)	0.00(1.00)	3.52	0.87	4.38	0.57
400 ppm 8HQ+400 ppm citric acid +one year old storage at low temperature (T_{13})	0.00(1.00)	55.25(48.19)	0.00(1.00)	3.18	0.89	4.07	0.56
400 ppm 8HQ+400 ppm citric acid+ 3% sucrose +one year old storage at low temperature (T_{14})	1.85(4.54)	6.75(8.91)	1.85(1.52)	3.25	0.92	4.17	0.57
Pro Flora, commercial formulation @ 1.5 ml/lit. (T_{15})	8.20(9.91)	81.11(65.94)	3.17(1.75)	2.82	0.66	3.47	0.62
Distilled water (T_{16})	13.58(20.31)	38.65(38.09)	4.09(2.22)	2.37	0.57	2.93	0.65
Fresh Leaves				5.07	2.13	7.20	1.74
CD (P=0.05)	13.74(15.92)	17.61(14.77)	NS	1.06	0.91	1.56	0.35
SE (m)	4.75(5.50)	6.09(5.10)	1.29(0.35)	0.37	0.32	0.54	0.12
SE (d)	6.71(7.78)	8.61(7.22)	1.82(0.49)	0.52	0.45	0.77	0.17
CV	118.49(90.16)	49.40(37.33)	187.86(44.50)	20.00	45.60	21.45	40.93

Figures in parentheses are transformed values

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