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A Nirmala
Department of Horticulture, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

A Manohar Rao
Department of Horticulture, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

P Prasanth
Department of Horticulture, Floriculture Division, College of Horticulture, SKLTSHU, Rajendranagar, Hyderabad, Telangana, India

S Narender Reddy
Department of Plant Physiology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

D Srinivasa Chary
Department of Agriculture Statistics, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

Correspondence
A Nirmala
Department of Horticulture, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India

Effect of pulsing with sucrose and sodium hypochlorite (NAOCL) on extension of vase life of cut *Chrysanthemum* cv. arctic queen

A Nirmala, A Manohar Rao, P Prasanth, S Narender Reddy and D Srinivasa Chary

Abstract
The present investigation was carried out in the Department of Floriculture and landscape Architecture laboratory, College of Horticulture, Rajendranagar, Hyderabad during the year 2017-2018, 2018-2019. The experiment was conducted with two different pulsing chemicals *i.e.* sucrose and sodium hypochlorite. The main objective of the investigation was to find out the efficacy of different pulsing chemicals on physical (fresh weight of flower, diameter of flower, percent neck bending, vase life and over all acceptability of flowers), physiological (water uptake, transpiration loss of water, fresh weight change, relative water content, chlorophyll content in calyx), biochemical parameters (TSS of petals, pH of vase solution, optical density of vase solution, electrolyte leakage) in two days interval during the vase life period of cut *Chrysanthemum*. The experiment was laid out in completely randomized design with factorial concept and replicated thrice. Among the two pulsing solutions, sucrose 10 percent was very effective in increasing the fresh weight of flower (8.26 g), flower diameter (6.9 cm), water uptake (13.76 g), fresh weight change (123.76 g), relative water content (89.36%), chlorophyll content of calyx (36.90), Total soluble solids (4.0 degrees), over all acceptability of flowers (9.22), vase life of *Chrysanthemum* cut flowers (10.23 days). It has led to lowest electrolyte leakage (82.03%) and transpiration loss of water (12.04 g/f).

Keywords: Pulsing, *Chrysanthemum*, sucrose, Vaselife, water uptake, transpiration loss of water

Introduction
Chrysanthemum flower (*Dendranthema grandiflora*,) is one of the most popular cut flowers. *Chrysanthemum* has long post harvest life and it continues to look attractive even when semi dry. It has wide range of colors, shapes and sizes. *Chrysanthemum* is ranked as the second most economic important cut flower in the world after rose (Kafi and Ghahsareh, 2009) [7]. Vase life is a yardstick for the longevity of cut flowers and is an important target for improving flower characteristics, whether by chemical treatments or by plant breeding. Maintaining good quality of cut flowers and extending the vase life are considered important to meet the consumer preference. Vase life of cut flowers is mainly affected by two main factors, namely ethylene which accelerates the senescence of many flowers, and microorganisms especially fungi and bacteria that grow in the vase solution, block the stem end and limit water uptake by the flowers, besides the production of chemical compounds that cause vascular blockage and thus reducing the vase life of cut flowers (Hashemabadi *et al.*, 2015) [4]. Cut flowers are short-lived and are prone to rapid deterioration. Shortening vase life of cut flowers could be attributed to destruction of the transport vessels of the stem after cutting, hence, the inability of the stem to absorb water due to blockage may be leading to excessive water loss and short supply of carbohydrates to support respiration. The addition of antibacterial, antimicrobial compounds such as metal salts in vase water can reduce number of bacteria and thereby extend flower longevity in holding solution. (Macnish *et al.*, 2008) [10], but effective concentrations of these biocides can be toxic to some flowers or unsuitable to others. A floral preservative is usually a complex mixture of sucrose, acidifier, an inhibitor of microorganisms and also an anti ethylene action (Tehranifar *et al.*, 2013, Darandeh and Hadavi, 2012) [18, 2]. Sugars are the main source of food for flowers. They are required for carrying out all biochemical and physiological processes after detachment from the mother plant. Sugars play an important role in keeping the quality of cut flowers because the amount of sugar contained in the cut flower is limited. Sucrose is the most widely used floral

Preservatives that maintain the pool of dry matter and respirable substrates in floral petals. Exogenous sucrose replaces the depleted endogenous carbohydrates utilized during post harvest life of cut flowers. Sucrose is the main transporting form of sugar to flower bud and it is also a major structural material used in cell growth and enlargement and a soluble component in petal tissues, and hence an important osmotic regulator of water potential (Mayak *et al.*, 2001) [12]. Research is required to find out the impact of pulsing solutions on increasing the vase life of different cut *Chrysanthemum* flowers as one of the most popular cut flowers. Therefore, the objectives of this study were to investigate the effect of pulsing solutions on improving the keeping quality, enhancing water uptake and extending the vase life period of cut *Chrysanthemum* flowers.

Materials and Methods

The present work was carried out in the Department of Floriculture and Landscape Architecture Laboratory, College of Horticulture, Rajendranagar, Hyderabad during the year 2017-18 and 2018-19. The experimental location, Rajendranagar is situated at an altitude of 542.3 m above mean sea level on 78° 29' East longitude and 17°19' North latitude. It falls under arid subtropical climatic zone with an average rainfall of 800 mm. The experimental flowers were held at ambient room temperature (average mean temperature of 24 °C, Maximum Relative humidity 83% and minimum of 48%) under 40W cool white fluorescent tubes.

Plant material

Flowers of *Chrysanthemum* (*Dendranthema grandiflora* L.) cultivar 'Arctic queen' were obtained from commercial farm located at Ravulavari palle village in Chevella mandal, 35 km away from the College of Horticulture, Rajendranagar. *Chrysanthemum* cv. Arctic queen is a spray type. The plant is multi-headed producing white colour flowers with green centre making the flower elegant and attractive, which fetches it a good market price. The cut stem length is about 65 -70 cm. Flower head is 6 to 8 cm diameter. The cut stem is hard and strong. The flowers were continuously held in the treatment solutions till the end of the vase life period and vase life was defined as days from the time of immersion in the test solution to the loss of ornamental value, like stem bending, blackening, wilting and abscission of petals. The experiments were repeated twice for confirmation of the results.

Experimental design and treatments

The flowers were subjected to 10 treatments of pulsing and holding solutions with 3 replications, arranged in a completely randomized design. Stems were inserted in glass bottles (500 ml) containing 250 ml of one of the following pulsing solutions at different levels: T_1- Pulsing (sucrose 5%) for 4 hours, T_2- Pulsing (sucrose 10%) for 4 hours, T_3- Pulsing (sucrose 20%) for 4 hours, T_4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours, T_5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours, T_6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours, T_7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours T_8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours, T_9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours, T_{10} - Control (without pulsing). After that, the flowers were kept in holding solution of distilled water alone.

Experimental measurements

Longevity: Time from the start of treatment until the senescence of flowers (days). Flower weight by using weighing balance. Flower head diameter measured by using scale. Water loss: Cumulative water loss was recorded for the entire period of vase life of the flower stalk (g/flower). Water uptake: Cumulative water uptake was recorded for the entire period of vase life of the flower stalk (g/flower). Relative water content (RWC) was estimated by Wheatherly method (1958) [20].

Chlorophyll content of calyx was measured with SPAD meter reading. Total soluble solids were measured by digital refractrometer. pH of vase solution measured by pH meter. Electrolyte leakage was calculated as percentage of electric conductivity.

Statistical analysis: Data were tabulated and subjected to analysis of variance as a completely randomized design with factorial concept.

Results and Discussion

The cut *Chrysanthemum* flowers under different treatments differed significantly for flower fresh weight (Table 1). Significantly highest flower fresh weight was observed with T_2 (8.26 g), followed by T_1 (8.08 g), T_3 (7.99 g). However, T_4 (6.99 g) recorded significantly lowest flower fresh weight which was on par with T_8 (7.09 g) and the remaining treatments recorded intermediate results. Significant differences were observed in flower fresh weight during different days of vase life period. The flower fresh weight decreased from day 2 (7.87 g) to day 6 (6.98 g) at each interval of observation. The interaction between days and treatments on flower fresh weight was found to be significant. On day 2, T_2 recorded maximum fresh weight (8.13 g), which was on par with T_1 (7.93 g), T_3 (7.93 g), whereas T_{10} recorded the lowest flower fresh weight (7.68 g) which was on par with T_7 (7.82 g), T_5 (7.89 g), T_6 (7.87 g), T_8 (7.80 g), T_4 (7.71g) and T_9 (7.93 g). On day 4, the highest flower weight was recorded with T_2 (8.49 g) which was on par with T_1 (8.26 g), T_3 (8.16 g) and the lowest flower weight was recorded with T_4 (7.03 g). On day 6, maximum flower fresh weight was recorded with T_2 (8.16 g) which was on par with T_1 (8.06 g), T_3 (7.87 g) and lowest flower fresh weight of cut *Chrysanthemum* was recorded with T_4 (6.22 g) which was on par with T_8 (6.35 g), T_9 (6.37 g) and T_{10} (6.62 g) and the remaining treatments recorded intermediate values of fresh weight of *Chrysanthemum* flowers. The data confirms that pulsing with sucrose 10% for 4 hours (T_2) was best in increasing the fresh weight of flowers as it helped to enhance the water uptake, sucrose acts as a source of substrate for respiration. In other treatments sodium hypochlorite might have prevented the accumulation of microbes in xylem vessels but has not improved the water uptake by the cut *Chrysanthemum* flower cv. Arcitcqueen, which might be the reason for reduced flower weight and flower diameter in most of the treatments in which sodium hypochlorite was included. These results are in accordance with finding the Rekha *et al.* (2001) [15] in cut gladiolus spikes and Tang *et al.* (2004) [17] in cut gerbera flowers.

The cut *Chrysanthemum* flowers under different treatments differed significantly for flower diameter (cm) (Table 1). The treatment T_2 has recorded the highest flower diameter (7.5 cm) which was on par with T_1 (7.3 cm) and T_3 (7.2 cm). The lowest flower diameter was recorded with T_9 (6.2 cm) and all other remaining treatments recorded intermediate values of flower diameter. There was significant difference in flower diameter during different days of vase life period. The *Chrysanthemum* flower diameter significantly decreased from day 2 (7.5 cm) to day 6 (6.1cm) at each internal of observation. The interaction effect on flower diameter between days and treatments was also found to be significant. The treatment combination of day 2 with treatment T_2 has recorded maximum flower diameter (8.2 cm), which was on par with T_1 (7.9 cm), T_3 (7.9 cm), T_{10} (7.7 cm) and T_6 (7.6 cm) and the lowest flower diameter was recorded with T_5 (7.0 cm). On day 4, the treatment T_2 had recorded higher flower diameter (7.6 cm) and the lowest flower diameter was recorded with T_9 (6.3 cm) and all other treatments recorded intermediate values of flower diameter. On day 6, the treatment T_2 (6.7 cm) and T_1 (6.7 cm) recorded highest flower diameter. The lowest flower diameter was recorded with T_9 (5.4 cm) which was on par with T_5 (5.5 cm) and the remaining treatments recorded intermediate values of flower diameter. The observation confirm that pulsing of cut *Chrysanthemum* cv. Arcticqueen with 10% sucrose for 4 hours, recorded highest flower diameter, this might be due to better water relations and also probable use of sucrose as carbohydrate source, when the natural carbohydrates are depleted sucrose is used as a substance of respiration. These results were in accordance with findings of Rekha *et al*. (2001) [15] in cut gladiolus spikes and Tang *et al.*(2004) [17] in cut gerbera flowers.

Significant differences were observed in water uptake among the treatments (Table 2). Significantly highest water uptake (13.76g) was observed with T_2 which was on par with T_1 (13.56g) and the lowest water uptake was recorded with T_9 (11.41g) and all other remaining treatments recorded the intermediate values.

The cut *Chrysanthemum* flowers differed significantly for water uptake during different days of vase life period. The water uptake increased from day 2 (11.74 g) to day 4 (13.39 g) and decreased from day 4 (13.39g) to day 6 (12.01 g). The interaction between days and treatments on water uptake (WU) was found to be significant. The treatment combination of day 2, with T_2 (12.99 g) recorded the highest water uptake and the lowest water uptake was recorded with T_4 (11.09g) which was on par with T_5 (11.29g), T_6 (11.46 g), T_7 (11.47g), T_8 (11.24 g), T_9 (11.28 g). On day 4, the highest water uptake was recorded with T_2 (15.06g) which was on par with T_1 (14.94 g) and T_3 (14.79g). Lowest water uptake was recorded with T_9 (12.20g) which was on par with T_4 (12.35 g) and T_5 (12.64g). On day 6, the highest water uptake was recorded with T_1 (13.31g) which was on part with T_2 (13.22 g), T_3 (13.18g) and T_{10} (12.88g) and all other remaining treatments recorded the intermediate values.

The data confirms that pulsing of cut *Chrysanthemum* cv. Arcticqueen with 10% sucrose was proved best in enhancing water uptake as it helped to provide source of energy as sucrose and which enhanced water uptake. In the present study water deficit has a direct effect on turgor of cut *Chrysanthemum* flowers and which decreased senescence. The sucrose concentration of 10% for pulsing effectively increased water uptake. A positive water balance was also maintained in sucrose 5%, 10% and 20% even on 6th day compared to all other treatments.

The cut *Chrysanthemum* flowers under different pulsing treatments differed significantly for transpirations loss of water (TLW) (Table 2). The highest transpiration loss of water was recorded with T_5 (15.12 g/f) which was on par with T_8 (14.80 g/f). Lowest transpiration loss of water was recorded with T_2 (12.04 g/f) followed by T_1 (12.09 g/f), T_3 (12.36 g/f) which are on par with each other and the remaining treatments recorded with intermediate values. There were significant differences in TLW during different days of vase life period. The TLW significantly increased from day 2 (12.61 g/f) to day 6 (14.83 g/f). Significantly highest transpiration loss of water was recorded on day 6 (14.83 g/f). The interaction effect of TLW between days and treatments was also found to be significant. The treatment combination of day 2 with treatment T_4 (13.41 g/f) recorded the highest TLW which was on par with T_5 (13.33 g/f), T_6 (13.07 g/f), T_7 (12.82 g/f), T_8 (13.36 g/f), the lowest value was recorded with T_2 (11.10 g/f) and the remaining treatments recorded the intermediate values. On day 4 the treatment T_5 (15.26 g/f) recorded the highest TLW which was on par with T_6 (14.89 g/f). Lowest TLW was recorded with T_1 (11.99 g/f) which were on par with T_2 (12.32 g/f). On day 6, the treatment T_5 (16.78 g/f) and T_7 (16.78 g/f) recorded the highest TLW which were on par with T_9 (16.06 g/f) and the lowest TLW as recorded with T_1 (12.64 g/f) which was on par with T_2 (12.69 g/f), T_3 (12.85 g/f) and all other remaining interactions recorded intermediate values. Pulsing with 10% sucrose recorded lowest transpiration loss of water and controlled transpiration loss of water, this might be due to higher water uptake to avoid water stress and thus led to increase the membrane viscosity. The results are in accordance with Sunanda (2007) [16] in cut carnation flowers. The lowest TLW by cut *Chrysanthemum* flowers might be due to the availability of respiratory substrate, sucrose which is responsible for maintenance of water balance in cut flowers by regulating the water loss from the cut flower *Chrysanthemum* cv. Arcticqueen further increased the longevity of flower (Marousky, 1969) [11].

The cut *Chrysanthemum* flowers held in different pulsing solutions differed significantly for fresh weight change. (Table 3). The highest fresh weight change was observed with the treatment T_2 (123.76 g) and the lowest FWC was observed with T_9 (103.14 g) and all other remaining treatments recorded the intermediate values.

There were significant differences in fresh weight change during different days of vase life period. The FWC of *Chrysanthemum* flowers gradually decreased at each successive interval of observation from day 2 (117.00 g) to day 6 (98.40 g). The interaction effect of FWC between days and treatments was also found to be significant. The treatment combination of day 2 with treatment T_2 (133.50 g) recorded the highest FWC and the lowest FWC was recorded with treatment T_5 (112.09 g). On day 4, the highest FWC was observed with T_2 (125.92g) and the lowest FWC was observed with T_9 (103.95 g). On day 6, the highest FWC was observed with treatment T_2 (111.85 g) and the lowest FWC was recorded with T_6 (91.01 g). All other remaining treatments recorded the intermediate values for FWC. According to De stigter (1980) [3], water uptake and water loss effects the fresh weight change in cut flowers, maximum water status in the flower tissue help to maintain more fresh weight of flowers. Similar results were observed by Sunanda (2007) [16] in cut carnation flowers, Prasanth (2006) [14] in cut gerbera flowers, Tsegaw *et al*. (2011) [19] in cut roses.

The cut *Chrysanthemum* flowers held in different pulsing solutions differed significantly in relative water content of petals (Table 3) Significantly highest relative water content of petals was observed with treatment T_2 (89.38%) which was on par with T_3 (89.24%). The lowest value of RWC was recorded with treatment T_4 (79.06%) and all other remaining treatments recorded the intermediate values. These were significant differences in RWC during different days of vase life period. The RWC of petals was gradually decreased from day 2 (88.15%) to day 6 (78.98%). The interaction values of RWC of petals of *Chrysanthemum* flowers between days and treatments were also found to be significant. On day 2, the highest RWC was recorded with treatment T_3 (91.36%) which was on par with T_1 (90.71%). The lowest RWC was recorded with T_4 (82.27%) and all other treatments recorded intermediate values. On day 4, the highest RWC of petals was recorded with T_3 (89.02%) which was on par with T_1 (88.68%), T_2 (88.96%), and all other remaining treatments recorded intermediate values of RWC. On day 6, the highest RWC was recorded with T_2 (88.22%) which as on par with T_1 (86.89%) and T_3 (87.35%). The lowest RWC was recorded with T_6 (70.86%) which was on par with T_7 (71.38%) and all other treatments recorded intermediate values. Highest RWC of petals was observed in pulsing treatment with sucrose 10% and the lowest RWC of petals was observed with sucrose 5% + NaOCl 50 ppm for 2 hours. The highest RWC of petals in T_2 might be due to highest WU by the flowers and also due to lowest TLW.

The chlorophyll content of calyx of flowers of cut *Chrysanthemum* recorded significant differences with regards to treatments (Table 4) The highest chlorophyll content of petals was recorded with treatment T_1 (36.90) which was on par with T_2 (36.88). The lowest chlorophyll value of calyx was recorded with T_5 (27.28) which was on par with T_7 (27.32) and all other treatments recorded intermediate values. There was significant difference in chlorophyll content of calyx with regards to days of vase life period. The chlorophyll values gradually decreased from day 2 (39.35) to day 6 (20.75). The interaction values of chlorophyll between days and treatments also recorded significant differences. On day 2, the treatment T_1 (53.83) recorded the highest chlorophyll content of calyx, the lowest value of chlorophyll was recorded with the treatment T_6 (25.27) and all other treatments recorded intermediate values. On day 4, the treatment T_2 (37.00) recorded the highest chlorophyll content of calyx, the lowest value of chlorophyll was recorded with T_4 (23.22). On day 6, the treatment T_2 (27.33) recorded the highest chlorophyll content, the lowest chlorophyll content of calyx was recorded with treatment T_4 (17.42) and all other treatments recorded the intermediate chlorophyll values. Chlorophyll content of calyx in cut *Chrysanthemum* flowers was decreased gradually because of destruction of chlorophyll pigment present in calyx and also might be due to reduction of chlorophyll in cells of *Chrysanthemum* flower. Similar results were observed by Tsegaw *et al*. (2011) [19] in cut roses.

The cut *Chrysanthemum* flowers under different treatments differed significantly on TSS content of flowers petals (Table 4) Significantly highest TSS content of petals was recorded with treatment T_2 (4.0) and T_3 (4.0) which was on par with T_6 (3.9), T_1 (3.8), T_8 (3.7), T_9 (3.6) and T_7 (3.6). The lowest TSS content of petals was recorded with treatment T_5 (2.7) which was on par with T_4 (3.1). There were significant differences observed in TSS of flowers petals during different days of vase life period. The TSS values of flowers petals increased gradually from day 2 (2.9) to day 4 (4.4). The interaction between days and treatments on TSS of flower petals was found to be significant. The treatment combination of day 2, with treatment T_2 (3.4) recorded the highest TSS values which on par with T_1 (3.1), T_3 (2.9), T_9 (2.8) and T_6 (2.8), the lowest TSS value was recorded with treatment T_5 (2.2) which was on par with T_8 (2.6). On day 4, the highest TSS was recorded with treatment T_3 (4.3) which was on par with T_1 (3.8) T_8 (3.8), T_9 (3.8) and T_2 (3.7) and the lowest TSS value was recorded with T_5 (2.4) which was on par with T_4 (2.9). On day 6, the highest TSS was recorded with treatment T_2 (4.9) and T_3 (4.9) followed by T_6 (4.7), T_8 (4.7) and the lowest TSS value was recorded with treatment T_5 (3.6) followed by T_4 (3.7), T_7 (4.0) and all other treatments recorded the intermediate values. TSS increase is more in treatments pulsed with sucrose 5%, 10%, 20% concentrations which lead to increased levels of fructose and glucose in flower petals. The increase of TSS gradually might be due to decrease of water content in flower petals might have increased the relative concentration of total sugars in flower petals. Nair *et al.* (2003) [13].

The cut *Chrysanthemum* flowers held in different pulsing treatments differed significantly for pH of vase solution (Table 5) The highest pH value of vase solution was recorded with the treatment T_6 (7.68) which was on par with T_4 (7.66), T_5 (7.65). The lowest pH value was recorded with the treatment T_{10} (6.00) and all others remaining treatments recorded the intermediate values. There were significant differences in pH value of vase solution during different days of vase life period. The pH values of vase solution was gradually deceased from day 2 (7.53) to day 6 (6.79). The interaction effect of pH of vase solution between days and treatments was also found to be significant. The treatment combination of day 2 with treatment T_9 (8.15) recorded the highest pH which was on par with T_5 (8.00) followed by T_6 (7.91) and T_4 (7.87), the lowest pH of vase solution was recorded with treatment T_{10} (6.05) and all other remaining treatments recorded the intermediate values for pH of vase solution. On day 4, the highest pH of vase solution was recorded with T_4 (7.85) which was on par with T_6 (7.71). On day 6, the highest pH of vase solution was recorded with T_5 (7.47) which was on par with T_6 (7.43). The lowest pH of vase solution was recorded with T_{10} (5.95). The remaining treatments were recorded the intermediate values for pH of vase solution of cut *Chrysanthemum* flowers.

The cut *Chrysanthemum* flowers under different treatments differed significantly on electrolyte leakage (Table 5). Significantly highest electrolyte leakage values was recorded with the treatment T_5 (94.31%) which was on par with T_9 (92.44%) and the lowest electrolyte leakage was recorded with the treatment T_2 (82.03%) which was on par with T_1 (83.69%), T_3 (84.10%) and all other remaining treatments recorded the intermediate values. Significant differences were observed in electrolyte leakage during different days of vase life period. The electrolyte leakage values gradually increased from day 2 (85.76%) to day 6 (92.36%) at each interval of observation. The interaction values for electrolyte leakage between days and treatments were also found to be significant. On day 2, highest electrolyte leakage was recorded with T_5 (91.25%) which was on par with T_4 (88.49%) and the lowest electrolyte leakage was recorded with T_2 (80.86%). On day 4, the highest electrolyte leakage was recorded with T_5 (93.27%) which was on par with T_4 (91.69%), T_6 (91.02%), T_9 (92.08%) and the lowest electrolyte leakage value was recorded with T_2 (81.73%) which was on par with T_1 (83.69%), T_3 (83.75%). On day 6, the electrolyte leakage highest values was recorded with T_9 (98.55%) which was on par with T_5 (98.41%), T_6 (96.47%) and the lowest electrolyte leakage was recorded with the treatment T_2 (83.49) and all other remaining treatments recorded the intermediate values. The maintenance of membrane integrity led to better water relations in the flower tissues there by lowest electrolyte leakage was recorded in treatments with sucrose. Similar results were reported by Prasanth (2006) [14], Anjum *et al*. (2004) in cut gerbera flowers.

The vase life of cut *Chrysanthemums* held in different vase solutions differed significantly, the highest vase life was recorded for treatment T_2 (10.23 days) which was significantly highest over other treatment followed by T_1 (8.7 days), T_3 (8.83 days), the lowest vase life was recorded with T_{10} (5.92 days) and all other remaining treatments recorded the intermediate values for vase life (Table 6). Pulsing with sucrose 10% concentration exhibited highest vase life of cut *Chrysanthemum* flowers might be due to better water relations by providing food as sucrose for metabolic activities like transpiration and respiration. Which is in line with Li *et al.* (2003) [9], kumar and Bhatttacharjee (2004) [8] in cut rose, Hongyi and Jinzhi (2005) [5] in cut lilies and Ichimura *et al.* (2005) [6] in cut rose, further sucrose in the vase solution might have increased the pool of dry matter and respirable substrate.

The overall acceptability of flowers held in different treatments differed significantly. The highest overall acceptability of flowers was recorded treatment T_2 (9.22) which was significantly superior over all other treatments and was on par with treatments T_1 (9.10) and T_3 (8.63). The lowest overall acceptability of flowers was recorded with treatment T_5 (6.54) which was on par with T_6 (6.72), T_7 (7.27), T_8 (7.19), T_9 (7.03) and T_{10} (7.71) (Table 6). Pulsing of sucrose 10% concentration recorded highest overall acceptability of cut *Chrysanthemum* cv. Arcticqueen might be due to good water uptake, lower transpiration loss of water, maintaining good water balance in cut flower.

Table 1: Effect of pulsing with sucrose and sodium hypochlorite on flower diameter (cm) and flower weight (g) of cut *Chrysanthemum* cv. Arcticqueen

	Flower diameter				Flower weight			
Treatments	2nd	4th	6th	Mean	2nd	4th	6th	Mean
T1- Pulsing (sucrose 5%) 4 hours	7.9	7.2	6.7	7.3	7.93	8.26	8.06	8.08
T2- Pulsing (sucrose 10%) 4 hours	8.2	7.6	6.7	7.5	8.13	8.49	8.16	8.26
T3- Pulsing (sucrose 20%) 4 hours	7.9	7.3	6.3	7.2	7.93	8.16	7.87	7.99
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	7.3	6.8	5.7	6.6	7.71	7.03	6.22	6.99
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	7.0	6.6	5.5	6.3	7.89	7.40	6.90	7.40
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	7.6	7.1	5.9	6.9	7.87	7.28	6.92	7.36
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	7.5	7.0	6.1	6.9	7.82	7.66	6.33	7.27
T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	7.3	6.9	6.0	6.7	7.80	7.12	6.35	7.09
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	7.1	6.3	5.4	6.2	7.93	7.50	6.37	7.27
T10 - Control (without pulsing)	7.7	7.1	6.0	6.9	7.68	7.39	6.62	7.23
Mean	7.6	6.2	6.1	6.8	7.87	7.63	6.98	7.49
	F test		Sem	CD(0.01)	F test		Sem	CD(0.01)
Treatment	**		0.10	0.36	**		0.07	0.27
Day	**		0.05	0.20	**		0.04	0.15
TXD	**		0.17	0.63	**		0.12	0.46

Table 2: Effect of pulsing with sucrose and sodium hypochlorite on water uptake (g/f) and transpiration loss of water of cut *Chrysanthemum* cv. Arcticqueen

	Water uptake				**Transpiration loss of water**			
Treatments	**2nd**	**4th**	**6th**	**Mean**	**2nd**	**4th**	**6th**	**Mean**
T1- Pulsing (sucrose 5%) 4 hours	12.43	14.94	13.31	13.56	11.65	11.99	12.64	12.09
T2- Pulsing (sucrose 10%) 4 hours	12.99	15.06	13.22	13.76	11.10	12.32	12.69	12.04
T3- Pulsing (sucrose 20%) 4 hours	12.06	14.79	13.18	13.34	11.78	12.44	12.85	12.36
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	11.09	12.35	10.53	11.32	13.41	14.40	15.59	14.46
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	11.29	12.64	11.80	11.91	13.33	15.26	16.78	15.12
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	11.46	13.09	12.19	12.25	13.07	14.89	15.41	14.46
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	11.47	12.87	11.20	11.85	12.82	14.32	16.78	14.64
T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	11.24	12.65	11.01	11.63	13.36	15.11	15.91	14.80
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	11.28	12.20	10.75	11.41	13.01	14.48	16.06	14.52
T10 - Control (without pulsing)	12.08	13.31	12.88	12.76	12.56	13.05	13.56	13.06
Mean	11.74	13.39	12.01	12.38	12.61	13.82	14.83	13.75
	F test		Sem	CD(0.01)	F test		Sem	CD(0.01)
Treatment	**		0.07	0.25	**		0.11	0.40
Day	**		0.04	0.14	**		0.06	0.22
TXD	**		0.12 0.44		**		0.19	0.70

Table 3: Effect of pulsing with sucrose and sodium hypochlorite on RWC (%) of petals and fresh weight change (g) of cut *Chrysanthemum* cv. Arctic queen.

	Relative water content of petals				**Fresh weight change**			
Treatments	**2nd**	**4th**	**6th**	**Mean**	**2nd**	**4th**	**6th**	**Mean**
T1- Pulsing (sucrose 5%) 4 hours	90.71	88.68	86.89	88.76	116.86	113.62	105.45	111.98
T2- Pulsing (sucrose 10%) 4 hours	90.96	88.96	88.22	89.38	133.50	125.92	111.85	123.76
T3- Pulsing (sucrose 20%) 4 hours	91.36	89.02	87.35	89.24	118.68	113.63	107.26	113.19
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	82.27	82.20	72.72	79.06	115.84	109.63	92.88	106.12
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	85.21	82.65	77.25	81.70	112.09	108.32	96.47	105.63
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	88.91	86.48	70.86	82.08	115.49	108.07	91.01	104.86
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	88.26	87.11	71.38	82.25	114.80	106.43	94.38	105.21

T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	88.07	85.27	73.68	82.34	112.87	105.66	91.99	103.51
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	86.80	85.82	78.13	83.59	113.87	103.95	91.61	103.14
T10 - Control (without pulsing)	88.91	86.50	83.28	86.23	115.96	111.85	101.07	109.63
Mean	88.15	86.27	78.98	84.46	117.00	110.71	98.40	108.70
	F test		Sem	CD (0.01)	F test		Sem	CD (0.01)
Treatment	**		0.10	0.37	**		0.09	0.34
Day	**		0.05	0.20	**		0.05	0.18
TXD	**		0.17	0.63			0.15	0.58

Table 4: Effect of pulsing with sucrose and sodium hypochlorite on chlorophyll content of calyx and TSS of cut *Chrysanthemum* cv. Arcticqueen

	Chlorophyll content of calyx				**Total soluble solids**			
Treatments	**2nd**	**4th**	**6th**	**Mean**	**2nd**	**4th**	**6th**	**Mean**
T1- Pulsing (sucrose 5%) 4 hours	53.83	34.69	22.17	36.90	3.1	3.8	4.6	3.8
T2- Pulsing (sucrose 10%) 4 hours	46.31	37.00	27.33	36.88	3.4	3.7	4.9	4.0
T3- Pulsing (sucrose 20%) 4 hours	45.65	30.22	23.68	33.19	2.9	4.3	4.9	4.0
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	43.60	23.22	17.42	28.08	2.7	2.9	3.7	3.1
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	32.41	28.13	21.29	27.28	2.2	2.4	3.6	2.7
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	25.27	50.47	17.47	31.07	2.8	4.2	4.7	3.9
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	35.80	30.60	15.57	27.32	3.1	3.6	4.0	3.6
T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	42.62	24.68	18.86	28.72	2.6	3.8	4.7	3.7
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	34.70	30.61	20.30	28.54	2.8	3.8	4.4	3.6
T10 - Control (without pulsing)	33.30	30.23	23.37	28.96	3.7	3.6	4.6	4.0
Mean	39.35	31.99	20.75	30.69	2.9	3.6	4.4	3.7
	F test		Sem	CD(0.01)	F test		Sem	CD(0.01)
Treatment	**		0.10	0.37	**		0.10	0.37
Day	**		0.05	0.20	**		0.05	0.20
TXD	**		0.17	0.64	**		0.17	0.64

** Significant at ($P \leq 0.01$) * Significant at ($P \leq 0.05$) NS: Not significant.

Table 5: Effect of pulsing with sucrose and sodium hypochlorite on pH of vase solution and electrolyte leakage of *Chrysanthemum* cv. Arcticqueen

	pH of vase solution				**Electrolyte leakage**			
Treatments	**2nd**	**4th**	**6th**	**Mean**	**2nd**	**4th**	**6th**	**Mean**
T1- Pulsing (sucrose 5%) 4 hours	7.24	7.00	6.33	6.85	81.91	83.69	85.46	83.69
T2- Pulsing (sucrose 10%) 4 hours	7.22	7.11	6.51	6.95	80.86	81.73	83.49	82.03
T3- Pulsing (sucrose 20%) 4 hours	7.35	6.92	6.57	6.95	82.15	83.75	86.41	84.10
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	7.87	7.85	7.26	7.66	88.49	91.69	94.47	91.55
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	8.00	7.46	7.47	7.65	91.25	93.27	98.41	94.31
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	7.91	7.71	7.43	7.68	87.44	91.02	96.47	91.64
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	7.79	7.35	7.16	7.43	85.88	88.88	91.68	90.60
T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	7.76	7.14	6.43	7.11	87.58	89.81	93.41	90.27
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	8.15	6.82	6.77	7.25	86.69	92.08	98.55	92.44
T10 - Control (without pulsing)	6.05	6.00	5.95	6.00	85.42	89.64	95.33	90.13
Mean	7.53	7.14	6.79		85.76	88.55	92.36	
	F test		Sem	CD(0.01)	F test		Sem	CD(0.01)
Treatment	**		0.02	0.08	**		0.62	2.33
Day	**		0.01	0.05	**		0.34	1.27
TXD	**		0.04	0.15	*		1.08	3.06

Table 6: Effect of pulsing with sucrose and sodium hypochlorite on vase life and overall acceptability of cut *Chrysanthemum* cv. Arcticqueen

Treatments	**Vase life of flowers**	**Over all acceptability of flowers of flowers of flowers of flowers**
T1- Pulsing (sucrose 5%)	8.7 b	9.10
T2- Pulsing (sucrose 10%)	10.23 a	9.22
T3- Pulsing (sucrose 20%)	8.83 b	8.63
T4 - Pulsing (sucrose 5% + NaOCl 50 ppm) for 2 hours	6.22 e	6.69
T5 -Pulsing (sucrose 5% + NaOCl 50 ppm) for 4 hours	6.03 f	6.54
T6 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 2 hours	7.36 c	6.72
T7 - Pulsing (sucrose 10% + NaOCl 50 ppm) for 4 hours	7.38 c	7.27
T8 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 2 hours	7.12 d	7.19
T9 - Pulsing (sucrose 20% + NaOCl 50 ppm) for 4 hours	6.24 e	7.03
T10 - Control (without pulsing)	5.92 f	7.71
Mean	7.56	7.61
F test	**	**
Sem	0.05	0.28
CD(0.01)	0.14	1.22

** Significant at ($P \leq 0.01$) * Significant at ($P \leq 0.05$) NS: Not significant.

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