EFFECT OF PULSING, PACKAGING AND STORAGE TREATMENTS ON VASE LIFE OF CHRYSANTHEMUM CUT FLOWERS

THESIS

BY

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C E R T I F I C A T E - I

This is to certify that the thesis entitled **"Effect of pulsing, packaging and storage treatments on vaselife of chrysanthemum cut flowers"** submitted in partial fulfilment for the award of the degree of **MASTER OF SCIENCE** in **POSTHARVEST TECHNOLOGY** to Dr. Y. S. Parmar University of Horticulture and Forestry, Solan is a record of bonafide research work carried out by **Ms. ANJU BHAT** (H-93-6-M) under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance received by her during the course of investigation has been fully acknowledged.

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C E R T I F I C A T E - II

This is to certify that the thesis entitled "**Effect of pulsing, packaging and storage treatments on vaselife of chrysanthemum cut flowers**" submitted by **Ms ANJU BHAT** (H-93-6-M) to Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **POSTHARVEST TECHNOLOGY** has been approved after an Oral Examination of the same in collaboration with the representative of the Dean.

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Needless to say, errors and omissions are mine.

Solan
Oct., 1995

(ANJU BHAT)

C O N T E N T S

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LIST OF ABBREVIATIONS

$AgNO_3$	Silver nitrate
$Al_2(SO_4)_3$	Aluminium sulphate
BA	6-Benzyladenine
°C	Degree centigrade
cm	Centimeter
$CoCl_2$	Cobalt chloride
cv.(s)	Cultivars
df	degree of freedom
°F	Degree Fahrenheit
Fig.	Figure
gm	gram
GA_3	Gibberlic acid
hr(s)	hour(s)
8-HQ	8-hydroxyquinoline
8-HQC	8-hydroxyquinoline citrate
8-HQS	8-hydroxyquinoline sulphate
lt	litre
M	Molar
m	meter
ml	milli litre
mM	millimolar
MSS	Mean sum of squares
nM	nano meter
ppm	Parts per million
RH	Relative humidity
STS	Silver thiosulphate
vs	Versus
%	Per cent
**	significant at 5% level of significance (in appendix I only)
$\propto$	Infinity

Chapter 1

INTRODUCTION

INTRODUCTION

Chrysanthemum (***Chrysanthemum morifolium*** Ramat) is one of the leading commercial flowers grown throughout the world. It is important both as a cut flower and pot plant. Commercially, for Florists chrysanthemum, the method of propagation from suckers as well as rooted cuttings is followed. The inflorescence is classified by the type and arrangement of florets. Being a short day plant, the natural period of flowering of chrysanthemum in India is November - December which coincides with the maximum demand of flowers in Europe and other countries.

Karnataka state is the leading producer mostly of loose cut flowers of chrysanthemum. The other states with significant area devoted to its production are Tamil Nadu, Maharashtra, Rajasthan and Gujrat. India's share in floricultural products was about Rs. 84.4 lakhs in 1983 and the value of trade increased by about 10 per cent every year (Gowda, 1987). In 1990, the worldwide trade in cut flowers fetched $ 100 billion, up from $ 60 billion in 1987 (Menon, 1991). Chrysanthemum is next only to roses in importance among the flower crops in the world. In Japan, it is the national flower and is regarded as the symbol of royalty. In England, the popularity of chrysanthemum as exhibition flower is at its peak and as a commercial crop

it occupies the second position in the value of crop produced. In Indian trade, it has been recognised as one among the five important commercially potent flower crops by All India Co-ordinated Floriculture Improvement Project of Indian Council of Agricultural Research (ICAR).

The aesthetic importance of chrysanthemum is due to its unparalleled diversity in shape, size, form, colour and blooming pattern. It has become an important source of income and integral part of beautification in indoor arrangements. In India, there is a great demand of cut flowers in metropolitan cities like Bombay, Madras, Calcutta and Delhi. Besides, their aesthetic importance, cut flowers contribute to amelioration of the polluted environment.

Most cut flowers have a limited vaselife. The high perishability of cut flowers makes them vulnerable to large postharvest losses. A report of National Floriculture Conference on commodity Handling states that approximately 20% of all floral crops are unsaleable due to improper handling. Although preharvest factors affect the postharvest life of cut flowerss, still there is a wide scope for increasing the vaselife of cut flowers using various postharvest management practices.

To preserve the best quality of flowers after harvest and to make them tolerant to fluctuations in the environmental conditions, treatment with floral

preservatives are recommended. These may be applied to flowers during the entire marketing chain from growers to wholesalers, retail florists and final purchasers. Floral preservatives affect the quality of flowers by prolonging the vaselife, increasing flower size, and maintaining the colour of leaves and petals. Most preservatives contain carbohydrates, germicides, ethylene inhibitors, growth regulators and some mineral compounds. Carbohydrates are the main source of nutrition for flowers and support the processes fundamental to prolonging vaselife, such as maintaining mitochondrial structure and functions, improving water balance by regulating transpiration and increasing water balance.

Appropriate packaging is an indispensable aspect of handling flowers and much depends on proper method of packing to ensure garden fresh quality of flowers for the consumers. Packing should protect flowers against physical damage, water loss and external conditions detrimental to transported flowers. It is often an advantage to wrap the bunches of flowers in paper or cellophane and then place the bunches in boxes made of corrugated fibreboard.

The storage of cut flowers makes it possible to adjust supply to market demands, and hence prevents gluts in the market. Low temperature is the most important factor in the successful storage of cut flowers as it slows down respiration rate. High relative humidity i.e. 90-95% is

optimum for cut flowers for slowing down transpiration. Storage life may be reduced if cut flowers are overmature or too immature. So cut flowers should be harvested at an appropriate stage of maturity.

Flowers such as gladioli, narcissi, tulips and roses develop well in water alone after storage whereas carnations and chrysanthemums open when treated with opening solutions.

After receiving cut flowers in retail shops or in houses, they are unpacked and placed in preservative solutions so that they remain fresh for longer time.

In India infrastructure is inadequate for the production of floral crops for export and floriculture industry is only at a budding stage. Improvement of keeping quality and enhancement of the vaselife of cut flowers are important areas of postharvest research. But until relatively recently, much work has not been done and more is yet to be done on this aspect especially in the midhills of Himachal Pradesh. The present investigations were, therefore, conducted with the following objectives with respect to cut flowers of chrysanthemum:

1. To find out the best pulsing treatment.
2. Comparison between two wrapping materials.
3. Standardization of storage method of chrysanthemum cut flowers.

Chapter 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Very little information is available in India on work done on cut flower physiology and handling. However, reports are available from other countries and the existing literature has been reviewed here.

Mayak (1987) suggested that in studying senescence of cut flowers, one should select ambient conditions (20-25°C temperature, 60-80% RH and constant cool white flourescent light) as a reference situation. Halevy and Mayak (1979) reported that the conditions during measurement greatly affect longevity. The most important of those are temperature, relative humidity, light, air velocity and ethylene concentration. They proposed that the term 'vaselife' should represent the potential useful longevity of the flower at the final consumer's home. Therefore, measurement of vaselife should not include the time of pretreatment and transport. The composition of holding solutions and quality of water also greatly affect longevity. (*Farnham et al.* 1971).

Chrysanthemums should be grown under high fertility levels without allowing high salt accumulation as a result of which flower quality can be reduced resulting in smaller flowers, shorter and weaker stems and flowers with shorter vaselife (Rutland, 1972).

Shinbori (1992) recommended cooling an essential process in the preservation of cut flowers. Vacuum cooling gave a more rapid decrease in temperature than other methods and rate of cooling was lower in lilies and chrysanthemums than in carnations. Wiersma and Boer (1974) reported that when precooled flowers were transported in a refrigerated lorry, there was less variation in temperature. He concluded that refrigerated flowers had little effect on flowers, that had not been precooled, but it kept the temperature of precooled flowers to the desired level. Also vacuum cooling was recommended as quickest method of cooling.

Pulsing is a preshipment short-term treatment the effect of which lasts for entire shelf life of flower even when it is held in water. The main ingredient of various pulsing solutions is sucrose which is often used in concentrations several time higher than that used in preservative formulations. However, for different flowers optimum concentration varies. The main reason for this concentration variability is the sensitivity of foliage of some plants to excessive sugar concentration (Halevy, 1976). Kesta (1989) studied the effects of various pulsing solutions on vaselife of cut chrysanthemum cv. Yellow Doi Khan in leaves and petals in relation to fresh weight changes, decay of stem-base and wilting. Chrysanthemums pulsed in 50mg/lt 8-HQS + 5% sucrose for 20 hours had

longest vaselife (7.5 days) while as non-pulsed flowers had lesser vaselife of 3.17-4.17 days. Su ***et al.*** (1991) pulsed cut blooms of chrysanthemum cv. Guangdong yellow in 5% sucrose + 0.3 mM STS or 5% sucrose + 50 ppm $AgNO_3$ + 150 ppm citric acid for 16 hours, then stored at 0°C for upto 5 weeks. The treatment increased flower soluble sugars during the first two weeks of storage with STS having greater effect.

Chrysanthemum flower stems (cvs. Polaris and Vero) were pulsed in solutions of 0.25gm nonylphenolpolyglycolether (detergent) per litre, 1 to 5 ppm GA_3, 150 to 200 ppm cytokinin or 25 ppm STS and in combination of these treatments for 4 or 24 hours at 10-15°C, 60-80% RH in dark, then stored in cardboard boxes for 5 days comprising 2 days in a cool cell (4.5°C), 2 days at room temperature (18°C) and 1 day again at 4.5°C. After storage, the stems were placed in vases at room temperature and it was observed that the combination of GA_3, STS and detergent delayed leaf wilting and yellowing for 10 days (D'hont ***et al.*** 1991). Halevy ***et al.*** (1978) obtained the best results with 'Albatross' standard chrysanthemums, when flowers were pretreated after harvest with 5% sucrose + 500 ppm sodium dichloro-s-trizinetrione + 200 ppm citric acid for 16 hours, precooled prior to shipment and shipped in insulated boxes with ice in end bunkers. Pulsing increased longevity and bloom diameter.

Comparison of costs and protection form injury were made between a slotted fibre board box, a semitelescoping polystyrene foamboard box and a semitelescoping fibre board box as a shipping container for chrysanthemums. There was little or no injury to flowers in any of the container but stem blockage was highest in semitelescoping fibre board box (Hagen and Hinsch, 1971).

Krahn (1978) reported that using a standard grower pack showed, that losses from mechanical damage in the form of shattered chrysanthemum blooms was high as 15%. A standard grower pack where individual blooms were packed separately and boxes lined with polythene was modified by (a) bunching flowers with protective sleeves covering each bunch, (b) bunching without protective sleeves, (c) sealing bunches in plastic bags, (d) using plastic sleeves to protect individual blooms. These modifications allowed more flowers to be packed per box and reduced mechanical damage during handling and transportation. The best blooms were obtained from (c) and (d) variant. Precooling before packing also improved bloom quality. Cut chrysanthemums stored at 40°F and 97% RH maintained acceptable quality for an additional 4 to 5 days at room temperature. Further storage under continuous light also increased keeping quality by an average of 4 to 5 days compared with flowers kept under day light only.

Kofranek *et al.* (1975) stored buds of *chrysanthemums, 5-12 cm in diameter* with 60 cm stem length, at low temperature (-0.5° to 1.5°C) for upto 5 weeks and then opened them in sucrose solution containing 25 ppm $AgNO_3$ + 75 ppm citric acid at 21°C and 10.8 K lux. The smaller sized buds developed flat heads when stored for over two weeks, the disc florets failed to develop fully, unlike large buds (10-12 cm); however Kofranek and Halevy (1972) reported 25 ppm $AgNO_3$ + 75 ppm citric acid + 2 to 5% sucrose, the best preservative solution for opening bud cut chrysanthemums at 21 to 22°C and 80 to 100 ft.c.

The bud cut flowers of chrysanthemum at low temperature (-0.5° to 0.5°C) were dry stored for 3 weeks (Marousky, 1972). Then the buds held at 23.3°C and 75 ft.c. in 200 ppm 8-HQC + 2% sucrose opened and were similar in form and quality to flowers opened on plant. Both intact and cut flowers held in above solution increased in carbohydrate content, fresh weight and dry weight. Hauge *et al.* (1950) reported that after 7 days in dry storage (4.4° to 7.2°C) without any pretreatment the pompon type chrysanthemums remained in an acceptable condition for 5 to 6 days and thus treated mums could be stored longer with improved vaselife. 'Albatross' standard chrysanthemums after harvesting were conditioned overnight (19 hrs) at ambient temperature (10-24°C) in solution containing deionized water (DI) + 25 ppm $AgNO_3$ and it gave maximum

vaselife of 16.6 days (Farnham **et al.** 1979). Preconditioning chrysanthemum stems in $AgNO_3$ solution eliminated the need to recut stems after shipment.

Chrysanthemum cv. 'Jyotsna' with 35 mm long stalks were dipped in injection vials containing test-solutions by Saradhi (1989). In cobalt chloride ($5x10^{-4}$ M) + sucrose (0.1 M), the vaselife was increased to between 22 and 24 days compared to 7 days in control; where as Chandra **et al.** (1981) obtained maximum vaselife (16 days) in chrysanthemum cv. 'Combatore Yellow' with $CoCl_2$ (750 uM) + sucrose (0.1 M) compared to 10 days in control. Mani (1992) reported that in chrysanthemum cvs. Shyama and Kundan, the vase solution (0.5 mM STS + 2% sugar) gave maximum vaselife (24.4 and 20.6 days respectively), whereas pulsing in STS (4mM) for 15 minutes gave greater longevity in same cvs. of chrysanthemum.

According to Lukaszewska (1980), when chrysanthemum cvs. 'Bronze Bornholm' and 'Crimson Robe' with 50-60 mm diameter and 50 cm stems, were placed in vase solutions containing 5 to 20% sucrose + 8-HQC at 200-500 ppm, vaselife in 'Bronze Bornholm' was longest (13.6 days) in flowers kept in 20% sucrose + 8-HQC (500 ppm) compared with 9.3 days in control; whereas the most effective compound to extend the vaselife of ***Chrysanthemum frutescence*** cv. 'Stradine Banaca', according to Giribaldi and Deambrogio (1988) was 8-HQC (200 ppm) + sucrose (2%). Woltz and

Engelhard (1971) also reported 200 ppm 8-HQC + 2% sucrose the best holding solution for increasing vaselife in chrysanthemum. Immersing the cut stems for 24-72 hrs. in thiabendazole (TBZ) and sucrose solution, improved quality and extended vaselife of chrysanthemums cut at bud stage (Apelbaum and Katchansky, 1981).

According to Wang and Baker (1979), the addition of rhizobitoxine analogs (0.1 mM) to holding solutions extended vaselife of chrysanthemums ; whereas the addition of 5% detergent disinfectant (conson) to holding solutions at the rate of 3 drops per litre to retard microbial activity and enhance water uptake in cut chrysanthemums was reported by Waters (1968). Staby and Robertson (1982) reported that cytokinins in the form of BA (Benzyl adenine) are used to retard the chlorophyll breakdown in chrysanthemum and statice foliage as a postharvest spray or dip and is used in some flower preservative solutions.

Khattab *et al.* (1987) investigated the effects of 3 concentrations (0, 2.5 and 5.0%) of an antitranspirent (Vapor Gard) and 4 concentrations of sucrose (0, 2, 5 and 10%), used singly or in combinations, on the vaselife of chrysanthemum cv. Jalaxy cut at bud stage. Using the antitranspirent alone at 5% significantly increase vaselife and inflorescence diameter while adding 5 and 10% sucrose resulted in an increase in inflorescence dry weight, stalk

dry weight and reducing sugar content in petals of chrysanthemum.

Marousky (1973) observed that the stem harvested at 5 cm above the soil and held in water or 8-HQS + sucrose decreased in fresh weight, wilted and absorbed less liquid than the stems harvested at 20 cm. D'hont (1989) observed that postharvest treatment with quarternary ammonium compounds (35 ppm) was effective in delaying wilting, thus prolonging chrysanthemum vaselife after storage. It was found out that the treatment had to exceed 8 hrs in order to be effective.

Paulin (1992) studied changes in ethylene and free radicle production, lipoxygenase activity and electrolyte leakage during flower senescence. A new strategy is presented for prolonging flower life using lipoxygenase inhibitors and free radicle scavengers. Singh and Moore (1992) reported that the wilting of florets in chrysanthemum is associated with a decline in water potential of flowers and leaves. Vascular occlusion in the stems occurred 3 days after harvest and the degree of vascular blockage increased with time which was accompanied by a decline in stem conductance. Likewise, it was reported by Marousky (1972) that loss of turgor or moisture depletion in cut flowers contribute to deterioration, and suggested that quinoline salts + sucrose reduce moisture stress.

In carnations, Halevy *et al.* (1978) reported that pretreatment with 10% sucrose + 50 ppm $AgNO_3$ + 150 ppm citric acid + 25 ppm 8-HQC + 100 ppm PBA for 16 hr. to be the best for increasing longevity and bloom diameter. However, Halevy and Kofranek (1977) increased longevity by directly coating the flowers of carnations with Ag ions by spraying or momentarily dipping flower heads in $AgNO_3$ (100 ppm).

Mori *et al.* (1981) reported that STS (4mM) + Physan (200 ppm) treatment before shipping extended vaselife of 'Scania' and 'Elegance' cultivars of carnation; whereas Goszczynska and Rudnicki (1983) dry stored carnation buds at 0-1°C after pulsing with 4.5 mM STS + 10% sucrose and opened in a solution containing 8-HQC (200 ppm) + $AgNO_3$ (25 ppm) + 7% sucrose. After 20 and 24 weeks of storage flowers had a vaselife of 12 and 6 days respectively. However, cvs. Red Ivetta and Sancho of carnations dry stored at 0-1°C for 3 months after treatment with Roval (0.1%) and overnight conditioning with 4.5 mM STS + 10% sucrose gave a vaselife 1.8 and 14.3 days respectively in 200 ppm 8-HQC + 5% sucrose (Rudnicki *et al.* 1989).

Holley and Cheng (1967) suggested that Cornell solution (200 ppm 8-HQC + 50ppm $AgNO_3$ + 5% sucrose) and Everbloom in low concentration were suitable for opening carnation buds even after dry storage of 2 weeks at 0.5°C.

Mayak and Dilley (1976) proposed that the effect of kinetin in extending longevity of carnations can be enhanced with supplementing sugars and reported a vaselife of 13.6 days in 0.23 mM kinetin + 5% sucrose compared to 5.3 days in control.

Kofranek and Halevy (1976) pulsed gladiolus stems at 21°C with 20 per cent sucrose in combination with 1000 ppm $AgNO_3$ before storage (2°C) for 7 or 10 days which resulted in greater floret opening and size than non-pulsed flowers.

Novak and Rudnicki (1984) reported that pretreatment of 'Dukat' gladiolus spikes with 4.5 mM STS + 5% sucrose, wrapped and stored upright at 4°C for 2 or 4 weeks was best without any reduction in vaselife.

Marousky (1968) held cut gladiolus spikes in 8-HQ (600 ppm) and sucrose (4%) and reported extension in vaselife; whereas Rameshwar (1974) found $Al_2(SO_4)_3$ an ideal preservative because of free availability, low cost, low pH and nontoxicity. The effectiveness of 0.1% $Al_2(SO_4)_3$ + 4% sucrose for vaselife of cut gladioulus cv. Friendship was equivalent to that of 8-HQ+sucrose.

Halevy and Mayak (1979) reported that the final stages of flower development are characterized by a decline in content of carbohydrates and dry weight of petals. The

respiratory pool is affected by rate of hydrolysis of starch and other polysaccharides.

Borochov and Woodson (1989) found that carbohydrate status of the petals is one of the factors which ultimately determine their longevity. The lack of availability of substrates for respiratory metabolism leads to petal senescence which is associated with a loss of carbohydrate including starch and reducing sugars. The senescent tissues often contain as much as 1 to 2 per cent reducing sugars.

Woltz and Engelhard (1971) reported that, of sugars determined, fructose was present in lowest amount followed by sucrose and glucose. Starch accounted for one third of total carbohydrates and the standard cultivars contained an average of 24% more total carbohydrates in chrysanthemum leaves than pompons.

Chapter 3

MATERIAL AND METHODS

MATERIAL AND METHODS

The cut flowers for present studies were collected from the experimental farms of the Department of Floriculture and Landscaping during 1994-95. The farm is located in the hills of Western Himalayas at an altitude of 1200 m above mean sea level.

3.1 Cultural Practices

For raising the crop, standard cultural practices were followed. The rooted cuttings of chrysanthemum were transplanted in June, so as to get flowers during October - November. The flowers were harvested in the morning at about 8 a.m.

3.2 Postharvest Handling

Cut flowers of two cvs. viz. Mountaineer (a standard type) and Kundan (a spray type with 3 to 5 flowers per stem) were used. The stem length of harvested cut flowers of cv. Mountaineer was 50-55 cm and that of cv. Kundan it was 40-45 cm. After harvesting the cut flowers were immediately placed in buckets filled with cold water and taken to laboratory within an hour for subsequent handling. Subsequent handling of cut flowers was done in the air conditioned laboratory at 22±2°C temperature and

40-45% RH with 1.24 k lux light intensity at flower level provided by Bajaj 40 watts cool day light flourescent tubes. The lower leaves were removed before putting the cut flowers into solutions in the glass cylinders. A clean slanting cut was given 1-2 cm above the lower ends of flower stems before putting them into solutions. Five cut flowers were placed in each cylinder containing 500 ml of treatment solution. Distilled water was used for preparing different solutions. Silver thiosulphate was prepared by the method given by Reid ***et al.*** (1980).

Table 1. Harvesting stage for cut flowers

Name of cut flower	Cultivar	Colour	Type	Harvesting stage
Chrysan-themum	Mountaineer	Yellow	Standard	Outer ray florets cease to elongate and the centre of the flower is well developed.
	Kundan	Yellow	Spray	When central florets of the topmost flower are fully developed.

3.3 Experiment-I (Holding solutions)

The cut flowers were placed in different holding solutions prepared from silver thiosulphate (STS), 8-hydroxyquinoline (8-HQ) and aluminium sulphate $\{Al_2(SO_4)_3\}$ as per following details:

PLATE-1

Harvesting stage of chrysanthemum cv. Mountaineer

PLATE-2

Harvesting stage of chrysanthemum cv. Kundan

Treatments	Holding solutions
HT_1	0.5mM STS + 2% sucrose
HT_2	250 ppm 8-HQ + 1.5% sucrose
HT_3	0.15% $Al_2(SO_4)_3$ + 2% sucrose
HT_4	200 ppm 8-HQ + 2% sucrose
HT_5	0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose
HT_6	Control (Distilled water)

The respective best holding solution for each cultivar was used after giving pulsing treatment in Experiment-II and after storage treatments in Experiment-III to evaluate the vaselife.

3.4 Experiment II (Pulsing Solutions)

The cut flowers were treated with different pulsing solutions prepared from silver thiosulphate (STS), benzyl adenine (BA), 8-hydroxyquinoline (8-HQ) and aluminium sulphate $\{Al_2(SO_4)_3\}$ as per following details:

Treatments	Holding solutions
PT_1	1mM STS + 10% sucrose
PT_2	0.025 mM BA + 0.4 mM STS + 0.65mM 8-HQ + 5% sucrose
PT_3	60 ppm $Al_2(SO_4)_3$ + 250 ppm 8-HQ + 3% sucrose
PT_4	Control (Distilled water)

The best pulsing solution for each cultivar was used to pulse cut flowers before storage treatment in Experiment III.

3.5 Experiment III (Storage)

The cut flowers of each cultivar were treated with their respective best pulsing solution. The flowers were bunched in a unit of 5 stems, each wrapped in cellophane or newspaper and placed horizontally in cardboard cartons {used for apple packaging also (55 x 22 x 34 cm)} in such a way that heads of each layer altered with tail ends.

After wrapping and packing, the cartons were placed in cold storage (4±1°C), zero energy cool chamber (11±2°C) and ambient conditions (room temperature) for 1-3 days as per following details:

Treatments

Storage		Wrapping	Storage duration (I) (hrs.)
ST_1	Cold storage	Cellophane	24, 48,72
ST_2	Cold storage	Newspaper	24, 48,72
ST_3	Zero energy cool chamber	Cellophane	24, 48, 72
ST_4	Zero energy cool chamber	Newspaper	24, 48, 72
ST_5	Ambient storage	Cellophane	24, 48, 72
ST_6	Ambient storage	Newspaper	24, 48, 72

The cut flowers after storage treatments were taken out of storage and then placed in their respective best holding solutions (from experiment I) to find out the final vase life.

3.6 Observations

3.6.1. Experiment-I (Holding Solutions)

1. Diameter of flower
2. Fresh weight changes
3. Total sugar content
4. Appearance (colour, freshness)
5. pH of solution on first and last day (termination of vaselife)
6. Total vase life
7. Disorders if any.

3.6.2 Experiment -II (Pulsing Solutions)

1. Appearance (colour, freshness)
2. Vaselife in best holding solution

3.6.3 Experiment-III (Storage)

1. Appearance (colour, freshness)
2. Vaselife in best holding solution
3. Total sugar content

3.7 Observational Procedures

3.7.1 Diameter of Flower

The equatorial diameter of the flower at two places was measured by a scale in cm after maximum opening.

3.7.2 Fresh weight changes

The fresh weight of all cut flowers including stems and few leaves was recorded in grams before putting in holding solutions. The weight was recorded with the help of a single top pan balance. Similarly, at the end of vaselife, the flower stems alongwith leaves were weighed. The per cent fresh weight change was worked out as:

$$\% \text{ Fresh weight changes} = \frac{\text{Initial weight-Final weight}}{\text{Initial weight}} \times 100$$

3.7.3 Estimation of total sugar content

Total sugars in the inflorescence of chrysanthemum were estimated by Phenol Sulphuric Acid Method (Dubois *et al.* 1951).

Method of Extraction

Whole inflorescence was taken and chopped into small pieces. Out of this 4 gm of sample was taken after

mixing the pieces thoroughly. The sample was boiled in 20 ml of 80 per cent ethanol for 20 minutes. The filtrate was decantated and again boiled in 80% ethanol. The process was repeated two times.

The supernatent was pooled and evaporated on water bath. The residue was dissolved in less than 50 ml of water. One ml of saturated lead acetate was added so as to make final volume 50ml. Pinch of sodium oxalate was added to precipitate excess of lead acetate and then it was filtered.

Estimation

One ml of appropriately diluted extract was taken. To this 1 ml of 5 per cent phenol was added. It was shaken properly and 5 ml of concentrated sulphuric acid was added. Orange red colour developed which was estimated at 490nm against glucose, with spectrophotometer.

3.7.4 Initial and Final pH of solutions

The pH of vase solutions was recorded at the time of preparing fresh solutions and after completion of vaselife using electric pH meter. After recording the pH of every solution, the bulb was washed with distilled water, dried with a blotting paper before being reused.

3.7.5 Vaselife

The vaselife of all cut flowers was measured from the day they were placed in vase solution upto the day when flowers and leaves deteriorated to the extent that they would be of no value to be displayed for decoration. The vaselife was considered to be finished when outer florets (ray florets) started wilting (Marousky, 1969).

3.7.6 Appearance (Colour and freshness)

The criteria for observing the appearance of cut flowers using visual sense were colour and freshness.

Colour

There was no apparent changes in colour of cut flowers from the time the flowers were placed in vase solution upto termination of vase life.

Freshness

For observing the freshness visually the cut flowers were ranked according to the method of Kendall (1965). The holding treatment in which inflorescence and leaves were the most turgid, were ranked 1. Accordingly, as the turgidity decreased, the flowers were ranked 2 and so on.

Relation among ranks given by several judges

$$S = \frac{m^2N\,(N^2-1)}{12}$$

$$W = \frac{12S}{m^2N\,(N^2-1)}$$

$$F = \frac{(m-1)\,W}{1-W}$$

Where;

m = number of judges,

N = number of treatments

S = Sum of square of the deviations of m sum sum of rank around their mean.

W = ratio of observed S to the value S and is called co-efficient of concordance.

For larger values of N and m, F test was used with degrees of freedom n_1 and n_2.

The ranks were given in decreasing order of freshness (more to less) and co-efficient of concordance (W) was calculated. When the value of W was 1, it meant all the judges were of the same opinion and if it was 0, it implied that the opinion of judges did not coincide at all.

Design of Experiment

Experiment-I

Number of treatments = Combination of 2 cvs. and 6 holding solutions i.e. = 12.

Number of replications = 3

No. of flowers per replication = 5

In case of freshness the treatments were analysed separately for each cv.

Experiment-II

Number of treatments = Combination of 2 cvs. and 4 pulsing = 8.

Number of replications = 3

No. of flowers per replication = 5

Experiment-III

Number of treatments = Combination of 2 cvs. and 6 storage treatments = 12

Number of replications = 3

No. of flowers per replication = 5

In all the experiments, five flower stems were taken per replication. The data was subjected to analysis of variance technique using complete randomized design (CRD) with combination of two factors as treatment (Gomez and Gomez, 1976).

Data recorded in per cent value was subjected to arcsine transformation.

Chapter 4

EXPERIMENTAL RESULTS

In the present study, the investigations were divided into three separate experiments, as explained earlier in material and methods. The best holding solution obtained in **Experiment-1** was used to test the vaselife after giving different pulsing treatments in **Experiment-II**. The best pulsing treatment standardized in **Experiment-II** was used for pulsing all the cut flowers for standardizing the optimum storage conditions in **Experiment-III** which were evaluated by the performance of the cut flowers in the best holding solution from **Experiment-I**. In all the experiments, the results of further sub-experiments are presented for each character as follows:

Experiment-I (Holding solutions)

4.1.1 Vaselife

Data tabulated in table 2 show that the mean vaselife for both cultivars was maximum (24.07 days) in HT_2 (250 ppm 8-HQ+1.5% sucrose) as compared to control (11.06 days). Individually, the cvs. Mountaineer and Kundan had maximum vaselife of 20.47 and 27.67 days, respectively, in this very treatment (HT_2). All holding solutions increased vaselife over the controls. The

control of 'Mountaineer' had a vaselife of 5.03 days; whereas for 'Kundan', it was 17.13 days.

In general, 'Kundan' had a longer mean vaselife (25.88 days) than 'Mountaineer' (13.77 days).

Table 2. Effect of holding solutions on the vaselife (days) of cutflowers

Holding solutions	Chrysanthemum		
	Mountaineer	Kundan	Mean
HT_1 0.5 mM STS + 2% sucrose	7.70	18.60	13.15
HT_2 250 ppm 8-HQ + 1.5% sucrose	20.47	27.67	24.07
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	14.27	19.13	16.70
HT_4 200 ppm 8-HQ + 2% sucrose	16.43	22.47	19.47
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	18.47	25.27	21.87
HT_6 Control	5.03	17.13	11.06
Mean	13.77	25.88	

$CD_{0.05}$ Holding solutions = 0.30

Cultivars = 0.17

Holding solution vs. cultivars = 0.43

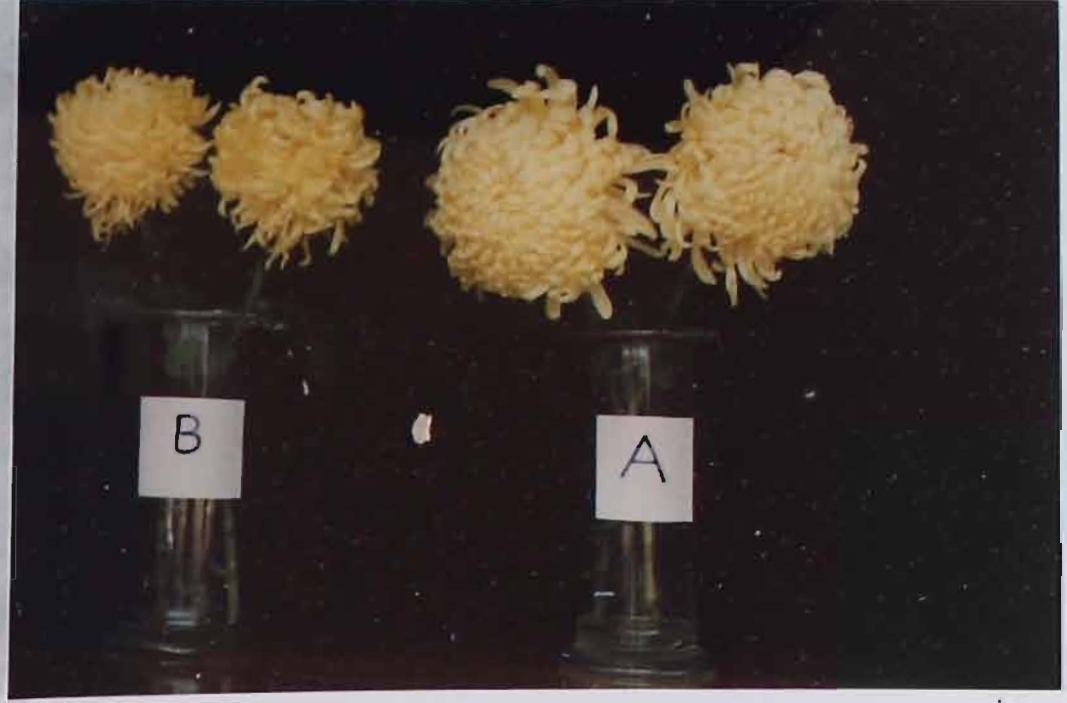


PLATE-3

Cut flowers of cv. Mountaineer kept in holding solution 250 ppm 8-HQ + 1.5% sucrose 1(A) and control (B) on 12th day

PLATE-4

Cut flowers of cv. Kundan kept in holding solution 250 ppm 8-HQ + 1.5% sucrose (A) and control (b) on 20th day

4.1.2 Flower diameter

From the data presented in table 3, it is evident that the holding solution HT_2 (250 ppm 8-HQ + 1.5% sucrose) was the best giving mean diameter as 8.45 cm, whereas, in control it was 6.50 cm. Individually, the diameter of cv. Mountaineer was maximum (12.93 cm) in HT_2 and that of cv. Kundan, it was maximum (3.96 cm) in this very treatment. However, all the holding solutions increased flower diameter over control. The controls of both the cvs. i.e. Mountaineer and Kundan had lesser diameter (10.13 and 2.86 cm, respectively) as compared to other holding treatments.

Table 3. Effect of holding solutions on diameter (cm) of cut flowers.

Holding solutions	Chrysanthemum		
	Mountai-neer	Kundan	Mean
HT_1 0.5 mM STS + 2% sucrose	11.20	3.01	7.01
HT_2 250 ppm 8-HQ + 1.5% sucrose	12.93	3.96	8.45
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	12.53	3.20	7.86
HT_4 200 ppm 8-HQ + 2% sucrose	12.00	3.76	7.80
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	12.87	3.91	8.39
HT_6 Control	10.13	2.86	6.50
Mean	11.94	3.45	

$CD_{0.05}$ Holding solutions = 0.30
Cultivars = 0.17
Holding solution vs. cultivars = 0.43

In general, cv. Mountaineer had more flower diameter (11.94 cm) than cv. Kundan (3.45 cm).

4.1.3 Final pH of solutions

All holding solutions exhibited lower final pH comparison to control (Table 4). The controls of both cvs. viz. Mountaineer and Kundan had maximum final pH (5.10 and 5.25, respectively). In general, cv. Kundan was at higher pH (4.10) than cv. Mountaineer (3.98), although they did not differ significantly from each other. The final pH of holding solutions for both cultivars was minimum in HT_3 (0.15%) aluminium sulphate $\{(Al_2(SO_4)_3\}$ + 2% sucrose giving mean value of 3.33 as compared to 5.17 in control. Individually, the cvs. Mountaineer and Kundan also had minimum pH i.e. 3.46 and 3.20, respectively, in this very treatment (HT_3).

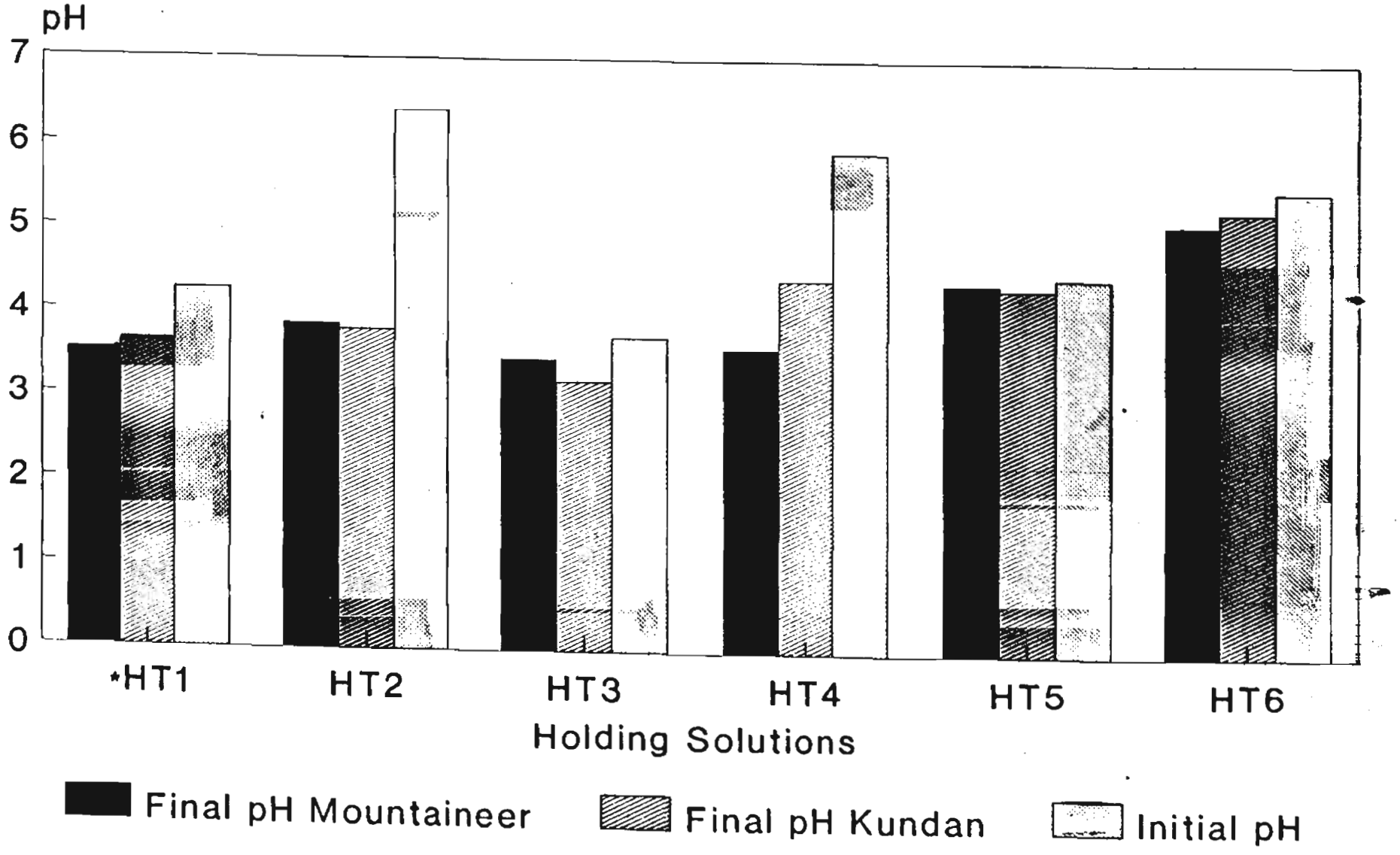
However, the maximum per cent reduction (39.84 and 40.78%) was observed in HT_2 (250ppm 8-HQ+1.5% sucrose) in cvs. Mountaineer and Kundan, respectively. The minimum reduction (1.34 and 2.92%) was noticed in HT_5 (0.5mM STS + 200 ppm 8-HQ+1.5% sucrose) in the Mountaineer and Kundan, respectively. Fig. 5 shows decrease in pH of holding solutions for chrysanthemum cut flowers.

Table 4. Initial and final pH of holding solutions and per cent decrease in pH of holding solutions in chrysanthemum cutflowers

Holding solutions	Initial pH	Chrysanthemum				
		Final pH			% decrease in pH	
		Mountaineer	Kundan	Mean	Mountaineer	Kundan
HT_1 0.5 mM STS + 2% sucrose	4.25	3.52	3.62	3.57	17.17	14.8
HT_2 250 ppm 8-HQ + 1.5% sucrose	6.40	3.85	3.79	3.82	39.84	40.78
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	3.72	3.46	3.20	3.33	6.98	13.97
HT_4 200 ppm 8-HQ + 2% sucrose	5.93	3.60	4.42	4.01	39.29	25.46
HT_5 0.5m MSTS + 200 ppm 8-HQ + 1.5% sucrose	4.45	4.39	4.32	4.35	1.34	2.92
HT_6 Control	5.50	5.10	5.25	5.17	7.27	4.54
Mean		3.98	4.10			

$CD_{0.05}$ Holding solutions = 0.18
Cultivars = 0.10
Holding solution vs. cultivars = 0.26

Decrease in pH of holding solutions for chrysanthemum.



* Details on page 18.

FIG- 5

4.1.4 Fresh weight changes

The holding solutions in general brought about reduction in the decrease in fresh weight of the flowers. The minimum fresh weight loss was observed in HT_2 (250 ppm 8-HQ+1.5% sucrose) giving a mean value of 13.67 per cent (21.68) for both the cultivars; whereas, controls experienced maximum mean fresh weight loss i.e. 26.49 per cent (30.84) as evident from the data presented in table 5. Individually, the fresh weight loss of both cvs. viz. Mountaineer and Kundan was minimum i.e. 14.83 per cent (22.65) and 12.50 per cent (20.70) in this very treatment (HT_2). The controls of both cvs. i.e. Mountaineer and Kundan had maximum fresh weight loss (32.33 per cent (34.65) and 20.64 per cent (20.02), respectively) as compared to other holding treatments.

In general, in cv. Mountaineer, there was greater loss in fresh weight i.e. 20.91 per cent (27.00) than in cv. Kundan in which a weight loss of 17.80 per cent (24.79) was recorded.

4.1.5 Total sugar content

4.1.5.1. Total sugars observed in cut flowers on 6th day in holding solutions.

The mean total sugar content for both cultivars was maximum (114.15mg/g) in HT_4 (200 ppm 8-HQ+1.5%

4.1.4 Fresh weight changes

The holding solutions in general brought about reduction in the decrease in fresh weight of the flowers. The minimum fresh weight loss was observed in HT_2 (250 ppm 8-HQ+1.5% sucrose) giving a mean value of 13.67 per cent (21.68) for both the cultivars; whereas, controls experienced maximum mean fresh weight loss i.e. 26.49 per cent (30.84) as evident from the data presented in table 5. Individually, the fresh weight loss of both cvs. viz. Mountaineer and Kundan was minimum i.e. 14.83 per cent (22.65) and 12.50 per cent (20.70) in this very treatment (HT_2). The controls of both cvs. i.e. Mountaineer and Kundan had maximum fresh weight loss {32.33 per cent (34.65) and 20.64 per cent (20.02), respectively} as compared to other holding treatments.

In general, in cv. Mountaineer, there was greater loss in fresh weight i.e. 20.91 per cent (27.00) than in cv. Kundan in which a weight loss of 17.80 per cent (24.79) was recorded.

4.1.5 Total sugar content

4.1.5.1. Total sugars observed in cut flowers on 6th day in holding solutions.

The mean total sugar content for both cultivars was maximum (114.15mg/g) in HT_4 (200 ppm 8-HQ+1.5%

Table 5. Effect of holding solutions on fresh weight loss (%) of cut flowers.

Holding solutions	Chrysanthemum		
	Mountaineer	Kundan	Mean
HT_1 0.5 mM STS + 2% sucrose	24.37 (29.58)*	26.07 (30.70)*	25.22 (30.14)*
HT_2 250 ppm 8-HQ + 1.5% sucrose	14.83 (22.65)	12.50 (20.70)	13.67 (21.68)
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	21.43 (27.57)	18.43 (25.42)	19.93 (26.50)
HT_4 200 ppm 8-HQ + 2% sucrose	15.17 (22.92)	15.76 (23.39)	15.46 (23.15)
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	17.33 (24.60)	13.43 (21.50)	15.38 (23.05)
HT_6 Control	32.33 (34.65)	20.64 (27.02)	26.49 (30.82)
Mean	20.91 (27.00)	17,80 (24.79)	
$CD_{0.05}$ Holding solutions	= 0.76 (0.54)*		
Cultivars	= 0.44 (0.31)		
Holding solution vs. cultivars	= 1.08 (0.54)		

* Figures in parentheses are arcsine transformation of percentage

sucrose) on 6th day in holding treatment as compared to control (58.85mg/g) (Table 6 B). Almost in all holding treatments, the carbohydrate content in cut flowers was statistically at par. Individually for both cvs. viz. Mountaineer and Kundan, maximum total sugar content (118.5 and 109.8 mg/g, respectively) was also found in this very treatment (HT_4). The controls of both cvs. i.e. Mountaineer and Kundan had minimum total sugar content (70.0 and 41.6 mg/g, respectively). In general, cv. Mountaineer had more total sugar content (109.85 mg/g) as compared to cv. Kundan (96.28 mg/g).

4.1.5.2. Total sugar content found in cut flowers at the termination of vaselife

Data presented in table 6C reveal that total sugar content was lesser at the termination of vaselife compared to that as on 6th day in holding solutions. Mean total sugar content on termination of vase life for both cultivars was maximum 69.95 mg/g in HT_4 (200 ppm 8-HQ+2% sucrose), whereas, in control it was only 50.27 mg/g. Individually, maximum total sugar content (77.2 and 62.7 mg/g) for cvs. Mountaineer and Kundan was observed in the treatment HT_4 whereas, the minimum sugar content (70.0 and 30.4, respectively) was observed in the cut flowers kept in control. In general, cv. Mountaineer had more total sugar content (73.2 mg/g) as compared to cv. Kundan (53.5 mg/g).

Table 6A. Initial total sugar content (mg/g) of fresh cut flowers of chrysanthemum

	Mountaineer	Kundan
Total sugar mg/g	98.56	82.72

Table 6B. Effect of holding solutions on total sugar content (mg/g) of cut flowers of chrysanthemum on 6th day in holding solutions

Holding solutions	Chrysanthemum		Mean
	Mountaineer	Kundan	
HT_1 0.5 mM STS + 2% sucrose	117.5	105.3	111.40
HT_2 250 ppm 8-HQ + 1.5% sucrose	114.7	108.2	111.45
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	117.2	104.5	110.85
HT_4 200 ppm 8-HQ + 2% sucrose	118.5	109.8	114.15
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	115.2	108.2	111.87
HT_6 Control	70.0	41.6	55.80
Mean	109.85	96.28	

$CD_{0.05}$ Holding solutions = 1.95
Cultivars = 1.13
Holding solution vs. cultivars = 2.76

Table 6A. Initial total sugar content (mg/g) of fresh cut flowers of chrysanthemum

	Mountaineer	Kundan
Total sugar mg/g	98.56	82.72

Table 6B. Effect of holding solutions on total sugar content (mg/g) of cut flowers of chrysanthemum on 6th day in holding solutions

Holding solutions	Chrysanthemum		Mean
	Mountaineer	Kundan	
HT_1 0.5 mM STS + 2% sucrose	117.5	105.3	111.40
HT_2 250 ppm 8-HQ + 1.5% sucrose	114.7	108.2	111.45
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	117.2	104.5	110.85
HT_4 200 ppm 8-HQ + 2% sucrose	118.5	109.8	114.15
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	115.2	108.2	111.87
HT_6 Control	70.0	41.6	55.80
Mean	109.85	96.28	

$CD_{0.05}$ Holding solutions = 1.95
Cultivars = 1.13
Holding solution vs. cultivars = 2.76

Table 6C. Effect of holding solutions on total sugar content (mg/g) of cut flowers of chrysanthemum at the termination of vaselife.

Holding solutions	Chrysanthemum		
	Mountaineer	Kundan	Mean
HT_1 0.5 mM STS + 2% sucrose	70.7	55.1	62.92
HT_2 250 ppm 8-HQ + 1.5% sucrose	75.6	57.6	66.63
HT_3 0.15% $Al_2(SO_4)_3$ + 2% sucrose	76.6	58.1	66.40
HT_4 200 ppm 8-HQ + 2% sucrose	77.2	62.7	69.95
HT_5 0.5mM STS + 200 ppm 8-HQ + 1.5% sucrose	71.1	57.1	64.15
HT_6 Control	70.0	30.4	50.27
Mean	73.2	53.5	

$CD_{0.05}$ Holding solutions = 0.20
Cultivars = 0.11
Holding solution vs. cultivars = 0.28

4.1.6 Appearance

4.1.6.1 Freshness

Table 7A and 7B show the effect of holding solutions on freshness of cut flowers of 'Mountaineer' and 'Kundan', respectively.

Table 7A. Effect of holding solutions on freshness of cutflowers of 'Mountaineer'

Freshness observed after number of days	W	F_{cal}	F_{tab}
3	0.94	31.3	3.63
6	0.94	31.3	3.63
9	0.97	64.6	3.63
12	1	$\propto$	3.63
15	1	$\propto$	3.63

W = co-efficient of concordance.
N = 6, n_1 = 4 n_2 = 9, m = 3.

Table 7B. Effect of holding solutions on freshness of cutflowers of 'Kundan'

Freshness observed after number of days	W	F_{cal}	F_{tab}
3	0.80	8.0	3.63
6	0.94	31.3	3.63
9	0.94	31.3	3.63
12	0.94	31.3	3.63
15	0.97	64.6	3.63
18	1	$\propto$	3.63
21	1	$\propto$	3.63

W = Coefficient of concordance.
N = 6, n_1 = 4, n_2 = 9, m = 3.

When the value of W (co-efficient of concordance) is 1, it implies that the ranks given by judges regarding the freshness of cut flowers are uniform and coincide with one another. If the value of W is 0, it implies that the judges are of different opinion regarding the freshness of cut flowers kept in difrerent holding solutions. However, if the value of W is less than one, so it can be said that there is slight variation among the opinion of judges.

The data show that during initial days there is slight variation among the opinion of judges. However, ranking coincided as the number of days proceeded further. The cut flowers kept in holding solution HT_2 (250 ppm 8-HQ+1.5% sucrose) retained freshness for longer time and gave best effect in both the cvs. viz. Mountaineer and Kundan.

4.1.6.2. Colour

There was no noticeable change in the colour of cut flowers kept in different holding solutions.

4.2 Experiment-II (Pulsing solutions)

After pulsing for 16 hours in different pulsing solutions, the cut flowers of both the cvs. were kept in the best holding solution i.e. (250 ppm 8-HQ+1.5% sucrose) standardized from experiment-I for evaluation of vaselife.

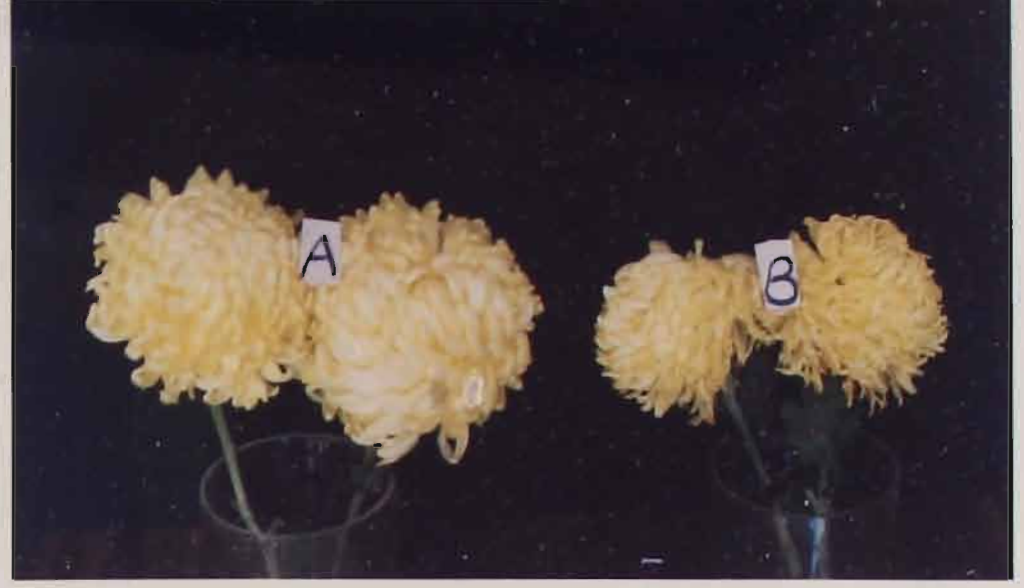


PLATE-6

Cut flowers of cv. Mountaineer after pulsing for 16 hrs in 0.025 mM BA + 0.3mM STS + 0.65 mM 8-HQ + 5% sucrose (A) and control (B) kept in best holding solution on 18th day

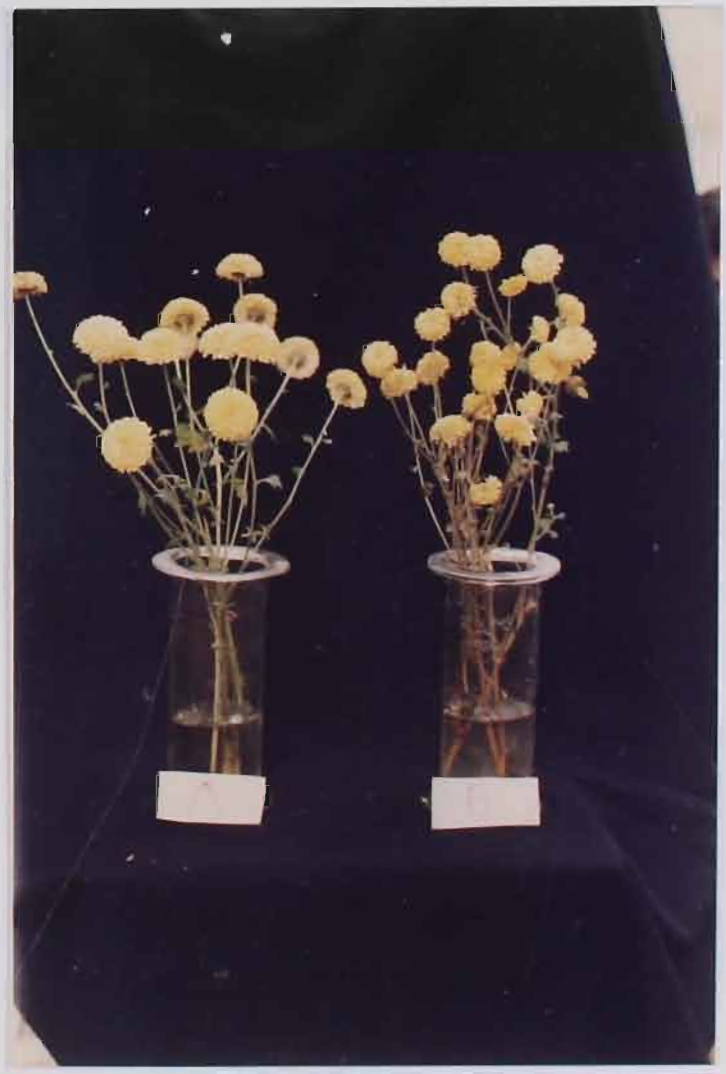


PLATE-7

Cut flowers of cv. Kundan after pulsing for 16 hrs in 0.025 mM BA +0.3mM STS + 0.65 mM 8-HQ + 5% sucrose(A) and control (B) kept in best holding solution on 25th day

4.2.2. Appearance

4.2.2.1. Freshness

From the data presented in tables 9A and 9B, it is evident that cut flowers of cvs. Mountaineer and Kundan pulsed with solution PT_2 (0.025mMBA + 0.4mM STS +0.65mM 8-HQ +5% sucrose) exhibit maximum freshness and occupied number 1 rank among various pulsing solutions.

4.2.2.2. Colour

There was noticeable change in colour of cut flowers pulsed with different pulsing solutions.

4.3 Experiment-III (Storage)

The cut flowers of both the cvs. of chrysanthemum were pulsed with 0.25mM BA + 0.4 mM STS + 0.65 mM 8-HQ +5% sucrose (the best pulsing solution from Experiment-II) for 16 hours before storage. After storage the cut flowers were kept in 250 ppm 8-HQ + 1.5% sucrose (the best holding solution from Experiment-I) for recording vaselife.

Table 9A. Effect of pulsing on freshness of cutflower of cv. Mountaineer

Freshness observed after number of days	W	Fcal	Ftab
3	0.73	5.4	5.79
6	0.77	6.6	5.79
9	0.90	18.0	5.79
12	0.90	18.0	5.79
15	1.00	∝	5.79
18	1.00	∝	5.79

W = Co-efficient of concordance
N = 4, n_1 = 2, n_2 = 5, m = 3.

Table 9B. Effect of pulsing on freshness of cutflowers of cv. Kundan

Freshness observed after number of days	W	Fcal	Ftab
3	0.64	3.5	5.79
6	0.77	6.6	5.79
9	0.77	6.6	5.79
12	0.90	18.0	5.79
15	1.00	∝	5.79
18	1.00	∝	5.79

w = Co-efficient of concordance
N = 4, n_1 = 2, n_2 = 5, m = 3.

Table 9A. Effect of pulsing on freshness of cutflower of cv. Mountaineer

Freshness observed after number of days	W	Fcal	Ftab
3	0.73	5.4	5.79
6	0.77	6.6	5.79
9	0.90	18.0	5.79
12	0.90	18.0	5.79
15	1.00	∝	5.79
18	1.00	∝	5.79

W = Co-efficient of concordance
N = 4, n_1 = 2, n_2 = 5, m = 3.

Table 9B. Effect of pulsing on freshness of cutflowers of cv. Kundan

Freshness observed after number of days	W	Fcal	Ftab
3	0.64	3.5	5.79
6	0.77	6.6	5.79
9	0.77	6.6	5.79
12	0.90	18.0	5.79
15	1.00	∝	5.79
18	1.00	∝	5.79

w = Co-efficient of concordance
N = 4, n_1 = 2, n_2 = 5, m = 3.

4.3.1 Vase life

Data presented in Table 10 show that mean vase life was maximum (22.63 days) in storage treatment ST_1 (cut flowers wrapped in cellophane and kept in carton in cold storage for 24 hrs). Vaselife of cut flowers wrapped in cellophane was greater as compared to newspaper wrapped cut flowers in all the three storage systems. However, cut flowers stored under ambient conditions whether wrapped in cellophane or in newspaper had lesser vaselife as compared to other storage systems. In ambient conditions, also, cellophane wrapped cut flowers had slightly more vaselife (10.03 days) as compared to newspaper wrapped cut flowers (7.97 days). Taking into account the duration of storage (24, 48 or 72 hr.) it was evident that vaselife decreased with an increase in storage period of the cut flowers. The vase life decreased from 25.47 days after 24 hours storage to 13.13 days after storage for 72 hours for the cv. 'Mountaineer' under the best storage treatment (ST_1). Similarly, the vase life of cv. 'Kundan' decreased from 32.50 days to 18.83 days for the corresponding increase in storage duration under the best storage treatment (ST_1).

In general, vaselife was maximum (24.53 days) in cv. Kundan followed by cv. Mountaineer (18.39 days) when both were stored for 24 hrs but on increasing the storage

Storage box and wrappers used for cut flowers

PLATE - 8

Table 10. Effect of storage and wrapping on vaselife (days) of cut flowers.

Treatment			Vase life						
			I_1 (24 hrs)		I_2 (48 hrs)		I_3 (72 hrs)		
	Storage	Wrapping	Mountaineer	Kundan	Mountaineer	Kundan	Mountainner	Kundan	Mean
ST_1	Cold storage	Cellophane	25.47	32.50	19.40	26.47	13.13	18.83	22.63
ST_2	Cold storage	Newspaper	23.43	29.53	17.43	24.40	10.83	17.43	20.51
ST_3	Zero Energy	Cellophane	20.27	25.93	14.53	19.73	7.83	12.87	16.86
ST_4	Zero Engegy	Newspaper	17.77	24.40	13.17	18.13	5.73	10.23	14.89
ST_5	Ambient storage	Cellophane	12.80	18.40	7.20	12.73	3.23	5.83	10.03
ST_6	Ambient storage	Newspaper	10.60	16.40	5.20	10.20	2.06	3.36	7.97
Mean			18.39	24.53	12.82	18.59	7.13	11.43	

$CD_{0.05}$

Storage treatments	=	0.37
Cultivars	=	0.21
Storage duration	=	0.26
Storage treatments vs. cultivar	=	0.52
Storage treatments vs. storage duration	=	0.64
Cultivar vs. storage duration	=	0.37
Storage treatments vs. cultivar vs. sotrage duration	=	0.89

PLATE-9

Cut flowers of cv. Mountaineer pulsedfor 16 hrs in best pulsing solution, stored for 24 hrs in cold storage (A), zero energy chamber (B) and ambient storage (C) and kept in best holding solution on 12th day

PLATE-10

Cut flowers of cv. Kundan pulsed for 16 hrs in best pulsing solution, stored for 24 hrs in cold storage (A), zero energy chamber (B) and ambient storage (C) and kept in the best holding solution on 18th day

period to 72 hrs their mean vase life under different treatments decreased to 7.13 and 11.43 days, respectively.

4.3.2. Total sugar content (mg/g) after storage

The data in table 11 indicate that mean total sugar content was maximum (112.1 mg/g) after 24 hrs duration when flowers were stored in cold storage wrapped in cellophane. However, there is not much difference in total sugar content of cut flower whether wrapped in cellophane or newspaper. The cut flowers stored under ambient conditions had minimum sugar content for cellophane (64.09 mg/g) and newspaper wrapped (62.92 mg/g) flowers as compared to other storage treatments, when stored for 72 hrs. Cv. Mountaineer had higher sugar content as compared to the cv. Kundan Taking into account the duration of storage (24, 48 and 72 hrs), it was evident that cut flowers stored for 24 hrs duration had maximum mean sugar content (126.5 and 109.1 mg/g for cvs. Mountaineer and Kundan, respectively) as compared to cut flowers stored for 72 hrs duration (63.52 and 52.36 mg/g for cvs. Mountaineer and Kundan, respectively). Further cv. Mountaineer stored in cold storage for 24 hours and wrapped in cellophane had the highest sugar content (143.9 mg/g).

Table 11. Effect of storage on total sugar content (mg/g) of cut flowers

Treatment			Sugar content						
			I_1 (24 hrs)		I_2 (48 hrs)		I_3 (72 hrs)		
	Storage	Wrapping	Mountaineer	Kundan	Mountaineer	Kundan	Mountainner	Kundan	Mean
ST_1	Cold storage	Cellophane	143.9	128.7	132.3	114.0	81.33	72.07	112.1
ST_2	Cold storage	Newspaper	142.0	127.3	130.50	114.0	78.10	70.83	110.5
ST_3	Zero Energy	Cellophane	134.8	115.1	109.30	92.00	65.20	53.33	94.96
ST_4	Zero Engegy	Newspaper	131.9	114.7	112.20	93.10	62.33	54.00	94.54
ST_5	Ambient storage	Cellophane	104.0	84.83	63.17	52.47	47.80	32.30	64.09
ST_6	Ambient storage	Newspaper	102.4	84.00	61.50	51.67	46.33	31.60	62.92
Mean			126.5	109.1	101.3	86.21	63.52	52.36	

$CD_{0.05}$

Storage treatments	=	1.16
Cultivars	=	0.67
Storage duration	=	0.82
Storage treatments vs. cultivars	=	NS
Storage treatments vs. storage duration	=	2.01
Cultivars vs. storage duration	=	1.15
Storage treatments vs. cultivars vs. storage duration	=	2.84

4.3.3. Appearance

4.3.3.1. Freshness

After storing cut flowers for 24, 48 and 72 hours in different storage conditions, the appearance (freshness) was determined separately for 24, 48 and 72 hours duration and for each storage duration, cold stored flowers wrapped in cellophane were ranked first (Table 12). The ranking given by judges was uniform for both the cultivars of chrysanthemum.

4.3.3.2. Colour

There was no noticeable effect of storage conditions on colour of cut flower of chrysanthemum.

Table 12 Effect of storage conditions on freshness of cutflowers

Period	W	F_{cal}	F_{tab}
24 hrs	1	∞	3.63
48 hrs	1	∞	3.63
72 hrs	1	∞	3.63

W = co-efficient of concordance.

N = 6, n_1 = 4, n_2 = 9, m = 3.

(Ranking is same as for both cultivars i.e. Mountaineer and Kundan).

Chapter 5

DISCUSSION

DISCUSSION

The present studies were conducted to evaluate the effects of various holding solutions, pulsing, wrapping and storage treatments on vaselife of cut flowers of chrysanthemum cvs. Mountaineer and Kundan. The results of these investigations are discussed below in the light of available literature.

5.1 Effect of holding solutions on cut flower characters

(Experiment-I)

All holding solutions improved the vaselife of cut flowers over control with the maximum vaselife being obtained with 8-hydroxyline quinoline (8-HQ) and sucrose. The increase in vaselife with the use of these substance may be due to the fact that 8-HQ is bactericidal (Gershon *et al.*, 1969). ***In vitro*** experiments show complete inhibition of growth of several fungi by 8-HQ (Zentmeyer, 1943). Larsen and Scholes (1965) suggested that 8-HQ prolongs vaselife by inhibiting bacterial growth in holding solutions, and cut flower stems in solutions free of microorganisms would be less prone to blockage. Sucrose improves the quality of cut flowers by supporting the integrity of cell membranes and by reducing senstivity to ethylene.

The present results are in conformity with those of Krishnamurthi and Negi (1985), who reported a vaselife of 21 and 19.5 days in chrysanthemum cvs. Kikubiyori and Temptation with 8-hydroxyquinoline. Giribaldi and Deambrogio (1988) reported a vaselife of 20 days in chrysanthemum cv. Stradine Bihaca with 8-HQ and sucrose. Also in cv. Bronze Bornholm of chrysanthemum longest vaselife (13.6 days) was reported by Lukaszewska (1980) with 8-hydroxyquinoline sulphate (8-HQS) and sucrose.

All the holding solutions increased flower head diameter over control, and maximum diameter was obtained with 8-HQ and sucrose. 8-HQ is believed to inhibit stem blockage and allows greater water conductivity as reported by Marousky (1972). So cut flower stems held in 8-HQ and sucrose absorbed more solution and developed large flowers.

These results obtained are in conformity with those of Lukaszewska (1980) in case of chrysanthemum cv. Bronze Bronholm and Crimson Robe. However, variation between flower size of cvs. viz. Mountaineer and Kundan are apparently due to their genetic makeup.

All holding solutions maintained a lower pH (less than 4.5) than the controls which contributed to prolonged vaselife. The maximum reduction in pH was observed in 8-HQ and sucrose. The benefits of lower pH of holding

solutions have long been recognised as it helps in reducing bacterial population (Halevy and Mayak, 1981). Most preservative formulations contain an acid to reduce the pH of holding solution. Marousky (1971) reported that low pH retarded stem blockage of roses in bacteria free water and increased water absorption, thereby increasing longevity. Halevy and Mayak (1981) found an increase in flow rate of water through rose stem segments with decrease in pH from 6 to 3. The change in pH may be due to specific interactions of holding solutions with inherent transport physiology and metabolism of cut flowers.

Our study showed minimum fresh weight loss with 8-HQ and sucrose; whereas in controls weight loss was maximum. The increase in weight is caused by an increase in fluid absorption. 8-HQ also acts as an antitranspirent as reported by Stoddard and Miller (1962) and might have decreased transpirational losses. Our results are in conformity with those of Marousky (1968, 1969) and Gladon and Staby (1976).

The maximum total sugar content was observed in 8-HQ (200 ppm) and sucrose (2%). In the petals of flowers placed in holding solutions, the total sugar content increased when observed on 6th day. Indeed, the longevity of cut flowers is often extended when they are held in vase solutions containing carbohydrates. When petal

senescence starts, there is loss of carbohydrates also. However, petal senescence is invaribly associated with loss of proteins also as is reported in carnations (Halevy and Mayak, 1989). Therefore, limited respiratory substrate is not likely to be the only major controlling factor in petal senescence.

Kaltaler and Steponkus (1975) reported that in roses maintained in distilled water, petal sugar content decreased after first day; whereas, sugar level in petals of flowers maintained in 200 pm 8-HQ + 2% sugar increased during the entire four days. Decreased level of sugar in petals of flowers in distilled water would have been due to smaller sugar pool as compared to those from the preservative solution.

The present study showed that the petals of the standard cultivar had a higher total sugar content than those of the spray cultivars. Woltz and Engelhard (1971) found that the leaves of standard chrysanthemum cultivars had an average of 24 per cent more total carbohydrates than sprays. It may be assumed that the flower petals would reflect the carbohydrate status available in leaves.

The freshness of chrysanthemum cut flowers was improved with all holding treatments over control due to the fact that preservatives and sucrose improved the quality of flowers, 8-HQ and sucrose giving the best

effect. There was no change in the colour of cut flowers. Sucrose supports the integrity of cell membranes and reduces sensitivity to ethylene (Halevy and Mayak, 1979).

5.2 Effect of pulsing on cut flower characters

(Experiment-II)

The present investigations showed that all pulsing treatments improved vaselife. A combination of benzyl adenine, silver thiosulphate, 8-hydroxyquinoline and sucrose gave the best results in terms of longevity. BA inhibits leaf yellowing by delaying senescence whereas, STS acts as an ethylene antagonist.

Kesta (1990) observed that chrysanthemum cv. Yellow Doi Khan pulsed in 50 mg/lt $AgNO_3$ + 200 ppm 8-HQC + 5% sucrose for 20 hours had longest vaselife (7.5 days) whereas, non pulsed flowers had a vaselife of 3.17-4.17 days. Further, chrysanthemum cv. Polaris pulsed with a combination of GA_3, STS and nonylphenolpolyglycolether (detergent) delayed leaf wilting and yellowing for 10 days (D'hont *et al.*, 1991). Halevy *et al.* (1978) also obtained improved longevity and size in chrysanthemum cv. Albatross when pulsed with sodium dichloro-s-triazinetrione (SDT), citric acid and sucrose with SDT acting as a bactericide. Mayak and Dilley (1976) reported that the effect of kinetin in extending longevity of carnations can be enhanced with supplementing sugars.

All pulsing solutions improved freshness as compared to control, without changing colour of cut flowers. A combination of BA, STS and 8-HQ gave the best effect.

5.3 Effect of storage on cut flower characters (Experiment-III)

In the present studies cold stored cut flowers lasted longer as compared to those stored in zero energy cool chamber storage and under ambient conditions. There was reduction in vaselife on increasing storage duration. Further, cut flowers wrapped in cellophane had slightly longer vaselife than those wrapped in newspaper. Cellophane wrapped cut flowers lasted longer due to the fact that besides maintaining relative humidity, because of its moisture proof nature, it helps in preventing mechanical injuries and wilting. The most suitable package material for cut blooms is cardboard box which is not only cheap but also light in weight.

Hauge ***et al.*** (1950) obtained most promising results by packaging cut flowers of chrysanthemum in cellophane. This method not only facilitated handling of cut flowers but also resulted in superior keeping quality. They packaged pompons in cellophane and stored them for 7 days at 40-45°F in refrigerated storage and the flowers remained in an acceptable condition for 5 to 6 days.

Pompons which were placed in water for a period of 6 or 24 hours before packaging remained in acceptable condition at room temperature approximately 24 hours longer than those packaged direct. Halevy *et al.* (1978) reported that there are two main requirements for good results with storage of chrysanthemum cv. Albatross (a) chemical treatment of flowers before storage and (b) maintaining flowers at 1-2°C throughout storage. Their study revealed that the best way to maintain low temperature throughout transit was to precool the flowers to 4°C or below and then pack them in cold room in insulated boxes. Wiersma and Boer (1974) also reported that when precooled flowers are transported in a refrigerated lorry, there is less variation in temperature and refrigerated storage can keep the temperature of precooled flowers at a desired level.

In the present investigations, maximum total sugar content was found in cut flowers stored in cold storage for 24 hours, whereas, in zero energy storage it was less. However cut flowers stored under ambient conditions had the least total sugar content. This condition is due to the fact that with increase in temperature, respiration also increases as a result of which more sugars are utilized. Further, the decrease in vase life of cut flowers on increasing the duration either in cold storage, zero energy chamber or under ambient conditions can be attributed to decrease in the

carbohydrate content because respiration keeps on going during storage, thereby utilizing the sugar pool.

There was no detrimental effect of cold storage and zero energy storage on the freshness and colour of cut flowers. However, cut flowers lost their freshness in a short duration when the flowers were stored under ambient conditions. There was decrease in freshness by increasing the duration of storage. Cold stored cut flowers retained maximum freshness. Kofranek ***et al.*** (1975) concluded that long term storage of 'Albatross' may have limited use if one adheres strictly to high quality standards of achieving incurved globular flowers. Halevy and Mayak (1981) reported that flowers look fresh when they come out of storage but do not last long as fresh flower.

The important consideration in long term or storage of flowers is pulsing. Halevy ***et al.*** (1978) pulsed chrysanthemum cv. Albatross in 5% sucrose, 500 ppm sodium-dichloro-s-triazinetrione (SDT) and 200 ppm citric acid for 16 hr, transported in refrigerated trucks at 5°C for 5 days and reported that vaselife was longer in pulsed flowers than non pulsed flowers.

This study showed that pulsing with a combination of BA, STS, 8-HQ and sucrose for 16 hours gave increase in subsequent vaselife over non-pulsed flowers showing the

importance of preshipment pulsing in extending vaselife. Another important consideration in long-term storage of cut flower is temperature management. Cutflowers stored in cold storage lasted longer than flowers stored under ambient conditions. Taking into account duration of storage, long term storage reduced vaselife, hence cut flowers stored for 72 hours had lesser vaselife as compared to cut flowers stored for 24 hours.

Previous studies (Halevy **et al.**, 1978) showed that the best way to prolong vaselife is precooling the flowers to 4°C, pulsing with sodium di-chlorothrizinetriane (SDT) and sucrose for 16 hrs and storing in insulated boxes with ice placed in close proximity of the blooms in refrigerated storage for 5 days, which resulted in an increase in vaselife over non-pulsed chrysanthemum cv. Albatross. Thus it is clear that cut flowers should be pulsed, precooled and packed in insulated boxes so as to prolong their subsequent vaselife.

Chapter 6

SUMMARY

SUMMARY

The present investigations include studies on vaselife of cut flowers as affected by pulsing solutions, packaging and storage conditions in case of chrysanthemum. The salient results of the three separate experiments as given below:

6.1 Holding Solutions

To standardize the holding solution, six different solutions were tried and their effect on six characters of cut flowers was observed.

6.1.1 Vaselife

8-HQ (250 ppm) with 1.5% sucrose was the best holding solution for both the cultivars of chrysanthemum in terms of longevity.

6.1.2 Flower diameter

The maximum diameter in cut flowers of cvs. Mountaineer and Kundan was observed in 8-HQ (250 ppm) + 1.5% sucrose.

6.1.3 Final pH of solution

The minimum pH was obtained with 0.15% $Al_2(SO_4)_3$ + 2% sucrose whereas, the final pH of controls was maximum (5.10 to 5.25).

6.1.4 Fresh weight changes

Maximum loss in fresh weight was observed in controls whereas, it was least in flowers held in a solution of 250 ppm 8-HQ + 1.5% sucrose in both cvs. of chrysanthemum.

6.1.5 Total sugar content

8-HQ (200 ppm) with 2% sucrose gave maximum total sugar content.

6.1.6 Appearance

6.1.6.1 Freshness

It was improved with all treatments with 250 ppm 8-HQ + 1.5% sucrose giving the best effect.

6.1.6.2 Colour

The original colour was maintained in all treatments.

6.2 Pulsing Solutions

Four different pulsing solutions were tried and two characters were observed.

6.2.1 Vaselife

0.025mM BA + 0.4 mM STS + 0.65mM 8-HQ + 5% sucrose for 16 hours gave the longest vaselife in both the cvs. of chrysanthemum.

6.2.2 Appearance

6.2.2.1 Freshness

Cutflowers pulsed with 0.025 mM BA + 0.4mM STS + 0.65 mM 8-HQ + 5% sugar for 16 hr retained freshness for maximum time.

6.2.2.2 Colour

There was no noticeable change in colour of flowers in any of the treatment.

6.3 Storage

Eighteen storage treatments were tried and three characters were observed for cut flowers.

6.3.1 Vaselife

The vaselife was influenced by duration and conditions of storage. The maximum vaselife was obtained in case of flowers stored under refrigeration (4±1°C) for 24 hours wrapped with cellophane.

6.3.2 Total sugar content

Maximum total sugar content was observed in cellophane wrapped cut flowers and stored in cold storage for 24 hours.

6.3.3 Appearance

6.3.3.1 Freshness

Cold stored flowers (24 hrs.) appeared fresh as compared to cut flowers stored in zero energy chamber or under ambient conditions.

6.3.3.2 Colour

There was no noticeable change in colour of cut flowers stored under different condition.

The best treatments have been summarized in table 13.

Table 13. Summary of best treatments

Treatments (Crop/cv.)	Pulsing solution	Storage condition	Holding solution
Chrysanthemum			
a) Mountaineer	0.025mM BA + 0.4mM STS + 0.65mM 8-HQ + 5% sucrose for 16 hours.	Cutflowers wrapped in cellophane and kept in cold storage (4±1°C) for 24 hours.	250 ppm 8-HQ + 1.5% sucrose
b) Kundan	-do-	-do-	-do-

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APPENDIX-I

SUMMARY OF ANALYSIS OF VARIANCE

1. Experiment-I (Holding solutions)

Character-vaselife (Table 2)

Source of variation	df	MSS
Treatment	5	189.19**
Cultivar	1	480.89**
Treatment vs. cultivar	5	11.34**
Error	24	

2. Experiment-II (Pulsing solutions)

Character-vaselife (Table 8)

Source of variation	df	MSS
Treatment	3	96.00**
Cultivar	1	345.80**
Error	16	

3. Experiment-III (Storage)

Character-vaselife (Table 10)

Source of variation	df	MSS
Treatment	5	593.18**
Cultivar	1	787.32**
Storage duration	2	1335.4**
Treatment vs. cultivar	5	4.80**
Treatment vs. storage duration	10	2.06**
Cultivar vs. sotrage duration	2	8.63**
Treatment vs. cultivar vs. storage duration	10	1.54**
Error	72	