BIBLIOGRAPHY

CAMID, MARCELA L. APRIL 2007. Postharvest Characteristics of 'Green Mint' Carnation (*Dianthus caryophyllus)* as Affected by Different Concentrations of Ascorbic Acid in the Holding Solution. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

This study was conducted to determine the effects of holding solutions containing different concentrations of ascorbic acid (to replace citric acid) + 20% sucrose + 1 ml Chlorox with varying pH levels of the holding solution; on the vaselife and other postharvest characteristics of carnation cutflowers.

Carnation cutflowers harvested at the star stage were held in different holding solution with pH levels containing different concentrations of ascorbic acid + 20% sucrose + 1 ml/li Chlorox.

Results revealed that the holding solutions containing 2.50 g/li ascorbic acid with a pH of 3.87 delayed flower opening resulting to longer vaselife of cutflowers.

However, holding solutions with a pH of 6.90 or tap water only promoted better leaf and stem quality of carnation cutflowers and were comparable with those cutflowers held in solutions containing 2.50 g/li of ascorbic acid solution (pH 3.87).

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INTRODUCTION

The cutflower industry is one of the major sources of income of farmers in the province of Benguet. Cutflower production of roses, chrysanthemum, carnation, anthurium and others is already widespread in the locality. The cultivation of new species or varieties of cutflowers is then needed in order to improve the industry further.

Among the many flowering plants cultivated, carnation (*Dianthus caryophyllus*) is one of the favorite cutflower and ornamental plants that are being profitably cultivated. However, carnation cutflowers rapidly deteriorate once they are harvested. Respiration after harvest and sensitivity to various gasses contribute to the physiological and physical deterioration of carnation cutflowers.

Carnation is also a perpetual flowering type of greenhouse plant, but is usually maintained for only one, or at the most, two years. Carnation is a cool-temperate crop and therefore less expensive to produce than roses. It is considered as one of the costly flowers and have a delightful fragrance and beauty.

The use of floral preservatives like citric acid was found to be very effective in all cutflowers like carnation to lengthen their aesthetic durations; thus, the use of proper postharvest technologies can contribute in prolonging the vaselife of cutflowers from harvesting to senescence. Since consumers look for the aesthetic value of carnation, damaged cutflowers such as those showing wilting; infection with insect pests and diseases usually have lower prices compared to high quality cutflowers.

Furthermore, the high quality of harvest must be preserved from cutting of the flowers to marketing in order to get higher prices and thus, increase in the farmer's income. It is also necessary to prolong the postharvest life of cutflowers to reduce

postharvest losses.

This study was conducted at the Department of Horticulture Service Laboratory, College of Agriculture, Benguet State University, La Trinidad, Benguet from January to March 2007 to determine the effect of the various holding solutions containing different concentrations of ascorbic acid (to replace citric acid) + 20% sucrose + 1 ml Chlorox.

REVIEW OF LITERATURE

Use of Preservatives

Floral preservatives are used to prolong the postharvest life of cutflowers and to maintain their aesthetic value and quality for longer periods. Flower preservatives usually contain carbohydrates in the form of sucrose, plus a bactericide, fungicide and a wetting agent. The latter chemicals prevent organisms from developing in the water to block water uptake in the sterns and improve water uptake (Hornet, 1998).

In carnation, 1 mm silver thiosulfate (STS) and 10% sucrose and a pH adjusted to 3.0-3.5 is recommended (Rimando, 1982).

Organic acids are used to lower the pH of the solutions. A low pH was shown to favor the activity of the enzymes since acidification of the vase water tends to minimize physiological stem blockage. A pH of 3.5 to 4.0 extends vaselife because it inhibits indigenous enzymes essential for stern plugging. Citric acids also improve water balance and reduce stem plugging (Alacyang, 1998).

Senescence

Senescence is a concept of physiological and biochemical process. The initial event if senescence remains obscure, during the development of some cutflowers like rose and carnation, a climacteric rise in ethylene production signifies the promotion of senescence. Thereafter, a change in permeability of the tissues can be detected (Mayak, 1987).

A fresh cutfoliage is still living and actively metabolizing entity whose life span is subsequently terminated by senescence, as distinguished from aging which involves

gradual changes that are deteriorative but not lethal in them (Leopold, 1975).

Whether it is still attached to the mother plant or not, the loss of turgidity is a very important factor affecting senescence. Senescence especially involves deteriorative changes which lead to death. According to Mastalerz (1977), the deteriorative process of senescence accelerate at the moment flowers are harvested. Flowers remaining on the plant senescence but at much slower pace. The onset of senescence is related to some decisive factors; however, senescence triggers the cutflower at any stage of as development.

Water pH

Acidity alteration is the most important of the three considerations of components of a floral preservative since alkaline or high pH water, solution is damaging to cutflowers. If it does not move through the stem, and flowers will have difficulty in obtaining sufficient water. A low pH inhibits indigenous enzyme essential for stem plugging (Reid, 2000) and tends to minimize physiological stem blockage.

Various chemicals are used to increase the acidity of a solution. The most available and affordable chemical is vinegar. However, vinegar causes whitening of the stem when included in the holding solution (Alacyang, 1998). Citric acid can also be used to increase the acidity of the solution (Agricarta, 1999).

Harvesting Stage

Respiration rates of carnation flower is quite high and reaches a minimum at the time when the sepal has folded out from the developing buds. At commercial harvest,

when the first petals break away from the flower body, respiration declines rapidly (Rimando, 1982).

Generally, flowers are cut at the earliest stage in order to assure full opening and development with good quality and longer vase life (Halevy and Mayak, 1979). Hornet (1998) stressed that postharvest technologies cannot improve the quality of cutflowers at harvest but rather it helps to maintain it. Rogers (1973) said that flowers that are harvested should be placed in opening solution to prevent rapid wilting. It is important to know the stage at which the flower as to be harvested because this will affect the longevity of the postharvest life of the flowers (Nowak and Rudnick, 1990). For the immediate use or for nearby markets, flowers are normally harvested when they reach the paintbrush stage or when the flowers are fully opened (Reid, 2000).

Longevity of the Flower

Coorts (1965) found that respiratory rate for intact rose flowers was quite high and was reduced to a minimum at the time when the sepals had folded out from the developing bud.

At commercial harvest, when the first petals were breaking away from the flower body, respiration declined. Further, he stated that to maintain cutflower quality, cutflower should be harvested at the right stage of maturity; however, maturity stages vary from flower to flower under different cultural and marketing situations.

On the other hand, the bud stage is preferred harvesting stage due to convenience in handling and less susceptibility to adverse environmental conditions like temperature and ethylene. Thus, it influences the respiration rate of the flowers and their response to ethylene, moisture loss and physical change.

Holding Solution

Sucrose had been shown to increase the fresh weight and longevity of cutflowers. Sucrose also reduces moisture stress in cutflower by decreasing the size of leaf stomata (Marousky, 1969). Flowers held in sucrose were comparable to field opened flowers, hence it is the source of energy of cutflowers.

According to Rimando (1982), the optimum levels of sucrose must be provided to successfully open cutflowers to quality blooms. Furthermore, the preservatives in addition to extending the vaselife of cutflowers had been used as opening solutions for cutflowers harvested at immature stage of flower development.

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MATERIALS AND METHODS

Materials

The materials used were‘Green Mint’ carnation cutflowers at star stage with a uniform length of 40 cm, catsup bottles and holding solutions, stirring rod, beaker and weighing balance in the preparation of the solution. A pH meter determine the pH level of the preservative solutions.

The preservatives on holding solution used were the following: ascorbic acid (to replace citric acid) at different rates to vary the pH solution; sucrose (20%) by weight and Chlorox (1 ml/li solution).

Methods

Experimental design and treatments. The study was laid out in completely randomized design (CRD). Three flowers represent a treatment replicated four times. The treatments were as follows:

Code	Ascorbic acid (g/li)	pH
T_1	Control (tap water only	6.90
T_2	1.0	5.20
T_3	1.5	4.57
T_4	2.0	4.10
T_5	2.5	3.87
T_6	3.0	3.73
T_7	3.5	3.58
T_8	4.0	3.47

Cutflower preparation. Before holding the cutflowers in the different solutions, the leaves at the lower 1/3 of the stem of carnation cutflowers were removed and recut in a slanting manner. All cutflowers had uniform length of 40 cm. Each catsup bottle contains 200 ml solution where the sample flowers were held.

Data gathering. The data gathered and subjected to variance analysis and mean separation test by Duncan's multiple range tests (DMRT) were as follows:

1. Vaselife. This was obtained by counting the number of days covering the period from holding of the cutflowers in the solution up to the termination of the aesthetic value of the flower.

2. Volume of the solution used/taken-up. This was obtained by measuring the volume of the solution left in the bottle upon the termination of vaselife. A bottle was filled with similar volume of holding solution left without a flower and used as a correction factor of the volume lost through evaporation and absorption.

3. Number of days from holding to 50% anthesis. This was obtained by counting the number of days from holding to 50% anthesis.

4. Neck bending. This was observed at the time when the neck of flower started to show bending.

5. Number of days from holding to full flower opening (100% anthesis). This was done by recording the number of days from holding to full flower opening.

6. Visual quality rating (VQR). This was evaluated daily until the onset of senescence.

a. Stem quality

Index	Description
1	No browning
2	Up to 2.0 cm browning from the base of the stem
3	Up to 4.0 cm browning from the base of the stem
4	Up to 6.0 cm browning from the base of the stem

b. Leaf quality

Index	Description
0	No yellowing
1	1-10% yellowing
2	11-20% yellowing
3	21-30% yellowing
4	31-40% yellowing
5	75% yellowing

c. Flower quality

Index	Description
1	Excellent, field fresh, no defects
2	two petals wilted
3	three petals wilted
4	four petals wilted
5	five petals wilted

7. Initial and final pH of the holding solution. These were taken before immersion of the cutflower stem ends and after the termination of the experiment.

8. Documentation by pictures.

9. Temperature. The experiment was conducted with an average temperature of 17.5^0 and 20.4^0 in the months of January and February 2007, respectively.

Figure 1. Overview of the experiment

RESULTS AND DISCUSSION

Days from Holding to 50% and 100% Anthesis

Table 1 shows that there were no significant differences among the various concentrations of ascorbic acid ranging from 1.00-4.00 g/li of the holding solutions with pH levels ranging from 3.47-6.90 from holding to 50% anthesis. However, cutflowers held in a solution with 2.0 g/li with a pH of 4.10 opened faster with a mean of 5.17 days while cutflowers in the holding solution with 1.5 g/li with a pH of 4.57 had the longest duration from the date of holding in vase to full flower opening which has a mean of 6.25 days.

Table 1. Number of days from holding to 50 and 100% anthesis

ASCORBIC ACID CONCENTRATION (g/li, pH)	50% ANTHESIS (days)	100% ANTHESIS (days)
Tap water only (6.90)	5.75a	13.79a
1.00 (5.20)	6.17a	12.59a
1.50 (4.57)	6.25a	12.67a
2.00 (4.10)	5.17a	13.75a
2.50 (3.87)	5.50a	14.59a
3.00 (3.73)	6.17a	13.25a
3.50 (3.58)	5.75a	14.21a
4.00 (3.47)	6.00a	13.88a

In a column, means with a common letter are not significantly different at 5% level by DMRT

Likewise, there were no significant effects of the various ascorbic acid concentrations in the holding solutions with regards to duration to full flower opening (Table 1). Results showed, however, that cutflowers held in 1.0g/li ascorbic acid with a pH 5.20 opened faster with a mean of 12.59 days while cutflowers held in the holding solution with 2.5 g/li ascorbic acid with a pH of 3.87 had the longest duration to full flower opening which had a mean of 14.59 days.

Percentage Neck Bending

Table 2 shows that there were significant differences obtained on the percentage of neck bending. Cutflowers held in solution with 3.0 g/li ascorbic acid with a pH of 3.73 had the highest percentage of neck bending with a mean of 25.00 while the lowest percentage was observed on the cutflowers held in tap water with pH of 6.90, 5.20 (1.0g/li), 4.10

Table 2. Percentage of neck bending

ASCORBIC ACID CONCENTRATION (g/li, pH)	MEAN (%)
6.90 Tap water only (6.90)	0.00c
1.00 (5.20)	0.00c
1.50 (4.57)	8.33b
2.00 (4.10)	0.00c
2.50 (3.87)	0.00c
3.00 (3.73)	25.00a
3.50 (3.58)	16.67b
4.00 (3.47)	16.67b

Means with a common letter are not significantly different at 5% level by DMRT

(2.0g/li), and 3.87 (2.5g/li) with an identical means of 0.00%.

Visual Quality

The visual quality for all the cutflowers in the experiment was rated from the 9th day of holding and was done every after three days (Tables 3-5).

Stem quality. Statistically, significant effects of the different concentrations of ascorbic acid ranging from 1.00-4.00 g/li in the holding solutions with pH levels ranging from 3.47-6.90 were noted on the stem quality rating (Table 3). Cutflowers held in holding solutions with lower concentrations on the 9th day had significantly higher ratings for stem damage ranging from 1.17-1.50 which was described as up to 2.0 cm browning from the base of the stem compared to those held in tap water only (pH 6.90) which had a mean of 1.00,

Table 3. Stem quality rating

ASCORBIC ACID CONCENTRATION	DAY				
(g/li, pH)	9	12	15	18	21
Tap water only (6.90)	1.00c	1.00c	1.00d	1.00e	1.00e
1.00 (5.20)	1.49a	1.83a	2.04a	2.21a	2.38a
1.50 (4.57)	1.46a	1.71ab	1.92ab	2.04ab	2.38a
2.00 (4.10)	1.33ab	1.58ab	1.96ab	2.21a	2.42a
2.50 (3.87)	1.42ab	1.59ab	1.79ab	1.96abc	2.09ab
3.00 (3.73)	1.33ab	1.58ab	1.75abc	1.84bcd	1.96b
3.50 (3.58)	1.50a	1.46b	1.71abc	1.75cd	2.09ab
4.00 (3.47)	1.17bc	1.38b	1.59c	1.67d	1.83b

In a column, means with a common letter are not significantly different at 5% level by DMRT

and described as no stem browning of the stem ends. However, cutflowers held in a solution containing 3.5 g/li with a pH of 3.58 had the highest rating of 1.50 which means 1 cm browning of the stem end was observed.

On the 12th day, cutflowers held in solution in solution containing 1.0 g/li with pH 5.20 had significantly the highest mean of 1.83, likewise on the 15th day having a mean of 2.04 which means up to 2.0 cm browning from the base of the stem observed.

At day 18th, cutflowers held in solution with a 2.0 g/li (pH 4.10) had the highest rating of 2.21. However, it was comparable with those that were held in solutions with 2.5 g/li (pH 3.87-5.20) while those held in tap water only with a pH 6.90 had no stem browning.

On the 21th day of observation, it was observed that cuflowers held in tap water only (pH 6.90) had significantly no stem browning; while cutflowers held in solutions with lower pH values showed different degrees of stem browning.

These results imply that the acidifying agent helped to minimize microbial build-up and served as pH buffer but when applied in excess may damage the stems of cutflowers (Rimando, 1980).

Leaf quality. Table 4 shows that there were significant differences with regards to leaf quality of cutflowers held in different concentrations of ascorbic acid in the holding solution. On day 9, cutflowers held in solution of 3.0 g/li having a pH of 3.73 had the highest leaf quality of 0.84 which means less than 1-10% leaf yellowing was observed while the lowest rating was noted on cutflowers held in tap water only (pH 6.90) with a mean of 0.00 which means that these were no yellowing of leaves observed.

At day 12, cutflowers held in solution with a pH of 3.73 and 5.20 had the highest

leaf quality rating of 1.67 which means that 1-10% leaf yellowing was noted. However, on the 15th day, cutflowers held at pH 3.73 had again the highest rating of 2.59 which means 11-Table 4. Leaf quality rating

ASCORBIC ACID CONCENTRATION	DAY				
(g/li, pH)	9	12	15	18	21
Tap water only (6.90)	0.00b	0.00b	0.00b	0.00b	0.00b
1.00 (5.20)	0.75a	1.67a	2.25a	3.42a	4.83a
1.50 (4.57)	0.83a	1.50a	2.25a	3.25a	5.00a
2.00 (4.10)	0.67a	1.50a	2.42a	3.17a	4.50a
2.50 (3.87)	0.59a	1.34a	2.25a	3.17a	4.75a
3.00 (3.73)	0.84a	1.67a	2.59a	3.33a	4.595a
3.50 (3.58)	0.58a	1.50a	2.25a	3.17a	4.50a
4.00 (3.47)	0.75a	1.42a	2.25a	3.17a	4.67a

In a column, means with a common letter are not significantly different at 5% level by DMRT

20% yellowing in the leaves was attained.

On the 18th day, cutflowers held in solution with 1.0 g/li with a pH 5.20 resulted to a rating of 3.42 for the highest percentage of yellowing of the cutflower leaves.

Lastly, at day 21, cutflowers held in 1.5 g/li of ascorbic acid (pH 4.57) had the highest rating of 5.00 which was described as 75% leaf yellowing while no leaf yellowing was noted on cutflowers held in tap water only (pH 6.90).

Flower quality. Statistical analysis showed that there were significant differences observed on the flower quality rating at days 9 and 15 (Table 5). On the 9th day of observation, cutflowers held in solution with 1.0 g/li of ascorbic acid with a pH 5.20 had

the highest rating of 2.08 with two petals wilted; while cutflowers held in solution with 2.5 g/li (pH 3.87) and 4.0 g/li of ascorbic acid (pH 3.47) had the lowest rating of 1.33 which was Table 5. Flower quality rating

ASCORBIC ACID CONCENTRATION	DAY			
(g/li, pH)	9	12	15	18
Tap water only (6.90)	1.67ab	2.58a	4.17ab	6.84a
1.00 (5.20)	2.08a	2.92a	4.58a	5.00a
1.50 (4.57)	1.83ab	2.67a	4.42ab	4.92a
2.00 (4.10)	1.75ab	2.33a	3.92ab	4.84a
2.50 (3.87)	1.33b	2.08a	2.83c	4.33a
3.00 (3.73)	1.67ab	2.59a	4.17ab	4.75a
3.50 (3.58)	1.67ab	2.33a	4.17ab	4.75a
4.00 (3.47)	1.33b	2.25a	3.42bc	4.75a

In a column, means with a common letter are not significantly different at 5% level by DMRT

described as excellent, field fresh and no defects.

The flower quality rating of cutflowers at days 12 and 18 were comparable. However, on the 15th day of observations, those that were held in solution with 2.50 g/li with a pH of 3.87 had significantly better quality than cutflowers held in solution with the other ascorbic acid concentrations evaluated.

Rogers (1973) observed that chemical preservatives were used to maintain flower quality and extend vaselife of cutflowers. They were also used as opening solutions for flowers at immature stage, but excess chemicals added to the vase solutions may lead to early deterioration. The basic components of most preservatives are: a source to enhance the water retaining capacity of the tissues and as a source of substrate; a germicide to help maintain the efficient uptake and water conducting function of the stem; as acidifying agent and a buffer to inhibit the activity of certain enzymes; and heavy metals to help stabilize color and prevent microbial build-up.

Volume Taken-up

Statistical analysis showed that there were significant differences in the volume of the solution used or taken-up by the cutflowers as affected by the different ascorbic acid levels in the holding solution (Table 6). Results showed that cutflowers held in tap water only (pH 6.90) had the highest volume absorbed with a mean of 49.17 ml. On the other hand, cutflowers held in solution with 3.5 g/li ascorbic acid having a pH of 3.58 had the lowest volume of solution absorbed with a mean of only 28.17 ml.

These findings confirmed the earlier findings of Kebasen (2002) who found that carnation harvested at star and cross stages and held in tap water only, had the highest

Table 6. Volume of solution used/taken-up

ASCORBIC ACID CONCENTRATION (g/li, pH)	MEAN (ml)
Tap water only (6.90)	49.17a
1.00 (5.20)	35.75c
1.50 (4.57)	28.25d

2.00 (4.10)	29.00d
2.50 (3.87)	30.58d
3.00 (3.73)	29.58d
3.50 (3.58)	28.17d
4.00 (3.47)	40.25b

Means with a common letter are not significantly different at 5% level by DMRT

volume of solution taken-up.

Vaselife

Table 7 showed the vaselife of the cutflowers as affected by the different ascorbic acid concentrations with various pH levels of the holding solutions. Results showed that cutflowers held in 2.5 g/li (pH 3.87) had the longest vaselife of 18.12 days but were comparable to those held 2.0-4.0 g/li having pH 3.47, 3.58, 3.73, 4.10, and 6.90. Cutflowers held in 1.0 g/li of ascorbic acid (pH 5.20) had the shortest vaselife of 14.67 days.

Rimando (1980) stated that the lose of turgidity, exposure to ethylene and shortage of respirable substances are the most decisive factors which may trigger the onset of senescence of cutflowers at any stage of their development, whether they are still attached or already detached from the parent plant.

Table 7. Vaselife

ASCORBIC ACID CONCENTRATION (g/li, pH)	MEAN (days)
Tap water only (6.90)	16.09abc
1.00 (5.20)	14.67c
1.50 (4.57)	15.42bc

2.00 (4.10)	16.26abc
2.50 (3.87)	18.12a
3.00 (3.73)	16.08abc
3.50 (3.58)	16.67abc
4.00 (3.47)	17.09ab

Means with a common letter are not significantly different at 5% level by DMRT

Furthermore, vaselife could have been affected by the microoganisms present in sucrose solutions which have caused stem plugging. These microorganisms hindered the entry of water into the stem and to other parts of the cutflowers to maintain turgidity as well as the distribution of food on the different parts of the cutflowers (Whealy, 1992; Rogers, 1973).

However, adding floral preservatives to the holding solutions have been very effective in extending the vaselife of cutflowers because they provide food. Acidifiers also helps to reduce bacterial action that may lead to early deterioration of cutflowers. The bactericide or germicides kills bacteria in the solution and preclogging of the stem ends that can resist water uptake.

Final pH

The final pH solutions containing various ascorbic acid concentrations after the termination of the experiment is shown in Table 8. Based from the results, there was a decrease in the pH of the holding solutions and became more acidic that affected the vaselife of the cutflowers. The acidity of the different concentrations significantly affected how the respiratory substrates were utilized and increase of the microbial build-

up in the holding solutions. Rimando and Maralit (1980) pointed out that lower pH of opening solutions is advantageous to cutflowers as it helps minimize microbial build-up and inhibit the activity of certain enzymes leading to early senescence.

Table 8. Final pH of the holding solution

ASCORBIC ACID CONCENTRATION (g/li, pH)	FINAL pH
(Tap water only (6.90)	7.0
1.00 (5.20)	3.2
1.50 (4.57)	3.0
2.00 (4.10)	3.1
2.50 (3.87)	3.0
3.00 (3.73)	3.2
3.50 (3.58)	3.1
4.00 (3.47)	3.1

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

Carnation ('Green Mint') were harvested at star stage. The stem ends were recut in a slanting manner and had a uniform stem length of 40 cm. Leaves at the lower 1/3 of the stem were removed and the stem ends were held in holding solutions containing different concentrations of ascorbic acid (to replace citric acid) + 20% sucrose + 1 ml Chlorox.

Based on the results of the study, there were not significant differences on the number of days from holding to 50 and 100% of anthesis. Cutflowers held in solutions with different concentrations of ascorbic acid with various pH levels. However, cutflowers held in a solution with 2.5 g/li ascorbic acid (pH 3.87) had the longest duration to full flower opening.

With regards to percentage neck bending, cutflowers held in holding solution with 3.0 g/li ascorbic acid (pH 3.73) had the highest percentage of neck bending.

Observations on stem quality rating showed that cutflowers held in tap water only (pH 6.90) had no stem browning up to 21 days of observations; while cutflowers held in the different holding solution with ascorbic acid concentrations showed stem browning from the base of the stem. It was also observed that in leaf quality rating, cutflowers held in tap water did not have leaf yellowing up to the termination of the experiment; while cutflowers held in the different holding solutions with ascorbic acid had yellowing of the leaves; hence, holding solutions with 1.5 g/li ascorbic acid (pH of 4.57) had the highest percentage of yellowing (75%). With regards to flower quality rating, holding solution

with 2.5 g/li ascorbic acid (pH 3.87) had the best flower quality..

On the other hand, cutflowers held in tap water only (pH 6.90) had the highest volume of solution absorbed while cutflowers held in solutions with 2.0 and 1.0 g/li of ascorbic acid (pH 4.10 and 5.20) absorbed comparable amounts of the solutions.

However, in the final pH of the holding solution, there was a decrease in the pH of the holding solutions which means that the solutions became more acidic except for the tap water. Cutflowers held in 1.5 g/li ascorbic acid (pH 3.87) had the longest vaselife of 18.122 days while the shortest was observed in cutflowers held in solution containing 1.0 g/li ascorbic acid (pH 5.20) with a mean of 14.69 days.

Conclusion

Results showed that using holding solution with 2.5 g/li of ascorbic acid 2.5 g/li + 20% sucrose (by weight) + 1 ml/li Chlorox with a pH of 3.87 delayed flower opening resulting to longer vaselife of carnation cutflowers ('Green Mint'). However, it was comparable to those cutflowers held in tap water only.

Recommendation

It is therefore recommended, that a holding solution with 2.5 g/li of ascorbic acid + 20% sucrose (by weight) + 1 ml/li Chlorox having a pH of 3.87 can be used to delay flower opening, in carnation cutflowers harvested at star stage to prolong vaselife with better cutflower quality.

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APPENDICES

Appendix Table 1. Number of days from holding to 50% anthesis

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	5.67	6.00	5.67	5.67	23.01	5.75
T_2	6.00	6.33	6.67	5.67	24.67	6.17
T_3	5.67	6.33	6.67	6.33	25.00	6.25
T_4	5.00	5.67	5.00	5.00	20.67	5.17
T_5	6.00	5.00	6.00	5.00	22.00	5.50
T_6	6.00	6.67	7.00	5.00	24.67	6.17
T_7	5.67	5.33	6.00	6.00	23.00	5.75
T_8	6.67	5.67	5.67	6.00	24.01	6.00

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	3.970	0.567	2.34ns	2.43	3.50
Error	24	5.810	0.242			
Total	31	9.779				

ns = Not significant

Coefficient of variation = 8.42%

Appendix Table 2. Number of days from holding to full flower opening (100%)

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	13.17	13.83	14.00	14.17	55.17	13.79
T_2	12.67	12.17	13.17	12.33	50.34	12.59
T_3	12.17	14.67	12.50	11.33	50.67	12.67
T_4	14.33	13.50	14.67	12.50	55.00	13.75
T_5	14.50	14.17	16.00	13.67	58.34	14.59
T_6	14.67	12.33	13.00	13.00	53.00	13.25
T_7	14.50	12.83	14.83	14.67	56.83	14.21
T_8	15.67	14.17	12.67	13.00	55.51	13.88

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	13.989	1.998	2.00ns	2.43	3.50
Error	24	24.161	1.007			
Total	31	38.150				

ns = Not significant

Coefficient of variation = 7.38%

Appendix Table 3. Percentage neck bending

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.000	0.000	0.000	0.000	0.00	0.000
T_2	0.000	0.000	0.000	0.000	0.00	0.000
T_3	0.000	0.000	33.33	0.000	33.33	8.333
T_4	0.000	0.000	0.000	0.000	0.00	0.000
T_5	0.000	0.000	0.000	0.000	0.00	0.000
T_6	33.33	0.000	33.33	33.33	99.99	24.998
T_7	33.33	3.333	0.000	0.000	66.66	16.665
T_8	0.000	0.000	66.67	0.000	66.67	16.667

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	2777.389	396.770	5.56**	2.43	3.50
Error	24	6110.889	254.620			
Total	31	8888.278				

** = Highly significant

Coefficient of variation = 19.49%

Appendix Table 4. Stem quality at day 9

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.00	1.00	1.00	1.00	4.00	1.00
T_2	1.50	1.33	1.50	1.50	5.83	1.46
T_3	1.33	1.67	1.17	1.67	5.84	1.46
T_4	1.50	1.33	1.17	1.33	5.33	1.33
T_5	1.67	1.33	1.17	1.50	5.67	1.42
T_6	1.33	1.33	1.67	1.00	5.33	1.33
T_7	1.50	1.67	1.33	1.50	6.00	1.50
T_8	1.33	1.00	1.17	1.17	4.67	1.17

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	0.820	0.117	3.79**	2.43	3.50
Error	24	0.742	0.031			
Total	31	1.561				

** = Highly significant

Coefficient of variation = 13.18%

Appendix Table 5. Stem quality at day 12

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.00	1.00	1.00	1.00	4.00	1.00
T_2	1.83	1.50	1.83	2.17	7.33	1.83
T_3	1.50	1.67	1.50	2.17	6.84	1.71
T_4	1.83	1.33	1.33	1.83	6.32	1.58
T_5	1.50	1.67	1.50	1.67	6.34	1.59
T_6	1.67	1.50	1.83	1.33	6.33	1.58
T_7	1.83	1.17	1.33	1.50	5.83	1.46
T_8	1.33	1.17	1.50	1.50	5.50	1.38

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	1.763	0.252	4.8**	2.43	3.50
Error	24	1.259	0.052			
Total	31	3.022				

** = Highly significant Coefficient of variation = 15.12%

Appendix Table 6. Stem quality at day 15

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.00	1.00	1.00	1.00	4.00	1.00
T_2	2.17	1.67	2.00	2.33	8.17	2.04
T_3	1.67	2.17	1.67	2.17	7.68	1.92
T_4	2.00	1.67	2.00	2.17	7.84	1.96
T_5	1.83	1.83	1.83	1.67	7.16	1.79
T_6	1.83	1.50	2.00	1.67	7.00	1.75
T_7	1.83	1.50	1.67	1.83	6.83	1.71
T_8	1.50	1.67	1.50	1.67	6.34	1.59

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	2.977	0.425	11.58**	2.43	3.50
Error	24	0.881	0.037			
Total	31	3.858				

** = Highly significant

Coefficient of variation = 11.14%

Appendix Table 7. Stem quality at day 18

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.00	1.00	1.00	1.00	4.00	1.00
T_2	2.17	1.83	2.33	2.50	8.83	2.21
T_3	1.83	2.17	2.00	2.17	8.17	2.04
T_4	2.00	2.17	2.17	2.50	8.84	2.21
T_5	2.17	1.83	2.00	1.83	7.83	1.96
T_6	2.00	1.67	2.00	1.67	7.34	1.84
T_7	1.83	1.50	1.83	1.83	6.99	1.75
T_8	1.67	1.67	1.67	1.67	6.68	1.67

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	4.278	0.611	20.22**	2.43	3.50
Error	24	0.725	0.030			
Total	31	5.004				

** = Highly significant

Coefficient of variation = 9.48%

Appendix Table 8. Stem quality at day 21

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.00	1.00	1.00	1.00	4.00	1.00
T_2	2.33	2.00	2.50	2.67	9.50	2.38
T_3	2.17	2.50	2.33	2.50	9.50	2.38
T_4	2.00	2.67	2.17	2.83	9.67	2.42
T_5	2.17	2.00	2.00	2.17	8.34	2.09
T_6	2.00	1.83	2.17	1.83	7.83	1.96
T_7	2.00	1.67	2.00	2.67	8.34	2.09
T_8	1.83	2.00	1.83	1.67	7.33	1.83

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	5.991	0.856	13.86**	2.43	3.50
Error	24	1.482	0.062			
Total	31	7.473				

** = Highly significant Coefficient of variation = 12.33%

Appendix Table 9. Leaf quality at day 9

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.00	0.00	0.00	0.00	0.00	0.00
T_2	0.33	1.00	1.00	0.67	3.00	0.75
T_3	0.33	1.00	1.00	1.00	3.33	0.83
T_4	0.33	0.33	1.00	1.00	2.66	0.67
T_5	0.67	0.00	1.00	0.67	2.34	0.59
T_6	1.00	0.67	0.67	1.00	3.34	0.84
T_7	0.33	1.00	0.67	0.33	2.33	0.58
T_8	0.67	0.33	1.00	1.00	3.00	0.75

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	2.056	0.294	3.00*	2.43	3.50
Error	24	2.348	0.098			
Total	31	4.405				

* = Significant

Coefficient of variation = 50.05%

Appendix Table 10. Leaf quality at day 12

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.00	0.00	0.00	0.00	0.00	0.00
T_2	1.33	1.67	2.00	1.67	6.67	1.67
T_3	1.33	1.67	1.33	1.67	6.00	1.50
T_4	1.00	1.33	1.67	2.00	6.00	1.50
T_5	1.67	1.00	1.00	1.67	5.34	1.34
T_6	1.33	1.67	1.67	2.00	6.67	1.67
T_7	1.33	1.67	2.00	1.00	6.00	1.50
T_8	1.33	1.00	1.67	1.67	5.67	1.42

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	7	8.363	1.195	11.76**	2.43	3.50
Error	24	2.439	0.102			
Total	31	10.802				

** = Highly significant

Coefficient of variation = 24.09%

Appendix Table 11. Leaf quality at day 15

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.00	0.00	0.00	0.00	0.00	0.00
T_2	2.33	2.00	2.33	2.33	8.99	2.25
T_3	2.00	2.67	2.33	2.00	9.00	2.25
T_4	2.33	2.33	2.33	2.67	9.66	2.42
T_5	2.67	2.00	2.00	2.33	9.00	2.25
T_6	2.67	2.33	2.67	2.67	10.34	2.59
T_7	2.00	2.33	2.67	2.00	9.00	2.25
T_8	2.67	2.00	2.33	2.00	9.00	2.25

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	19.272	2.753	44.46**	2.43	3.50
Error	24	1.486	0.062			
Total	31	20.758				

** = Highly significant Coefficient of variation = 12.25%

Appendix Table 12. Leaf quality at day 18

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.00	0.00	0.00	0.00	0.00	0.00
T_2	3.33	3.67	3.33	3.33	13.66	3.42
T_3	3.00	3.33	3.67	3.00	13.00	3.25
T_4	3.00	3.33	3.33	3.00	12.66	3.17
T_5	3.00	3.00	3.33	3.33	12.66	3.17
T_6	3.33	3.33	3.00	3.67	13.33	3.33
T_7	3.00	3.00	3.67	3.00	12.67	3.17
T_8	3.00	3.33	3.33	3.00	12.66	3.17

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	7	36.922	5.275	98.72**	2.43	3.50
Error	24	1.282	0.053			
Total	31	38.205				

** = Highly significant

Coefficient of variation = 8.16%

Appendix Table 13. Leaf quality at day 21

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	0.00	0.00	0.00	0.00	0.00	0.00
T_2	4.67	5.00	5.00	4.67	19.34	4.84
T_3	5.00	5.00	5.00	5.00	20.00	5.00
T_4	4.00	4.33	4.67	5.00	18.00	4.50
T_5	5.00	4.67	4.67	4.67	19.01	4.75
T_6	4.00	4.67	4.67	5.00	18.34	4.59
T_7	4.67	4.33	5.00	4.00	18.00	4.50
T_8	4.33	4.33	5.00	5.00	18.66	4.67

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	77.841	11.120	116.85**	2.43	3.50
Error	24	2.284	0.095			
Total	31	80.125				

** = Highly significant

Coefficient of variation = 7.52%

Appendix Table 14. Flower quality at day 9

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	1.67	1.67	1.67	1.67	6.68	1.67
T_2	2.00	2.33	2.33	1.67	8.33	2.08
T_3	2.00	1.33	2.00	2.00	7.33	1.83
T_4	1.33	2.00	1.33	2.33	6.99	1.75
T_5	1.00	1.33	1.33	1.67	5.33	1.33
T_6	1.33	2.00	1.67	1.67	6.67	1.67
T_7	1.67	2.00	1.67	1.33	6.67	1.67
T_8	1.00	1.67	1.33	1.33	5.33	1.33

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	1.721	0.246	2.58*	2.43	3.50
Error	24	2.286	0.095			
Total	31	4.007				

* = Significant

Coefficient of variation = 18.52%

Appendix Table 15. Flower quality at day 12

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	3.00	2.33	2.67	2.33	10.33	2.58
T_2	2.67	3.00	3.00	3.00	11.67	2.92
T_3	3.00	2.00	3.00	2.67	10.67	2.67
T_4	2.00	2.33	2.00	3.00	9.33	2.33
T_5	1.33	2.00	2.33	2.67	8.33	2.08
T_6	1.67	3.00	2.67	3.00	10.34	2.59
T_7	2.00	2.33	2.33	2.67	9.33	2.33
T_8	1.33	2.00	2.67	3.00	9.00	2.25

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	2.006	0.287	1.19ns	2.43	3.50
Error	24	5.765	0.240			
Total	31	7.771				

ns = Not significant

Coefficient of variation = 19.85%

Appendix Table 16. Flower quality at day 15

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	4.33	3.33	4.67	4.33	16.66	4.17
T_2	4.33	5.00	4.33	4.67	18.33	4.58
T_3	5.00	3.33	5.00	4.33	17.66	4.42
T_4	3.67	4.33	2.67	5.00	15.67	3.92
T_5	2.33	3.33	2.67	3.00	11.33	2.83
T_6	3.00	4.67	4.33	4.67	16.67	4.17
T_7	4.00	4.67	4.33	3.67	16.67	4.17
T_8	2.66	3.33	3.67	4.00	13.66	3.42

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	9.171	1.310	3.10*	2.43	3.50
Error	24	10.132	0.422			
Total	31	19.303				

* = Significant

Coefficient of variation = 16.42%

Appendix Table 17. Flower quality at day 18

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	5.00	4.67	5.00	4.67	19.34	4.84
T_2	5.00	5.00	5.00	5.00	20.00	5.00
T_3	5.00	4.67	5.00	5.00	19.67	4.92
T_4	5.00	4.67	4.67	5.00	19.34	4.84
T_5	4.00	4.33	4.33	4.67	17.33	4.33
T_6	4.00	5.00	5.00	5.00	19.00	4.75
T_7	4.67	4.67	4.67	5.00	19.01	4.75
T_8	4.33	4.67	5.00	5.00	19.00	4.75

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	1.102	0.157	2.27ns	2.43	3.50
Error	24	1.663	0.069			
Total	31	2.766				

ns = Not significant

Coefficient of variation = 5.52%

Appendix Table 18. Vaselife (days)

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	15.67	17.00	15.17	16.50	64.34	16.09
T_2	15.00	14.00	14.67	15.00	58.67	14.67
T_3	14.33	17.33	15.00	15.00	61.66	15.42
T_4	16.67	16.00	18.00	14.37	65.04	16.26
T_5	19.33	17.83	18.33	17.00	72.49	18.12
T_6	18.67	15.33	15.33	15.00	64.33	16.08
T_7	16.33	17.00	16.67	16.67	66.67	16.67
T_8	19.67	17.50	15.17	16.00	68.34	17.09

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	30.465	4.352	2.71*	2.43	3.50
Error	24	38.479	1.603			
Total	31	68.944				

* = Significant

Coefficient of variation = 7.77%

Appendix Table 19. Volume absorbed (ml)

TREATMENT	REPLICATION				TOTAL	MEAN
	I	II	III	IV		
T_1	45.33	50.67	49.00	51.67	196.67	49.17
T_2	38.33	33.33	35.33	36.00	142.99	35.75
T_3	32.00	29.00	25.33	26.67	113.00	28.25
T_4	32.33	29.33	28.00	26.33	115.99	29.00
T_5	28.33	32.67	32.00	29.33	122.33	30.58
T_6	33.00	28.00	30.00	27.33	118.33	29.58
T_7	26.00	29.00	25.67	32.00	112.67	28.17
T_8	38.00	43.00	39.33	40.67	161.00	40.25

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	7	1581.086	225.869	35.34**	2.43	3.50
Error	24	153.406	6.392			
Total	31	1734.493				

** = Highly significant

Coefficient of variation = 7.47%