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Exploring the Potential of Organic Floral Preservative Solutions to Extend the Post-Harvest Life of Lotus (*Nelumbo nucifera*)

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Abstract

Among aquatic plants *Nelumbo nucifera* (lotus) has a great economic significance to mankind by owning a considerable share in the local aquatic cut flower market. The sliced surface of lotus flowers releases a large quantity of sticky, milky fluid, and latex congeals, preventing or decreasing water absorption and, eventually, shortening the vase life of the flowers. Vase life of flowers is one of the most crucial factors for cut flower marketing and commercialization. It can be improved by the use of different preservatives substances. Compared to harmful chemical floral preservatives, botanical extracts are natural, safe, and inexpensive compounds that are always crucial in this respect for large-scale applications. Hence, this study investigated the potential of some organic floral preservative solutions and their concentrations in improving the vase life of lotus. Lotus was blanched in the water bath at 40°C for 30 seconds and placed for pulsing in 5% sugar solution for 30 minutes. Then the flowers were kept under different holding solutions at varying concentrations. 2%, 3%, and 5% w/v concentrations of *Moringa oleifera* leaf extract and *Aloe vera* (L.) solutions and 20%, 30%, and 50 % v/v concentrations of coconut water were supplemented with 5% (v/v) vinegar. Two Factor Factorial Complete Randomized Experimental Design was used with five replicates, and Fisher's Least Significant Difference test was done for mean separation. For the statistical analysis, SAS 9.4 version software was used. The results proved that 30% (v/v) concentration of coconut water was best in prolonging the postharvest life of (10 days) lotus. The present study explored the potentialities of using organic floral preservatives to substitute the hazardous chemical preservatives to prolong the post-harvest life of lotus flowers.

Key words: floral preservatives, lotus, post-harvest life

1. Introduction

On a variety of important events, flowers are used to express feelings of gratitude, love, and emotions. The global cut flower trade is expected to develop due to the promotion and use of horticulture plants for their therapeutic properties, as well as the current increase in population and consumer demand.

Flowers are more perishable in nature and they are highly prone to postharvest damage. About 10-30% of postharvest losses in flowers are due to poor postharvest practices [1]. Therefore, extending the post-harvest life of flowers is mandatory to fetch a good market price, and to get a high demand. We need great attention to suitable techniques in delaying senescence to keep them fresh. Freshness is maintained by the use of a preservative solution and they are capable of prolonging the shelf life of flowers.

One of the most important elements for determining customer satisfaction and repeat business is the vase life quality of flowers. High-quality flowers must be grown for the ornamental industry. This will prolong the life of flowers after harvest and boost their marketability and financial worth. Flowers are actively metabolizing organs, much like the other plant components, and decay with time [2]. Water relationships, carbohydrate status, ethylene, and pathogens are the four main elements that affect vase life both during cultivation and postharvest [3]. Many flowers are ethylene sensitive and can result in illnesses including drowsiness and epinasty. The type of sugars (solutes) present and the rate of transpiration are the main factors affecting vase life. If the water balance is off due to transpiration, the effect is drooping and early wilting, which makes the product unappealing to consumers.

In addition to pre-harvest conditions that affect the vase life of flowers, other aspects that shorten the vase life of flowers and hasten their decomposition. Although it's usual practice to use carbs to extend the vase life of flowers, employing sugar alone will serve as a food source for microorganism growth. The growth of bacteria in preservation treatments, which results in clogging of the vascular system of stems and flowers, is a significant issue after the flowers have been harvested. In the past, antimicrobial substances like silver nitrate and citrate were used to extend the vase life of flowers, but in recent years, the usage of natural materials has gained more attention due to environmental pollution and its threat to humans. Numerous studies have demonstrated that the right vase solution chemistry can prolong the life of flowers by slowing the rate of senescence and respiration [4].

A significant element in the commercial value of flowers is postharvest performance. Although appearance, color, and consistency are the main factors influencing a buyer's decision to buy a flower, the durability of the product is crucial to persuading the consumer to buy it again [5]. To prolong flower preservation, a variety of methods are available, including the use of floral preservative solutions, ethylene action inhibitors, growth regulators, temperature control, and flower dehydration management. The use of sucrose in pulsating solutions or as a component of vase solutions increases water balance and energy or delays senescence by reducing ethylene production, hence extending the vase life of flowers. Lotus (*Nelumbo nucifera*) is a locally and abundantly available flower in Sri Lanka that belongs to the family Nelumbonaceae. It shows exotic and attractive flowers, known as a symbol of purity, holiness, and immortality.

Chemical floral preservative solutions containing silver compounds are environmental hazards. They are expensive, non-renewable, and capable of producing radioactive waste. However, organic floral preservatives are physiologically and chemically inactive, nontoxic, cheaper, highly available and non-flammability. This study was initiated with the objective of exploring the potential of organic floral preservative solutions to extend the post-harvest life of Lotus (*Nelumbo nucifera*) and to identify suitable organic preservatives to extend the post-harvest life of lotus.

2. Materials and methods

2.1 Study area

This Experiment was conducted at the Research and Training Center,Department of Agronomy Laboratory in Faculty of Agriculture, University of Jaffna during the period of March to June,2022 to determinate the post harvesting life of Lotus flower buds using Organic floral preservative solutions.

2.2 Experimental design

Two factor factorial Complete Randomized Design was carried out for this experiment. Three floral preservative solutions namely (*Moringa oleifera*, *Aloe vera* leaf extract and Coconut water) were used with three different concentrations (2%, 3% and 5%) in each. Distilled water was used as the control treatment. Five replicates were maintained for more precision.

2.2.1 Treatment and their combinations

Table 1 Treatment and their combinations

Preservative solutions	Concentration	Treatment code
Moringa oleifera leaf extract	2% (w/v)	H1C1
	3% (w/v)	H1C2
	5% (w/v)	H1C3
Aloe vera leaf extract	2% (w/v)	H2C1
	3% (w/v)	H2C2
	5% (w/v)	H2C3
Coconut water	20% (v/v)	H3C1
	30% (v/v)	H3C2
	50% (v/v)	H3C3
Distilled water (Control)		H4

2.3 Preparation of organic floral preservative solutions

2.3.1 Preparation of Moringa oleifera leaf extract

Moringa leaves were plucked just before the solutions were made. Leaves were cleaned well and 2 kg of young leaves were crushed and grinded with 200ml of distilled water. The extract was filtered through a filter paper. The supernatant was diluted to 2%, 3% and 5% (w/v) concentrations. The vinegar solution (5% (v/v) was added to each treatment.

2.3.2 Preparation of coconut water solution

400 ml, 600 ml and 1 l of fresh coconut water was diluted with2 l distilled water to prepare 20%, 30% and 50% solutions respectively. Distilled water (2 l) was used as control. 5% (v/v) of vinegar was added to all treatments.

2.3.3 Preparation of aloe vera solution

Aloe vera leaves were harvested just before the solutions were made. Leaves were cleaned well and the gel was extracted. 40g, 60 g and 100 g of Aloe Vera gel were blended with distilled water and volume up to 2 l with distilled water to prepare 2 %, 3 % and 5 % (w/v) solutions respectively. 2 l distilled water was used as control treatment. For all treatments, 5% (v/v) of vinegar was added.

2.4 Experimental setup

2.4.1 Preparation of flower

The cut lotus buds were collected from a local retailer, Kilinochchi, soon after harvesting. The stems of the cut flowers were trimmed to 25cm length at the base by a slanting cut of 2 cm to provide a larger surface area for water uptake.

2.4.2 Blanching

Each flower bud stalk was dipped in a water bath with a temperature of 40^{0}C for 30 seconds.

2.4.3 Pulsing

500g of table sugar was dissolved in 10 l of distilled water and vinegar (5%) was added to it. Each flower bud stalk was dipped in a pulsing solution and kept in the growth chamber for 4 hours under the temperature of 20^{0}C and 70 % relative humidity.

2.4.4 Holding in floral preservative solutions

After pulsing, each flower bud stalks were dipped in floral preservative solution and kept in Growth Chamber until the senescence symptoms begins.

2.5 Data recorded

2.5.1 Solution Uptake

Solution uptake was determined by taking flower stalks and subtracting the volume of water evaporated from a flask of the same volume without cut flower buds [6].

Solution uptake = S (t-1) – St/Initial fresh weight × 100

(St = Solution weight (g) at time 1, 4,8,12 and 16 days, St – 1 = Solution weight (g) of the control)

2.5.2 Petal moisture loss percentage

A dry weight of six outer petals was recorded using a sensitive balance (Model:SW 1S Germany) after drying the petals to constant weight in an oven (Model: JM-OD16, Japan) at 70^0C [6].

Petal moisture loss (%) =](Petal fresh weight – Petal dry weight)×100]/ Petal fresh weight

2.5.3 Maximum flower head diameter

Flower bud diameter was measured daily with Vernier-calliper [6].

2.5.4 Visual observations

Visual observations were daily recorded up to the stage where the flowers loose the saleable quality. For each non parametric indices such as browning index, fading index, petal fall index, wilting index and extent of flower opening were given [7] by observing the behaviour of cut lotus flowers dipped different floral preservatives solutions.

2.5.4.1 Browning index

Complete browning of second whorl – 5, Browning extended to second whorl – 4, Complete browning of first whorl – 3, Browning started at first whorl – 2, All whorls are fresh – 1

2.5.4.2 Fading index

Complete fading of second whorl – 5, Fading extended to second whorl – 4, Complete fading of first whorl – 3, Fading started at first whorl – 2, All whorls are fresh – 1

2.5.4.3 Petal falling index

Complete fall of second whorl – 5, Petal fall extended to second whorl – 4, Complete fall of petals at first whorl – 3, Petal fall started at first whorl – 2, No petal fall observed – 1

2.5.4.4 Extend of flower opening

Completely open – 5, 3/4th open – 4, 1/2nd open – 3, 1/4th open – 2, Completely closed – 1

3. Results and discussions

3.1 Physical properties of lotus cut flower buds

3.1.1 Solution uptake percentage of lotus

There was a significant difference ($p<0.05$) observed in percentage of solution uptake by lotus cut flowers in different floral preservative solutions except 5 % (w/v) moringa leaf extract and 30 % (v/v) coconut water compared to control treatment. Lowest solution uptake was observed in 5 % (w/v) Moringa leaf extract (H1C3). The highest solution uptake was observed in coconut water under 20 % concentration. The use of coconut water as a holding solution for tuberose flowers were studied [8]. They found that tuberose flowers treated with coconut water exhibited a higher solution uptake percentage compared to those treated with plain water. The high sugar and mineral content of coconut water were attributed to its ability to enhance water uptake by the flowers, thereby prolonging their vase life [8].

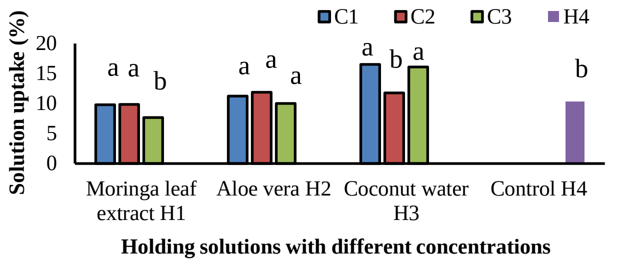

Fig.1. Effect of different floral preservative solutions in solution uptake (%) of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

3.1.2 Flower head diameter

Significant differences ($p<0.05$) were observed among different floral preservative solutions. Lowest flower head diameter was observed in 2% (w/v) concentration Moringa leaf extract. However, there was no any significant difference between Moringa leaf extract concentrations 2% and 5% (w/v). Using a holding solution containing a combination of sugar and a bactericide effectively extended the vase life of lotus flowers and maintained their diameter compared to water alone. A previous study highlighted the importance of selecting an appropriate holding solution to preserve the quality and appearance of lotus flowers, which are prized for their beauty and symbolism in many cultures [9].

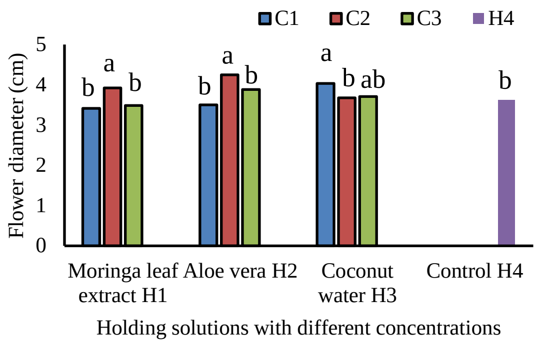

Fig.2. Effect of holding solution in flower diameter of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

*3.1.3 Pe*tal Moisture loss percentages

The highest petal moisture loss percentage was observed in control treatment. Treating lotus flowers with 2% (w/v) *Moringa oleifera* leaf extract resulted in least petal moisture loss percentage compared to untreated flowers. This might be attributed to *Moringa oleifera* leaf extract hydrating properties, which help to maintain the water balance within the petals and prevent dehydration [10]. No significant difference was observed among different floral preservative solutions such as *Moringa oleifera* leaf extract, *Aloe vera* and Coconut water

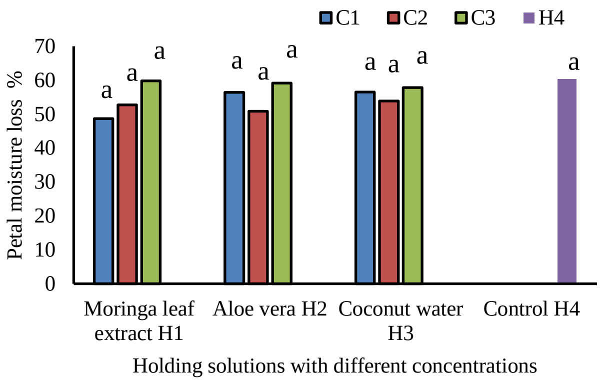

Fig.3. Effect of holding solution in Petal Moisture loss percentage of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

3.2 Visual observation scoring of lotus cut flower buds

3.2.1 Petal Browning of lotus

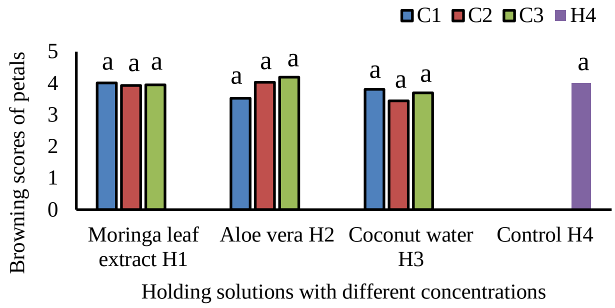

Fig.4. Effect of holding solution in browning of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

There was no significant difference ($p > 0.05$) among different holding solution and their concentration on petal browning of the lotus. Lowest browning was observed in 30 % (v/v) coconut water solution (C_2). The highest browning was observed in 5 % Aloe vera solution. Various holding solutions and their effects on the petal browning of cut lotus flowers were reported in previous studies and found that holding solutions containing antioxidants, such as citric acid or ascorbic acid, effectively reduced browning by inhibiting oxidation processes. Additionally, solutions with antimicrobial properties, such as silver nanoparticles or essential oils, helped control microbial growth, which can contribute to browning [11].

3.2.2 Petal Fading

There was no significant difference observed among different holding solutions on petal fading. However, less fading was observed in 30% (v/v) coconut water solution (C_2). The effect of coconut water on the vase life and postharvest quality of gerbera flowers was studied and found that treating gerbera flowers with coconut water significantly delayed wilting and petal senescence compared to water alone, indicating the potential of coconut water to extend the vase life of cut flowers [12].

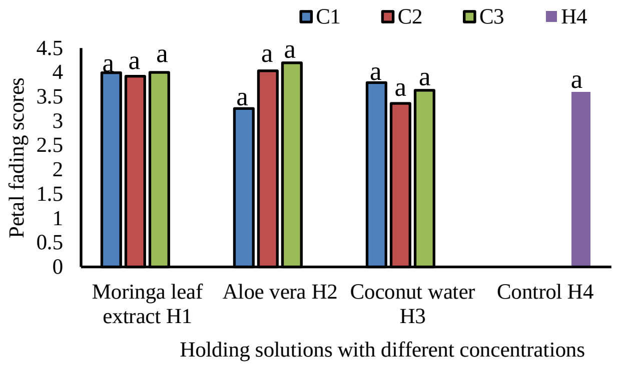

Fig.5. Effect of holding solution in fading of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

3.2.3 Petal falling of lotus

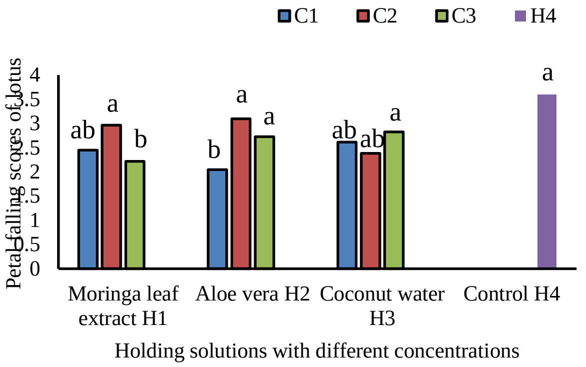

Fig.6. Effect of holding solution in petal falling of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively

Significance difference ($p > 0.05$) was observed in petal falling among different holding solutions. The lowest petal falling was observed in Aloe vera under 2 % concentration. The effect of Aloe vera gel on the postharvest quality of cut tuberose flowers were studied and observed that treating tuberose flowers with Aloe vera gel significantly reduced petal wilting and abscission, indicating the potential of aloe vera to extend the vase life of cut flowers by minimizing petal falling. At the same time, highest petal falling was observed when the flowers were kept in distilled water (control).

3.2.4 Petal wilting of Lotus

The lowest petal wilting was observed in a floral preservative solution of 2 % aloe vera (C_2). However, there were no significant difference ($p > 0.05$) among other holding solutions. In the previous study on effect of aloe vera gel on the postharvest quality of cut rose flowers found that treating rose flowers with aloe vera gel significantly reduced petal abscission and prolonged vase life compared to untreated flowers. Aloe vera's ability to minimize water loss and enhance water uptake by the flowers contributed to these positive effects [14].

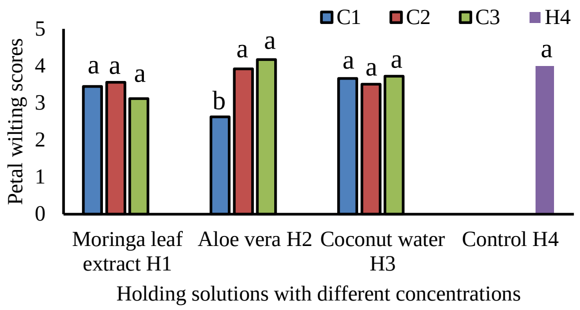

Fig.7. Effect of holding solution in wilting of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

3.2.5 Extent of flower opening

There was no significant difference observed among different holding solutions in extent of flower bud opening of lotus flowers except 3 % (w/v) moringa leaf extract, where significantly lowest extent of flower opening was observed. The effect of moringa leaf extract on the postharvest quality of cut gerbera flowers found that treating gerbera flowers with moringa leaf extract resulted in a slower rate of flower opening compared to untreated flowers. The moringa leaf extract appeared to have a conditioning effect on the flowers, delaying the process of flower opening and maintaining their freshness [15].

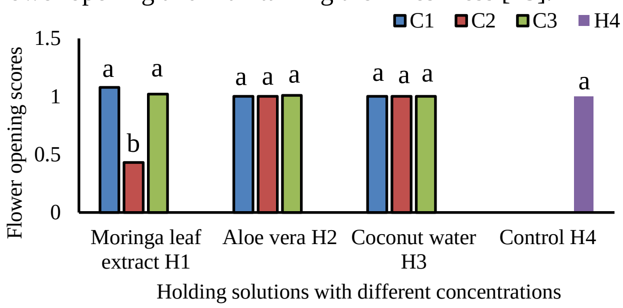

Fig.8. Effect of holding solution in flower opening of lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment

3.3 Post-harvest life of lotus

Highest post harvest life of lotus flowers (10 days) was observed, when they were kept in 30 % (v/v) coconut water, compared to other treatments, followed by 3% (w/v) Aloe vera (8 days) and 20% (v/v) coconut water (8 days). Longest post harvest life under coconut water might be due to higher amount of reducing sugar [16] and with increase of coconut water percentage in the solution, reducing sugar concentration increases. Aloe vera solution also has the potential to reduce microbial growth and also enhance the longevity of the cut flowers due to reduce ion leakage and suppress microbial growth at the stem base [18]. Meanwhile, least post harvest life of flowers was noted under distilled water (control treatment), where flowers were in the saleable condition just for 4 days. Water usually provides a favourable environment for the growth of bacteria on cut surface of the flower stalk and thereby block water conducting tissues. Therefore, flowers lose their ability to draw water from the vase solution a resulting vase life termination.

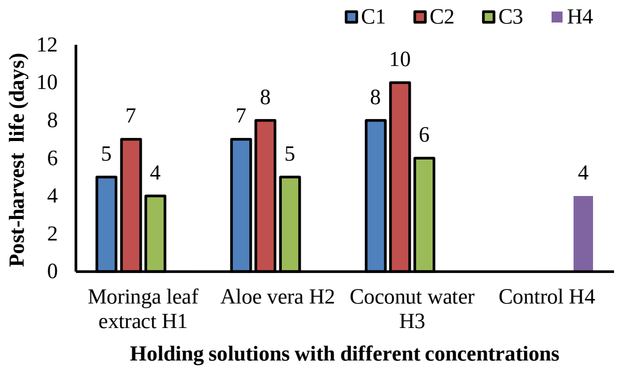

Fig.9. Effect of Holding Solution with different concentrations in Vase life of Lotus

H1C1, H1C2 and H1C3 codes denoted to 2, 3 and 5 % (w/v) of moringa leaf extract respectively, H2C1, H2C2 and H3C3 given to 2, 3 and 5 % (w/v) aloe vera extract respectively, H3C1, H3C2 and H3C3 referred to 20, 30 and 50 % (v/v) of coconut water respectively and H4 was control treatment.

4. Conclusions

Cut flowers are more perishable and under normal conditions they last only for a few days while maintaining their beauty and attractiveness. The relatively short postharvest life of most cut flowers has become a crucial issue in commercial cut flower production enterprises. Hence, improving the postharvest life of cut flowers has been promoted and an insightful understanding of several factors which determine the postharvest life of cut flowers are imperative to enhance the vase life of cut flowers. According to this study, the highest post-harvest life of lotus (10 days) was observed in coconut water under 30% (v/v) concentration with the lowest browning, fading, petal falling, and wilting index.

Conflicts of Interest

There are no conflicts to declare.

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