JOURNAL OF INTERDISCIPLINARY PERSPECTIVES

ISSN Print: 2984-8288, ISSN Online: 2984-8385
Vol. 2, No. 11, pp. 313-323, November 2024

Comparative Analysis of Sucrose and Moringa (*Moringa oleifera Lam.*) Leaf Extracts as Natural Additives to Prolong the Vase Life of Rose (*Rosa x hybrida*) Cut Flowers

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Date received: August 29, 2024
Date revised: September 29, 2024
Date accepted: October 11, 2024

Originality: 87%
Grammarly Score: 99%
Similarity: 13%

Recommended citation:
Telebrico, M. (2024). Comparative analysis of Sucrose and Moringa (*Moringa oleifera Lam.*) leaf extracts as natural additives to prolong the vase life of Rose (*Rosa x hybrida*) cut flowers. *Journal of Interdisciplinary Perspectives*, 2(11), 313-323. https://doi.org/10.69569/jip.2024.0456

Abstract. Roses, one of the most iconic flowers in the world, symbolize love, beauty, and elegance. Their vibrant colors and soft petals make them popular for special occasions like weddings, anniversaries, and romantic gestures. People from different walks of life usually admire roses for their aesthetic appeal and pleasant fragrance. Both florists and consumers in the flower industry depend on keeping cut roses fresh. Placing roses in water-filled vases is a standard method to extend their lifespan. This study explored the effectiveness of natural additives in prolonging the life of cut roses. A completely randomized design (CRD) was used, and four treatments were used: distilled water (control), a sucrose solution, moringa leaf extracts, and a combination of sucrose and moringa. The roses were observed over eight days to assess various factors such as leaf drop, stem rotting, bent necks, petal drop, flower condition, and petal color. The results showed that the combined treatment of sucrose and moringa led to the highest number of leaf drops, with 15 leaves dropping by day five. Distilled water resulted in 12 dropped leaves, moringa extract caused four leaves to drop, and sucrose had the least impact, with only two leaves dropping. The combination treatment also caused the most significant stem rotting (32.75 mm) and the most bent necks (14 roses). In contrast, roses treated with sucrose or moringa separately had better outcomes, with the least bent necks and minimal leaf drops. The combined treatment again had the worst results for petal drops, with eight petals dropping, followed by distilled water with six petals. The overall flower condition was poorest with the combined treatment, scoring 1 (completely open/damaged), while roses treated with sucrose or moringa separately had better scores, indicating they remained fresher. Petal color was also most affected by the combined treatment, which resulted in a light brown color, whereas the separate treatments maintained a darker red hue. Hence, while sucrose and moringa are beneficial when used individually, their combination negatively impacts the longevity and appearance of cut roses.

Keywords: Moringa (*Moringa oleifera Lam.*); Leaf extracts; Sucrose; Rose; *Rosa x hybrida*; Natural farming

1.0 Introduction

The cut flower industry plays a pivotal role in the global floriculture market, with roses being one of the most cherished and economically significant varieties. The aesthetic appeal and commercial value of cut roses are directly tied to their vase life, making it imperative for floriculturists and enthusiasts to explore innovative approaches to extend the longevity of these blooms. In this endeavor, the current research explores the possibility of utilizing sucrose and moringa leaf extract as natural supplements to prolong the cut flower roses. Rose, a quintessential symbol of beauty and romance, captivates hearts with its unparalleled elegance. Beyond its ornamental allure, the economic significance of roses is deeply rooted in agro-based industries, particularly cosmetics and perfumes. As integral players in the *Rosaceae* family, hybrid Tea Roses (*Rosa x hybrida L.*) contribute substantially to the booming cut-flower market. With over 150 species and 1400 cultivars under the Rosa genus. The rose has been popular as a cut flower since ancient times, continuing to captivate researchers (Kaur et al., 2021). Nonetheless, the primary focus of rose cultivation is the production of cut flowers, a significant aspect of the floriculture industry (Lan et al., 2022).

Understanding the challenges posed during the postharvest phase, research by Bhardwaj et al. (2021) sheds light on the phenomenon of "bent-neck" In instances where cut roses wilt and the floral stem bends just beneath the flower head. Another factor contributing to quality deterioration is the clogging of xylem vessels by bacterial or microbial build-up (Chen, 2021). This obstruction can result in inadequate water absorption and loss (Mohammed et al., 2023). Over the years, scholars such as (Azarhoosh, 2021), (Nasibi et al., 2024), (Lone et al., 2022), as well as (Hashemi et al., 2024) have investigated the capability of sucrose solutions to prolong vase life, recognizing the significance of soluble carbohydrates as vital substrates for respiration and the opening of flowers.

However, sucrose alone presents challenges, as documented by Ha & In (2022), who highlighted its propensity to promote bacterial proliferation, resulting in a shortened vase life. Mittal et al. (2021) observed that lower concentrations of sucrose extend the vase life of gladiolus florets by enhancing uptake, while higher concentrations appear to hinder uptake. In the intricate world of floriculture, the cultivation of roses extends beyond the mere production of blooms; it is a delicate dance that achieves a prolonged vase life for cut flowers. As highlighted by esteemed authors like Aleksis (2024) and Thörning et al. (2022), the primary goal of rose cultivation is to yield high-quality cut flowers that fuel the thriving floricultural business. A critical factor in determining the success of this venture lies in the length of vase life, a parameter that directly influences the commercial value of these delicate blooms.

Understanding the physiology of cut flowers is essential for uncovering the complexities of extending vase life. Factors such as water absorption, transpiration, and microbial proliferation significantly impact the post-harvest longevity of cut roses. The role of carbohydrates, including sucrose, in providing a continuous energy source for the flowers has been extensively documented (Si et al., 2023). Additionally, the antimicrobial properties of certain plant extracts, like those from moringa leaves, have garnered attention in recent research endeavors (Rahim et al., 2024).

The floral industry is vibrant and economically significant, with cut roses being a standout product. Roses are cherished worldwide for their beauty and symbolism, often representing love and celebration. In the global market, cut roses are a key commodity, playing an important role in both local and international trade due to their cultural and aesthetic value. To keep cut roses fresh, it's important to understand how they function after being cut. Studies have shown that water uptake and microbial growth greatly affect how long cut roses stay fresh. This has led to a focus on sustainable practices and natural methods, such as sucrose and moringa leaf extract, to extend their vase life and maintain quality.

The economic impact of cut roses is significant, especially in countries with ideal climates for their cultivation, like Colombia, Ecuador, and Kenya. These countries have become major suppliers in the global market, benefiting their national economies. Additionally, the ongoing demand for roses, driven by their cultural significance and aesthetic appeal, continues to fuel growth in the floral industry, with trends moving towards eco-friendly and sustainable practices. Thus, the researcher aims to conduct this study to explore the potential of using natural additives, specifically sucrose and moringa leaf extracts, to prolong the vase life of cut roses for sustainability.

2.0 Research Methodology

2.1 Experimental Design

The study employed a Completely Randomized Design (Maxwell, 2005). It consisted of four treatments replicated four times. The experimental units, in this case, were individual cut roses. The roses were grouped based on similar initial physiological age, size, and quality. Each group was subjected to various treatments, including sucrose, moringa leaf extract, and combinations of both. The random assignment of treatments within each group helped control for variability and ensured a more robust analysis.

The experiment was conducted in a controlled environment at room temperature at N Blessing Farm located at Sitio Dam-an Barangay Pamutan Cebu City. The room provided a stable climate, allowing for precise temperature and humidity control. This controlled environment was essential to minimize outside factors that could impact cut roses' lifespan and ensure consistency in experimental conditions (Ha et al., 2021). The room temperature was monitored using a home thermometer and hygrometer.

2.2 Experimental Procedure

Collection of Fresh Roses

The collection of roses was carried out early in the morning to aid in preserving the freshness of the flowers. Clean and sharp pruning shears were employed to harvest the flowers precisely above the node, ensuring a clean cut without crushing or tearing the stem. The cutting was performed through the stem about ¼ inches above the five leaflets at a 45-degree angle, using sharp and clean shears. After cutting the roses, the cut ends of the stems were plunged into a water container. Subsequently, the container of roses was placed indoors in a cool room, away from direct sunlight (Faust & Dole, 2021). The initial immersion of roses in water was done to ensure hydration immediately after cutting, preventing air embolism in the stems that could hinder water uptake. This step was based on standard practices in post-harvest flower care to maintain freshness before treatment (Faust & Dole, 2021). It can be clarified that the brief period in water did not interfere with the experiment's outcome. The methodology could explicitly state that water served as a temporary medium to stabilize the flowers before the experiment began, and studies like those by Dole (2021) confirm that this does not affect the comparative analysis between treatments.

Sucrose Preparation

The 10 g of granulated sugar was precisely measured and combined with 100 ml of distilled water in the vessel. Continuous stirring with a spoon until the sucrose was fully dissolved was done. The container was labeled with the concentration and the date it was processed. The solution was stored in a dark, dry, cool place.

Moringa Leaf Extract Preparation

Preparing leaf extracts from fresh *Moringa oleifera Lam* leaves involved collecting 200g of fresh leaves, cleaning, washing, and storing them overnight at freezing temperatures. After 24 hours, the stored leaves were crushed using a blender and sieved through cheesecloth, and 70 ml of *Moringa oleifera Lam* was collected. An aqueous extract was prepared by blending and filtering fresh moringa leaves, followed by dilution based on experimental requirements (Adewumi, 2021).

2.3 Data Analysis

To analyze the data, statistical analysis was performed using the STAR Program, which applied Analysis of Variance (ANOVA) based on a Completely Randomized Design (Acutis et al., 2022; Álvarez-Barreto et al., 2023). This method evaluated the significance of differences in the vase life of the roses among the different treatment groups, helping to determine the treatments' effectiveness in prolonging the cut roses' life. To summarize, the experimental units, high-quality cut roses, were sourced from a reputable farm and re-cut at a 45-degree angle to facilitate water uptake. These roses were then subjected to four treatments: distilled water as a control, a sucrose solution, a moringa leaf extract solution, and a combined treatment of both. Each treatment was applied by immersing the roses in pre-prepared solutions, followed by daily monitoring over eight days for any signs of deterioration, such as changes in petal color, stem rot, and flower neck bending.

3.0 Results & Discussion

3.1 Number of Leaf Drop

Moringa leaf extract and sucrose individually markedly improved the cut roses' ability to retain their leaves, as evidenced in Figure 1. The treatment groups with moringa leaf extract or sucrose applied alone exhibited the fewest dropped leaves. However, the combination of sucrose and moringa extract resulted in the highest leaf drop, particularly notable from day five onward, with fifteen leaves dropped. This trend was followed by the distilled water treatment, which saw twelve leaves drop. These observations were made under controlled conditions of 22 degrees Celsius and 80% relative humidity.

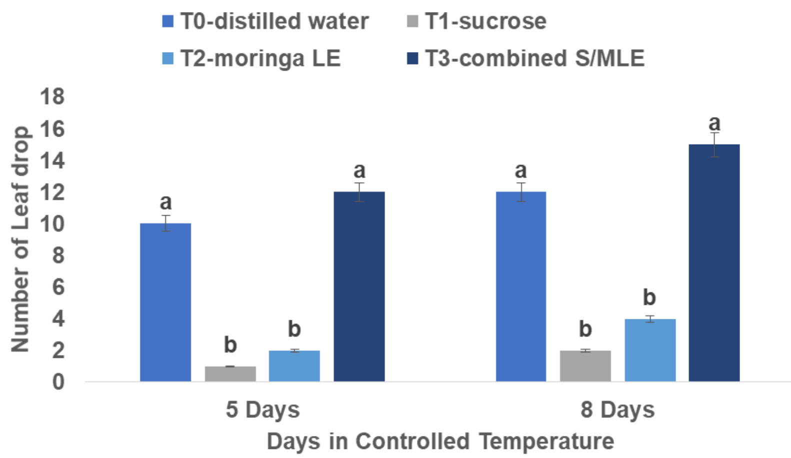

Figure 1. Impact of Sucrose and Moringa leaf extracts on the number of leaf drops of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of $\alpha = 0.05$

Moringa leaf extract and sucrose individually improved the cut roses' ability to retain their leaves. Sucrose serves as a substrate for respiration, maintains a balanced water level, and decreases susceptibility to ethylene, consequently prolonging the flower's lifespan (Kumar et al., 2022). Several researchers (Toscano et al., 2021; Mehmood, 2021) mentioned that the quantity of leaves is enhanced when treated with moringa leaf extract. Moringa leaves are rich in zeatin, a naturally occurring cytokine. Researchers (Arif et al., 2023; Soares et al., 2021) have noted the significance of *zeatin* found in moringa leaves, highlighting its role as a crucial growth hormone in plants.

Application of moringa extract has been reported to enhance agronomic crop yields of coffee, soybean, and maize by 25-30%. One notable biostimulant obtained from *Moringa oleifera Lam* is Moringa leaf extract (MLE). MLE is useful in agriculture and belongs to the *Moringaceae* family (Islam et al., 2022). Along with vital minerals, MLE contains bioactive substances such as proline, flavonoids, cytokinins (such as zeatin), ascorbic acid, phenolics, carotenoids, and vitamin A (Yuniati et al., 2022; Mashamaite et al., 2022; Farhat et al., 2023).

Expanding on utilizing amino acids to prolong the lifespan of cut roses, the study finds resonance with the findings of Shinde et al. (2023). The research highlights the role of amino acids sourced from marine waste fertilizers in promoting leaf retention, suggesting a potential avenue for enhancing the longevity of cut roses through similar mechanisms. Expanding on this concept, Rodrigues et al. (2023) showed the benefits of amino acid supplementation on the development and growth of native tomatoes grown in the Philippines, underscoring the broader applicability of amino acids in horticultural practices. Thus, the integration of amino acids, as observed in both studies, presents a compelling strategy for extending the lifespan of cut flower roses, aligning with the research focus on natural additives for flower preservation.

3.2 Stem Rotting (mm)

The result of this study is evident in cases involving the application of combined sucrose and moringa leaf extract. Stem rot incidences were noted consistently across all four replications, with an average length of rot reaching 32.75 mm. This decay was initially observed on day five and persisted for eight days under ambient conditions of 22 °C and 80% Relative Humidity. Stem rotting was notably observed in samples treated with combined sucrose and moringa leaf extract after eight days, indicating a significant impact on flower quality (Figure 2). Sucrose, a component of the treatment, is known to provide respiratory substrates, maintain water balance, lower ethylene sensitivity, slow down ethylene generation, and extend flower longevity (Ahmed et al., 2023). Additionally, studies by Aluko et al. (2021) have shown that carbohydrates, like sucrose, can increase plant tissue's fresh and dry weight, which could further contribute to stem stability. However, xylem vessel blockage brought on by bacterial or microbe accumulation might result in stem rotting, leading to water uptake deficiency and loss (Cornelis & Hazak, 2022); Bhattacharya, 2021).

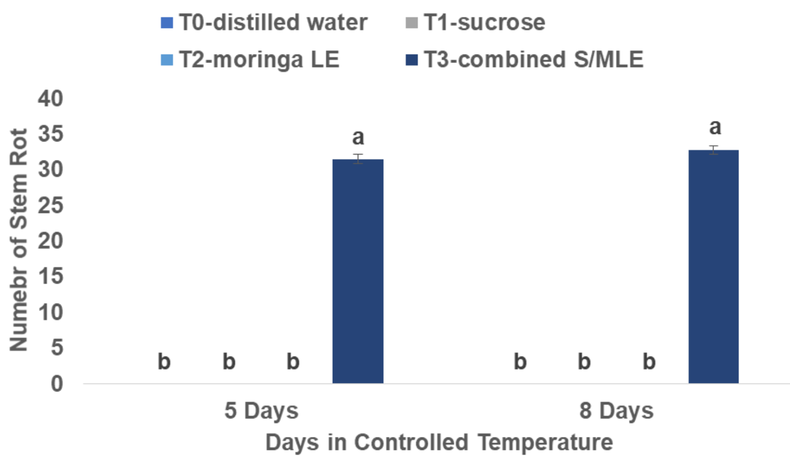

Figure 2. Impact of Sucrose and Moringa leaf extracts on the stem rot measured in mm of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of $\alpha = 0.05$

Therefore, controlling microbial proliferation is crucial for maintaining the quality and lifespan of roses (Naziri Moghaddam et al., 2021) using moringa leaf extract as a natural additive. Biocides are frequently employed to diminish bacterial proliferation in vase water, although certain ones carry potential health and environmental hazards and could lead to toxicity in flowers (Bika, 2021; Malakar et al., 2023). Despite these challenges, various approaches have been explored to explore alternative methods that are both efficient and environmentally friendly to meet the demands of the floral industry and sustainable agriculture to extend the lifespan of flowers, methods such as managing water levels, postponing senescence, decreasing microbial counts, and stimulating antioxidant mechanisms have been explored (Shantamma et al., 2021; Ngwenya, 2021; Seyed Hajizadeh et al., 2023).

3.3 Bent Neck

The bent neck was most observed in combined sucrose and moringa leaf extract, with an average of fourteen roses exhibiting a pronounced bend of 45 degrees, followed by distilled water with six roses similarly affected. In contrast, moringa leaf extracts alone displayed the least susceptibility, with only one rose exhibiting such deformity. This evaluation was performed over eight days at room temperature (22°C) and 80% relative humidity. The combination of sucrose and moringa leaf extract observed to lead to a higher occurrence of bent neck in cut flowers can be attributed to several factors (Figure 3). Firstly, the blockage of the xylem in the stem by either bacterial proliferation or other factors could hinder the transport of essential nutrients needed for the flower's structural integrity and health. This blockage prevents proper water and nutrient uptake, resulting in wilting and curvature of the flower stem (Muraleedhran et al., 2022). Secondly, low temperatures can cause the sucrose and moringa leaf extract solution to gel or become viscous, impeding water absorption by the flower stems. This reduced water uptake exacerbates the wilted appearance and bending observed in the flowers (Sukpitak et al., 2024). The idea of vase life, which refers to the duration from the start of treatment until the occurrence of bent stems, highlights the significance of tackling elements that lead to flower decay, such as stem curvature (Singh, 2023).

The rating system quantifying the degree of stem bending provides a standardized approach for assessing the severity of bent neck in cut flowers, facilitating comparisons across different treatments and environmental conditions (Dhiman et al., 2021). Certain vase solutions containing sucrose have demonstrated that certain substances can extend the lifespan of severed roses. However, the problem of bacterial growth in treatments containing only sucrose underscores the importance of careful selection when choosing vase additives (Yasemin & Beruto, 2024; Phan, 2021; Silvestri, 2022). The possibility of carbohydrate shortages contributing to short vase life underscores the importance of understanding the role of nutrients like sucrose in maintaining flower health and longevity. Overall, addressing factors such as bacterial proliferation and carbohydrate availability can help mitigate issues like bent neck, enhancing the quality and longevity of cut flowers.

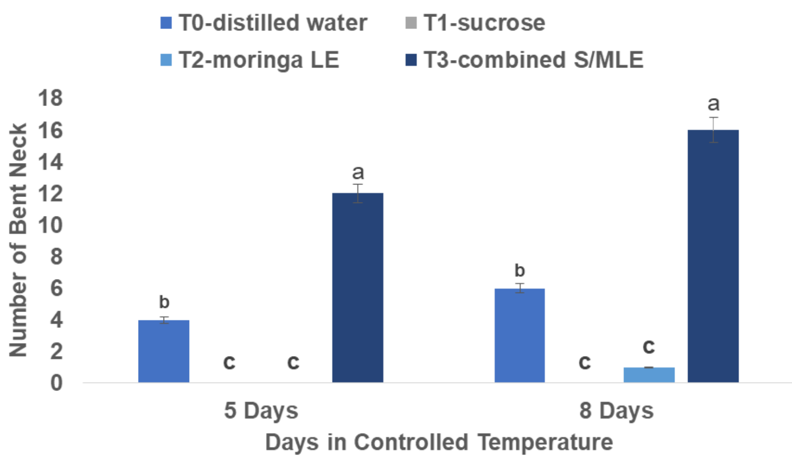

Figure 3. Impact of Sucrose and Moringa leaf extracts on the bent neck measured in degrees angle of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of α = 0.05

3.4 Petal Drop

Analysis of petal drop rates elucidated a similar pattern. The combined sucrose and moringa leaf extract exhibited the highest incidence of petal loss, with eight petals shed, followed by distilled water, with six petals shed. This evaluation was performed over eight days at room temperature (22°C) and 80% relative humidity.

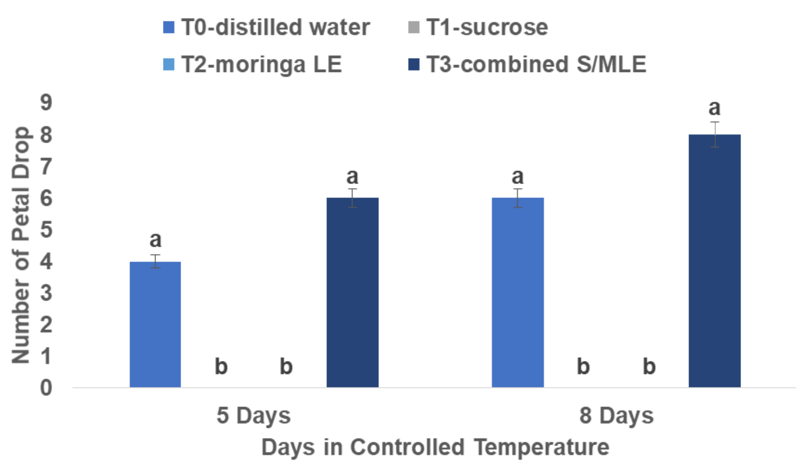

Figure 4. Impact of Sucrose and Moringa leaf extracts on the petal drop of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of α = 0.05

The observation of increased petal dropping in cut flowers treated with a combination of sucrose and moringa leaf extract and those treated with distilled water alone can be linked to several factors (Figure 4). Firstly, research by Tasmim (2023) has indicated that certain treatments, such as citric acid combined with sucrose, are more effective and safer for maintaining the quality of rose cultivars, and the makeup of the vase solution is pivotal in preserving flowers. Petal dropping can result from reductions in petal thickness, which decreases the overall quality of the flower in the vase (Singh et al., 2022). Oxidative stress is an additional element that decreases flower quality during handling and storage (Fanourakis et al., 2022; Verma & Singh, 2021). The act of cutting flowers can trigger oxidative damage, resulting in excessive production of reactive oxygen species (ROS) that harm cellular structures like nucleic acids, proteins, and membrane lipids (Hajam et al., 2023; Mansoor et al., 2022; Sachdev et al., 2021).

Studies have revealed that Moringa leaf extract (MLE) exhibits potent antimicrobial characteristics and can alleviate oxidative damage by boosting the performance of antioxidant enzymes that eliminate ROS, thus preserving the integrity of cellular membranes (Rawat et al., 2024; Shah & Oza, 2022; Ndlovu et al., 2023; Yang et al., 2022). The increased occurrence of petal dropping in cut roses treated with a combination of sucrose and moringa leaf extract and in those treated with distilled water alone contrasts with the lesser petal dropping observed in flowers treated with sucrose alone or moringa leaf extract alone. This disparity suggests that the composition of the preservation solutions plays a significant role in influencing flower quality.

3.5 Flower Opening

Flower opening dynamics were assessed from 1 (fully open) to 9 (excellent/fresh). The combined sucrose and moringa leaf extract displayed the lowest average score of 1 (completely open), indicative of optimal flower opening, followed by distilled water with an average score of 7, denoting good opening. In contrast, sucrose alone and moringa alone garnered an average score of 8.75, reflecting an excellent and fresh presentation. This evaluation was performed over eight days at room temperature (22°C) and 80% relative humidity.

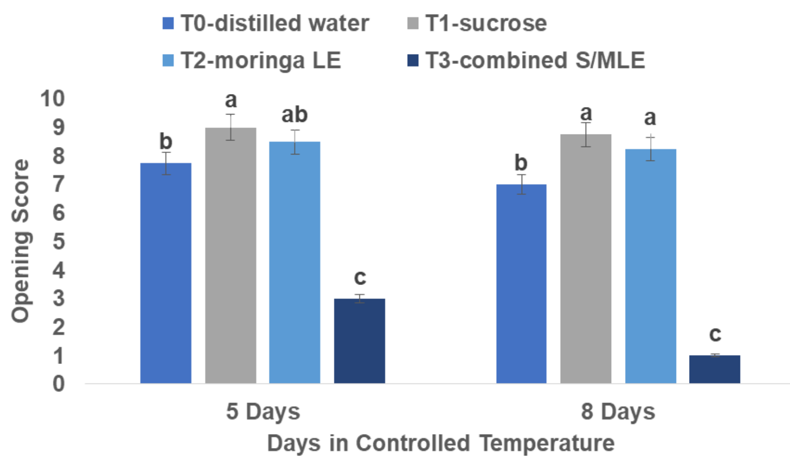

Figure 5. Impact of Sucrose and Moringa Leaf Extracts on the flower opening of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of $\alpha = 0.05$

This study is in connection with Liu et al. (2024), who state that the positive impact of sucrose on flower senescence is linked to their provision of substrates for respiration, structural components, and osmotic balance. This applies to cut flowers (Terry et al., 2021), as they lack access to food, hormones, and water post-detachment from the plant, relying solely on stored nutrients at harvest and the application of external sucrose (Fanourakis et al., 2021). Rezai et al. (2024) proposed a connection between uneven opening and inhibition of flower opening and decreased vase life. According to Sun et al. (2021), there is a correlation between the reduction in water potential and the inhibition of corolla expansion and flower opening. Recent studies have revealed the advantageous role of sucrose in delaying senescence in a range of cut flowers, including sweet peas (Haq et al., 2024), delphinium (Sharma et al., 2024), gentiana (Budniak et al., 2021), snapdragon (Han et al., 2022), rose (Mileva et al., 2021), and oncidium (Chang et al. (2021) this is attributed to the inhibition of ethylene production or its sensitivity.

Applying sucrose externally provides vital respiratory substrates to the flower, prolonging vase life and facilitating opening buds that would otherwise remain closed (Ketsa & Warrington, 2023). Biocides like moringa are commonly utilized to diminish bacterial proliferation and prolong the lifespan of flowers in vase water (Soliman & El-Sayed, 2023; Gururani et al., 2023). Consequently, sucrose, often combined with biocides like moringa leaf extract, has emerged as a crucial preservative for various cut flowers. Therefore, managing microbial growth is crucial in improving cut rose longevity and quality (Zeng et al., 2023).

3.6 Petal Color

Evaluation of petal color changes, gauged via the Visual Quality Rating (VQR) system ranging from (1 as dark brown, 3 as light brown, 5 as shriveled pale red, 7 as good/fairly dark red, 9 as excellent fresh dark red), unveiled a progression wherein combined sucrose and moringa leaf extract attained the lowest average VQR score of 3.75, indicative of a light brown hue, second was observed in distilled water with a score of 6.75 denoting good/fairly dark red, third was observed in moringa leaf extract with a score of 8 representing a good/fairly dark red tone, and finally third was observed in sucrose with a score of 8.25 reflecting a fairly dark red hue. This evaluation was performed over 8 days at room temperature (22°C) and 80% relative humidity.

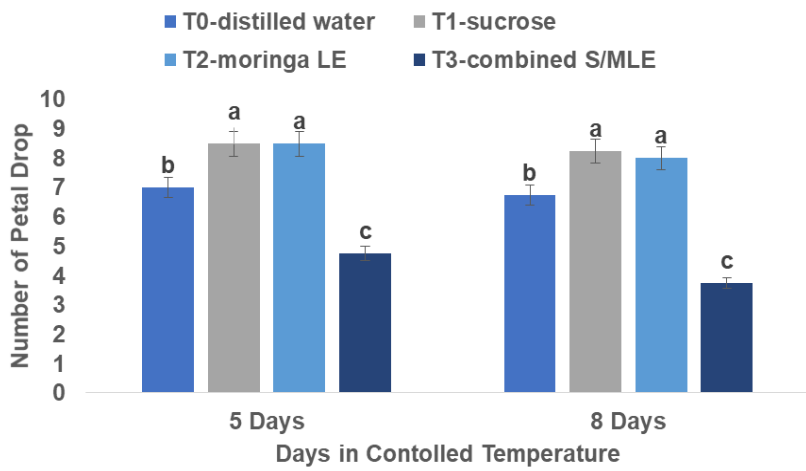

Figure 6. Impact of Sucrose and Moringa leaf extracts on petal color of Black Rose
Note: Distinct lowercase letters denote significant variances. Tukey HSD was employed with a significance level of α = 0.05

The observation that combined sucrose and moringa leaf extract scored lower in terms of petal freshness than sucrose alone or moringa leaf extract alone in research on extending cut flower vase life suggests a potential link between vase solutions and petal color. Sucrose is recognized for stimulating bud emergence and preserving the freshness of petals in various cut flowers, including roses, by providing essential nutrients for petal expansion (da Costa et al., 2021). Additionally, it has been discovered that sugar reduces water loss from rose petals, potentially by inducing stomatal closure, thus reducing transpiration and maintaining petal freshness (Villagran et al., 2024).

As emphasized by Khan et al. (2022), Moringa seed extract contains a wealth of phytohormones, antioxidants, and osmoprotectants, which can potentially trigger antioxidant defense mechanisms in plants. These antioxidants and osmoprotectants in Moringa seed extract may help maintain petal color by reducing oxidative stress and preserving cellular integrity, ultimately contributing to the longevity of the flowers. Similarly, in other studies, sucrose application during initial hydration has been shown to reduce water uptake, suggesting that sugars may help maintain adequate water balance in cut flowers by minimizing water loss rather than increasing uptake (Verdonk et al., 2023). Therefore, the effectiveness of sucrose and moringa leaf extract in preserving petal color and freshness may be attributed to its ability to support petal expansion, reduce water loss, and maintain water balance, highlighting its importance in vase solutions for cut flowers.

4.0 Conclusion

The study investigated the effects of sucrose and moringa leaf extracts as natural additives to increase the longevity of rose cut flowers, *Rosa x hybrida*. Through careful observation and data collection, it was evident that among the treatments tested T0 control-distilled water, T1 Sucrose, T2 Moringa leaf extract, and T3 Combined—sucrose and moringa leaf extract, the most significant improvements in vase life were observed with T1-Sucrose and T2- Moringa leaf extracts. These treatments significantly delay petal wilting, reduce stem rotting, and maintain overall flower quality over the experimental period. Applying sucrose and moringa leaf extract separately to cut roses significantly extends their vase life. However, using a combination of sucrose and moringa leaf extract does not have the same effect because it blocks the xylem, which is a primary reason for the reduced vase life. Additionally, low temperatures can cause the solution of sucrose and moringa leaf extract to gel or thicken, further hindering water absorption by the flower stems.

Given the results of this research, it is advisable to investigate the possible advantages of the combined approach, T3 - sucrose and moringa leaf extracts. While the combined treatment showed promise, it was noted that proper dilution might enhance its effectiveness. Therefore, future research should focus on optimizing the formulation and concentration of the combined treatment to maximize its benefits in prolonging the lifespan of cut-flower roses. Additionally, investigating the long-term effects of these natural additives on other flower species and exploring potential mechanisms underlying their action could provide valuable insights for the floral industry.

5.0 Contributions of Authors

The authors contributed equally to the conduct of this research.

6.0 Funding

This work received no specific grant from any funding agency.

7.0 Conflict of Interests

The author declared that they have no conflicts of interest.

8.0 Acknowledgment

The author would like to thank the research advisory board.

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