

The Effect of Glucose Concentration on The Resistance of Aster Flowers (*Aster* sp.) in The Fresh Flower Preservation Process

Melisa Sekarlina Putri Dayani, Priskila Gracia, Nabila Fauziah Hana, Audina Dwi Ramadhani,
Nova Apriliana Arlita, Nasywa Dwi Yulianti
Biology Education, Yogyakarta State University

Article Info	ABSTRACT
Article history: Received 01-02-2026 Revised 30-03-2026 Accepted 16-04-2024 Keywords: aster cut flowers glucose concentration preservative solution vase life postharvest physiology	The vase life of cut flowers is affected by postharvest physiological processes that continue after harvest, often leading to early wilting and quality loss. Aster (<i>Aster</i> sp.) cut flowers are known to be sensitive to these changes, particularly when water uptake and energy supply are limited. This study evaluated the effectiveness of glucose-based preservative solutions combined with lime juice and bleach in maintaining flower freshness. A completely randomized design was applied using five glucose concentrations (0, 12.5, 25, 37.5, and 50 g L⁻¹). Observations were conducted over fourteen days, focusing on solution uptake, vase life, and visible changes in flower condition (including stem texture and petal color). The results indicated that glucose concentration significantly affected vase life, while solution uptake showed only a slight increasing trend. Statistical analysis using one-way analysis of variance followed by Tukey's honestly significant difference test showed that higher glucose concentrations delayed senescence, with 50 g L⁻¹ glucose maintaining flower freshness for up to fourteen days. Overall, the use of glucose in combination with lime juice and bleach helped maintain osmotic balance and stem function in aster cut flowers, offering a simple and economical option for improving postharvest flower quality.
Corresponding Author: Melisa Sekarlina Putri Dayani Department of Biology Yogyakarta State University Email: melisasekarlina.2023@student.uny.ac.id	

1. INTRODUCTION

Cut flowers are widely used in the floriculture industry because of their high ornamental and economic value. However, their postharvest quality is often constrained by rapid senescence resulting from continued physiological processes such as respiration and transpiration after harvest. Disturbances in postharvest water relations, particularly excessive transpiration and limited water uptake, are recognized as major factors that accelerate senescence and reduce vase life by impairing cellular water balance and turgor maintenance (Fanourakis *et al.*, 2022). Aster (*Aster* sp.), a member of the Asteraceae family, is commonly cultivated as a cut flower due to its attractive appearance, color diversity, and adaptability to various environments. Despite these advantages, aster cut flowers are highly perishable and tend to wilt rapidly in the absence of appropriate preservative treatments, primarily due to reduced water uptake, depletion of carbohydrate reserves, and microbial blockage of xylem vessels, which collectively contribute to postharvest quality deterioration (Sutrisno *et al.*, 2025). Cut flowers are widely used in the floriculture industry because of their high ornamental and economic value however, their postharvest quality is often constrained by rapid senescence resulting from continued physiological processes such as respiration and transpiration after harvest. Disturbances in postharvest water relations, particularly excessive transpiration and limited water uptake, are recognized as major factors that accelerate senescence and reduce vase life by impairing cellular water balance and turgor maintenance (Fanourakis *et al.*, 2022). Aster (*Aster* sp.), a member of the Asteraceae family, is commonly cultivated as a cut flower due to its attractive appearance, color diversity, and adaptability to various environments. Despite these advantages, aster cut flowers are

highly perishable and tend to wilt rapidly in the absence of appropriate preservative treatments, primarily due to reduced water uptake, depletion of carbohydrate reserves, and microbial blockage of xylem vessels, which collectively contribute to postharvest quality deterioration (Sutrisno *et al.*, 2025). These limitations highlight the importance of appropriate postharvest handling strategies that can maintain water balance and metabolic stability in aster cut flowers during vase life.

Sodium hypochlorite is a chlorine-based compound commonly used as an antimicrobial agent in postharvest handling due to its ability to suppress microbial growth. In practice, sodium hypochlorite is widely available in the form of household bleach, which typically contains approximately 3-6% sodium hypochlorite as the active ingredient. At low concentrations, sodium hypochlorite can reduce microbial blockage in xylem vessels without causing phytotoxic effects in cut flowers. Preservative solutions containing carbohydrates, organic acids, and antimicrobial agents have been widely used to extend the vase life of cut flowers by supporting energy metabolism, improving water uptake, and suppressing microbial growth (Amnuaykan, 2023). Glucose functions as an external energy source that supports respiration and cellular metabolism after harvest. Organic acids, such as citric acid derived from lime juice, lower the pH of the solution, which enhances water uptake and suppresses microbial growth. In addition, antimicrobial agents such as sodium hypochlorite help prevent bacterial proliferation that may block xylem vessels and disrupt water transport. The effectiveness of preservative solutions is closely related to their ability to regulate osmotic potential and maintain continuous water transport through the stem. An appropriate balance between carbohydrate supply and antimicrobial activity is therefore essential to prevent xylem blockage while sustaining cellular metabolism in cut flowers.

Several studies have reported that preservative solutions containing glucose and antimicrobial compounds can effectively prolong the vase life of chrysanthemum cut flowers. However, variations in morphological and physiological characteristics among species within the Asteraceae family indicate that optimal glucose concentrations may differ between flower types, as plant species specificity has been shown to influence the effectiveness of preservative treatments in cut flowers (Wu *et al.*, 2025). To date, information on suitable glucose concentrations for aster cut flowers, particularly when combined with lime juice and household bleach remains limited. In addition, the interaction between carbohydrate availability and antimicrobial action in maintaining water relations and delaying senescence in aster cut flowers has not been fully clarified. Despite these findings, limited information is available regarding the combined use of glucose, organic acids, and sodium hypochlorite in preservative solutions specifically for aster cut flowers. Therefore, this study aimed to evaluate the effects of different glucose concentrations in a lime juice sodium hypochlorite (household bleach) preservative solution on water uptake, vase life, and physiological quality of aster (*Aster* sp.) cut flowers. This research also explored the role of osmotic mechanisms in maintaining flower freshness and proposes a simple, cost-effective preservative formulation for postharvest flower handling.

2. RESEARCH METHOD

The study was conducted for two weeks, namely from May 2 to 16, 2025, at the General Biology Laboratory of the Faculty of Mathematics and Natural Sciences, Yogyakarta State University (UNY). This study was designed in a Completely Randomized Design (CRD) using 5 solution formulations with different concentrations, namely without glucose (A), glucose 12.5 g L⁻¹ (B), glucose 25 g L⁻¹ (C), glucose 37.5 g L⁻¹ (D), and glucose 50 g L⁻¹ (E). Each solution was mixed with lime juice and bleach, each at a concentration of up to 1 ml/L. Each treatment was repeated 3 times to obtain 15 experimental units. The experiment began with preparing cut *Aster* sp. flowers. The flowers were obtained from the same place, namely a flower shop, and prepared in a uniform condition: each flower stem contains only 5 flowers, and the flower stems are cut diagonally from the bottom. Then the flower stem is placed in a perforated plug. The preservative solution was prepared by dissolving glucose in 1000 ml of water for each treatment. After dissolving, 1 mL of lime juice and 1 mL of bleach were added and stirred until homogeneous. The solution was then poured into jars at the same height. The cut flowers, which were in a uniform state, were immersed in the preservative solution according to the treatment in the labeled jars. Each jar contained 2 pieces of flowers and was tightly closed with a stopper. The jars were then wrapped in aluminum foil and placed at room temperature ($\pm 25^{\circ}\text{C}$). Observations were then continued for 14 days.

Observations on the volume of water absorbed were made by measuring the water level in the jar. This determined the flower's ability to absorb the preservative solution and maintain freshness. A ruler was used

to measure the difference in solution height in the jar between consecutive days. The absorbed solution was calculated by subtracting the solution height on the 14th day from the solution height on the 1st day of observation ($D_{14} - D_1$).

Observations of flower characteristics, specifically color and texture, were carried out visually by examining the flower after 14 days of immersion. The evaluation was conducted using a scoring table (Table 1). A score of 5 indicates a fresh flower with no signs of wilting, while a score of 1 indicates brownish discoloration, which signifies wilting.

Table 1 Criteria and numerical scale for cut flower color scoring test.

Criteria	Brief Description	Scale
Fresh pink	Bright and uniform color, intact petals, firm texture, 0% wilting/brownish	5
Slightly faded pink	Fading at petal edges, slightly soft texture, <10% wilting	4
Faded pink with brownish tint	Fading from petal edges toward the center, initial browning, 10-25% wilting	3
Faded pink with brownish tint	Browning dominant at petal edges, flower wilted, >25-50% damage	2
Brownish pink	Brown petals, dry and abscised edges, >50% damage	1

Observations on stem characteristics, namely color and texture, were conducted using the same approach as for flower characteristics, namely through visual observation after 14 days of immersion. Stem characteristics were assessed using a scoring table (Table 2). A score of 5 indicates a straight stem without any mucus, and a score of 1 indicates a stem with severe bending and mucus.

Table 2 Criteria and numerical scale for stem quality scoring of cut aster flowers

Criteria	Description	Scale
Very fresh	Upright stem, firm texture, bright green color, dry surface without slime	5
Fresh	Upright stem, moderately firm texture, green color, slightly soft at the basal part	4
Slightly wilted	Stem beginning to bend, slightly soft texture, color starting to fade	3
Wilted	Bent stem, soft texture, brownish discoloration and/or initial slime formation	2
Damaged	Severely bent stem, very soft texture, slimy surface, unable to support the flower	1

Table 3 Visual criteria and numerical scale for testing the freshness score of cut aster petals

Criteria	Description	Scale
Very fresh	All petals are fresh with a firm texture, petals are normally open, and the color is bright and characteristic of the variety	5
Fresh	Approximately 50% of the petals are still fresh, with a fairly firm texture; the color remains bright, although there is a slight decline	4
Slightly fresh	1–5% of the petals are starting to fade, and some petals are folding or appear less firm	3
Slightly wilted	5–10% of petals are wilted, color is fading and/or yellowing, and brown spots begin to appear on the edges of the petals	2
Wilted	>10% of petals are wilted and/or dried out, petals are brown in color with a dry and brittle texture	1

The age of the flower was assessed by counting the days until the flower showed signs of wilting. Wilting was indicated by brownish discoloration due to pigment loss. Flower age determination was based

on a visual scoring table (Table 3) (Sipayung *et al.*, 2021). Observation was terminated when the flower reached a wilting scale of 3 (slightly fresh). The day on which the flower reached scale 3 was recorded as the final age of the flower.

The measurement data obtained were then analyzed using a one-way ANOVA based on a Completely Randomized Design (CDR) at a 5% significance level. If significant differences were detected among treatments, the analysis was continued using the Tukey HSD test.

3. RESULTS AND ANALYSIS

This section presents the effects of glucose solution treatments at different concentrations on the physiological responses and quality attributes of cut aster flowers during storage. The evaluated parameters include solution uptake, visual quality, petal freshness, and vase life, which are summarized quantitatively and descriptively in the following tables.

Table 4 Results analysis on the absorbed solution of aster cut flowers

Source of Variation	Sum of Squares	df	Mean Square	F	P	η^2	ω^2
Treatment	2.464	4	0.616	1.051	0.429	0.296	0.013
Residuals	5.860	10	0.586				

Table 4 shows that glucose treatment did not significantly affect the height of the aster flower residual solution ($F(4,10) = 1.051$; $p = 0.429$). The effect size values indicate a low to moderate treatment effect ($\eta^2 = 0.296$; $\omega^2 = 0.013$).

Table 5. Results of descriptive analysis on the absorbed solution of cut aster flowers

Treatment	N	Mean	SD	SE	Coefficient of Variation
A (0 g L ⁻¹ glucose)	3	2.367	0.404	0.233	0.171
B (12.5 g L ⁻¹ glucose)	3	2.600	0.173	0.100	0.067
C (25 g L ⁻¹ glucose)	3	2.467	1.270	0.733	0.515
D (37.5 g L ⁻¹ glucose)	3	3.000	0.520	0.300	0.173
E (50 g L ⁻¹ glucose)	3	3.467	0.924	0.533	0.266

Table 5 show that the average height of the absorbed solution increases from treatment A to E. Treatment E shows the highest average value (3.467 cm), while treatment A has the lowest average value (2.367 cm). Data variability is relatively low in treatment B, as indicated by the lowest coefficient of variation value (0.067), while treatment C has the highest data variation (0.515).

Table 6 Quality results of cut aster stems on the 14th day

Treatment	Description of the Flower Stem (Day 14)	Score
A (0 g L ⁻¹ glucose)	The stem is erect, fairly hard in texture, green in color, and slightly softer at the base	4
B (12.5 g L ⁻¹ glucose)	The stem is erect, fairly hard in texture, green in color, and slightly softer at the base	4
C (25 g L ⁻¹ glucose)	The stem is erect, fairly hard in texture, green in color, and slightly softer at the base	4
D (37.5 g L ⁻¹ glucose)	The stem is erect, fairly hard in texture, green in color, and slightly softer at the base	4
E (50 g L ⁻¹ glucose)	The stem is erect, fairly hard in texture, green in color, and slightly softer at the base	4

As shown in Table 6, all glucose solution treatments with concentrations between 0 and 50 g L⁻¹ obtained a uniform stem condition score of 4 (fresh). Visually, the condition of the cut aster stems still appeared upright, green in color, and fairly hard in texture, although there was a slight softening at the base.

Table 7 Results of the quality of cut aster flowers on the 14th day

Treatment	Description Flowers (Day 14)	Score
A (0 g L ⁻¹ glucose)	Browning, dropping, >50% of flowers damaged	1
B (12.5 g L ⁻¹ glucose)	Yellowing, stiff, faded, 10-25% of flowers wilted	3
C (25 g L ⁻¹ glucose)	Browning, >25-50% of flowers damaged	2
D (37.5 g L ⁻¹ glucose)	Browning, >25-50% of flowers damaged	2
E (50 g L ⁻¹ glucose)	Fresh, 0% of flowers wilted	5

As shown in Table 7, treatment E (50 g L⁻¹ glucose) showed the best quality with the highest score (5), as indicated by flowers still being fresh, with no signs of wilting (0%). In contrast, treatment A (0 g L⁻¹ glucose) experienced the most severe quality decline with the lowest score (score 1), indicated by browning and flower drop with damage levels exceeding 50%. Treatments B, C, and D showed a moderate level of quality decline, with variations in the level of wilting and flower damage, each in the range of 10-50%.

Tabel 8 Visual description of cut aster petals when declared wilted based on the freshness scale

Treatment	Description	Score
A (0 g L ⁻¹ glucose)	5–10% of petals wilted, yellowing, and brown spots began to appear on the edges of the petals	2
B (12.5 g L ⁻¹ glucose)	5–10% wilted petals, faded and/or yellowing petal color, brown spots beginning to appear on the edges of the petals	2
C (25 g L ⁻¹ glucose)	5–10% wilted petals, pale faded petal color, slight brown spots beginning to appear on the edges of the petals	2
D (37.5 g L ⁻¹ glucose)	5–10% wilted petals, faded color, brown spots beginning to appear on the edges of the petals, some petals starting to fall off	2
E (50 g L ⁻¹ glucose)	On day 14, more than 50% of the petals are still fresh, with a fairly vigorous/firm texture. The color is still bright, but there is a slight decline	4

As shown in Table 8, based on visual observation of cut aster petals using freshness criteria presented in

Table 3, there were differences in the wilting time of flowers in each treatment. Treatments A, B, C, and D achieved a score of 2, indicating a decline in quality within 14 days. On the other hand, treatment E maintained good condition until day 14 with a score of 4.

Table 9 Vase life (days) of cut aster flowers

Treatment	Cut Flower Vase Life (days)
A (0 g L ⁻¹ glucose)	3.00 a
B (12.5 g L ⁻¹ glucose)	4.67 b
C (25 g L ⁻¹ glucose)	6.00 bc
D (37.5 g L ⁻¹ glucose)	7.00 c
E (50 g L ⁻¹ glucose)	14.00 d

Note: Mean values followed by the same letter are not significantly different based on the Tukey HSD test at 5% level.

Based on the results of the Tukey HSD multiple comparison test (Table 9), treatment E (50 g L⁻¹ glucose) produced the longest vase life (freshness duration) and was significantly different from all other treatment levels. Treatment D (37.5 g L⁻¹ glucose) and C (25 g L⁻¹ glucose) did not differ significantly from each other, nor did treatment C (25 g L⁻¹ glucose) and B (12.5 g L⁻¹ glucose). The control treatment (0 g L⁻¹ glucose) had the shortest vase life.

3.1. Solution Uptake

The ability to absorb solutions plays a crucial role in preserving cut flowers. This is because the cut flower has been separated from its original plant but continues to undergo metabolic activity and still needs energy produced by the respiration process. Metabolic activity keeps the cells alive, so the flowers still look fresh. The acquisition of water and nutrients to maintain the freshness of the cut flower is entirely dependent on the preservative solution (da Costa *et al.*, 2021). The preservative solution is absorbed through the transpiration pull mechanism, which is the process of solution entry due to the negative potential that arises from transpiration, or the evaporation of water from the stomata. This negative potential leads the water column to be drawn from the base of the stem so that it can reach the top (Mailidarni & Djafar, 2025). The freshness of cut flowers is influenced by the balanced processes of water absorption, internal translocation, and transpiration in cut flowers (Chen, 2024).

Based on the statistical analysis in Table 4 and descriptive analysis in

Table 5, it is known that the addition of glucose with different concentrations to the preservative solution shows a tendency to increase absorption capacity. This is seen from the increase in the average value of the water height that decreases with treatment, where treatment A (0 g L^{-1}) shows an average height of absorbed water that is smaller than the other four treatments, namely 2.367 cm. Meanwhile, in treatment B (12.5 g L^{-1}), there is a deviation in the data from the existing theory and trends in other data. Certain physiological conditions can cause this condition. One physiological factor that can affect this is the variation in transpiration rate. The process of solution absorption is affected by transpiration, so that a faster transpiration rate can cause a stronger transpiration pull (Nakazawa *et al.*, 2023). Treatment B showed a higher absorbed water height compared to treatment C (25 g L^{-1}), namely 2.6 and 2.467, suggesting that the transpiration rate of C was faster than that of B. Meanwhile, treatment D (37.5 g L^{-1}) showed an increase in the absorbed water height of 3.00 cm and increased to 3.467 cm in treatment E (50 g L^{-1}).

Although the addition of glucose tended to increase absorption capacity, the treatment effect was relatively weak and did not directly affect the absorption of the preservative solution. The addition of glucose affects water absorption capacity through metabolic and physiological activities. Glucose acts as an energy source for cells in cut flowers and replaces the products of photosynthesis that cannot be obtained anymore (Susila & Jonni, 2021). The presence of glucose maintains cell viability, thereby enabling cells to continue actively absorbing the preservative solution. The volume of solution absorbed also corresponds to the freshness age of cut flowers. This is consistent with research conducted by Simbawa *et al.* (2023), which found that the greater the volume of solution absorbed, the longer the freshness age of cut flowers. Glucose also acts as an osmotic agent. The presence of glucose in the solution can affect the osmotic gradient between the solution and the cut flowers, thus enabling better solution absorption. However, this effect occurs only at moderate concentrations. If the concentration is too high, the osmotic gradient could pull the water out of the glucose concentration in the extracellular space is higher than in the intracellular space (Sutrisno *et al.*, 2025).

The occurrence of air embolism also influences water absorption capacity. Air embolism is a common occurrence in the xylem channels of cut flowers. Embolism can occur because the water that previously filled the xylem space is replaced by air when the flower stem is cut (Manzoor *et al.*, 2024). Embolism can also be caused by the growth of microorganisms within the flower stem. The presence of excess glucose that does not meet the physiological needs of the flower can cause microorganisms to accumulate, thus living within the flower stem and causing air embolism. Furthermore, the presence of microbes can cause blockages in the xylem (Kikon *et al.*, 2025). Therefore, an optimal glucose concentration is required in the flower preservation process.

3.2 Quality of Cut Flowers Stem

Table 6 presents the stem quality scores for cut flowers, with each treatment achieving a score of "4." Treatment A, with a composition of 0 g L^{-1} glucose, treatment B (12.5 g L^{-1} glucose), treatment C (25 g L^{-1} glucose), treatment D (37.5 g L^{-1} glucose), and treatment E (50 g L^{-1} glucose), resulted in cut flower stems that remained upright until the 14th day, with a fairly hard texture, green color, and a slightly soft base. The uniformity of scores in Table 6 indicates that differences in glucose concentration in the preservative solution did not significantly affect the stability of cut aster stems. This suggests that as long

as water availability and xylem transport pathways are unimpeded, cut flower stems will maintain turgor pressure and stem tissue volume. Stable turgor pressure plays a role in maintaining the strength and texture of cut flower stems, ensuring upright, firm, and resistant to wilting (Verdonk *et al.*, 2023)

The stability of the stems indicates that the preservative solution did not cause physical or biochemical damage to the stem tissue, allowing for optimal fluid absorption and maintaining turgor pressure in the flower petals (Iriani, 2022). Furthermore, the growth of microorganisms and air embolism in *Aster* sp. stems can result in obstruction of xylem vessels, which can shorten shelf life by inhibiting water absorption. Air embolism is the entry of air into the xylem at the end of the stem that has been cut. Cut aster exposed to air result in total embolization because air easily enters the vessels due to the negative pressure within the xylem. Exposed to open air, cut aster will experience the difference between external pressure and the negative pressure within the xylem, allowing air to easily enter the transport vessels. If embolization occurs extensively, water flow will stop, causing the tissue in the flower stem to experience a water deficit, which causes wilting (Halim *et al.*, 2022).

The composition of the preservative solution in treatments A-E was considered effective in inhibiting microbial growth. Microbial growth in the preservative solution can cause blockages in the cut flower stems, thereby inhibiting the respiration process and leading to faster wilting (Mildaryani & Swasono, 2025). Stem tissue undergoing respiration and transpiration causes senescence and a reduction in the carbohydrate content of the stem. During senescence, starch, protein, and cell wall polysaccharides decrease in abundance. This protein reduction can lead to pigment degradation, leading to discoloration of the flower stem (Kunarto *et al.*, 2024) In previous research, the stems remained green and fresh, suggesting that the physiological condition of the cut flowers was well maintained. This was supported by adequate water availability, relatively undisturbed xylem transport pathways, and the effectiveness of the preservative solution composition in suppressing factors that cause tissue damage.

An important factor in maintaining the longevity of cut flowers is the concentration of the preservative solution, as excessively high concentrations can cause plasmolysis. If the preservative solution concentration is insufficient, the cells in the stem tissue will experience physiological stress, resulting in structural damage and reduced stability of the stem, which compromises its ability to maintain strength. Furthermore, reduced tissue capacity can also increase the risk of microbial growth on the surface and interior of cut flower stems. This can lead to blockage of blood vessels by mucus and bacteria. Plasmolysis can cause damage to the constituent cells in the flower stalk, leading to bacterial growth and the formation of mucus, which hampers the absorption of the solution (Timpalan *et al.*, 2023). Therefore, the optimal composition of the glucose and bleach solution in this study has an impact on the texture of the stem, which remains sturdy and is able to maintain the integrity of the solution transport.

3.3. Color Quality of Cut Flowers

In Table 7 the quality of cut flowers with the highest score (5) is in treatment E. The visual condition of the flower petals is bright and predominantly fresh until day 14 with a score (4) as shown in Tabel 8. This indicates that the solution composition is effective in maintaining the color and freshness of the aster flowers. The success of treatment E in maintaining flower quality shows that the composition of the ingredients in the preservative solution can work synergistically in slowing down the physiological processes that can cause wilting. The solution in lime contains citric acid, vitamin C, and natural antimicrobial compounds. These contents can lower the pH of the solution, which helps in increasing air absorption and inhibiting bacterial growth (Simbawa *et al.*, 2023). Decreasing the pH of the preservative solution creates conditions less favorable for the development of microorganisms, thereby supporting the xylem vessels to continue functioning properly. The use of bleach in the preservative solution can inhibit bacterial growth. In addition to using bleach, the citric acid content in squeezed lime also acts as a bactericide to prevent the growth of harmful bacteria; these bacteria will increase ethylene formation and accelerate the wilting process. By inhibiting bacterial activity and ethylene production, the rate of flower senescence can be suppressed so that the shelf life of cut flowers is longer. Symptoms of wilting are characterized by yellowing of the petals and the release of some petals on the aster flowers (Mildaryani & Swasono, 2025).

The flower cutting process can reduce flower quality due to physiological processes, including transpiration, respiration, ethylene production, and microbial infections that cause blockages in the xylem

vessels. The flower cutting process is a critical step because it directly cuts off the supply of nutrients and water to the flower tissue or stem. This condition forces cut flowers to adapt to the new environment, which depends on the stem's ability to absorb the preservative solution. As a result, flowers wilt quickly and become visually unattractive (Sisca *et al.*, 2025). The inability to absorb water and high transpiration will cause cut flowers to experience a rapid decline in freshness and tissue deterioration (Sukma *et al.*, 2023). Tissue degradation is characterized by changes in the texture of the petals, which change color and fall off. In Tabel 8, treatments B, C, and D exhibited a moderate decline in quality, with wilting and flower damage ranging from 10% to 50%. This was characterized by wilted petals, faded color, and the appearance of brownish spots on the petal edges. This condition indicates that the tissues in cut flowers are gradually deteriorating in physiological functions, including cell membrane stability and the ability to maintain intracellular water balance. Furthermore, changes in cell structure accelerate the degradation of color pigments, further diminishing the flower's visual quality. This indicates that the solution composition is less effective in maintaining the color of cut flowers. The Glucose composition significantly affects flower freshness because glucose plays a role in cellular respiration, where sugar is converted into energy, thereby maintaining flower metabolism and freshness. The availability of sufficient glucose acts as the main energy source for flower cells to maintain metabolic activity, maintain cell and tissue integrity, and slow down the senescence process (Susila & Jonni, 2021).

Ineffective results were shown in treatment A, with the lowest score (1). This condition indicates that the composition of the preservative solution in treatment A is ineffective in maintaining the freshness and structural stability of cut flowers during storage. Cut flowers appeared yellow and experienced some shedding of petals. *Aster* sp. can experience flower decline during storage, characterized by increasingly faded colors with petals that continue to turn brown. The change in color of the petals to brown indicates the degradation of flower pigments and reduced tissue stability due to post-harvest physiological stress. Most post-harvest cut aster still have cells and tissues that ultimately cause senescence. Senescence is the final stage of plant organ development, involving physiological changes. Senescence is characterized by an increase in the activity of degradative enzymes and a decrease in the cell's ability to synthesize essential compounds. This process ultimately leads to a gradual decline in the quality of the flower tissue.

The main observable symptom is a change in flower color to yellow or brown due to the loss of colored pigments (Iriani, 2022). These changes in color pigments are related to the degradation of chlorophyll, anthocyanin, and carotenoids, which previously played a role in maintaining the stability of flower color. The low glucose composition results in a minimal energy supply to support the flower's metabolic processes, so the flowers will appear yellow-brown and show symptoms of wilting (Susila & Jonni, 2021). Therefore, the composition of glucose concentration in the preservative solution is an important factor in maintaining the shelf life and overall physiological quality of cut flowers.

3.4. Flowers Vase Life

Flower freshness is indicated by criteria such as stem characteristics and flower color that remain the same as at the beginning of the trial period. Wilting flowers are indicated by the presence of stems that begin to droop/curl with a soft texture, browning, and the appearance of mucus. In addition to the stem, symptoms of flower wilting are also visible in the condition of the flower petals that experience color fading, browning, or falling. The color of the petals can fade due to the loss of color pigments due to oxidative damage and cell death. This event also causes the color of the petals to turn brown and lose moisture, resulting in drying (Tazeen *et al.*, 2025).

The experimental results shown in Table 9 indicate that the use of a preservative solution can extend the vase of life. The vase life also increased gradually, with treatment A showing the shortest freshness, at 3 days. Cut flowers treated with a preservative solution containing a glucose concentration of 0 g L⁻¹ can last for three days due to the physiological capacity of the flower cells, which remain functional after being cut off the plants. The flower utilizes its remaining stored energy to perform these various physiological processes. Meanwhile, the presence of water in the preservative solution maintains the flower's turgor pressure. This relatively short vase life is due to the limited amount of stored energy. One of the processes happening is respiration, which needs glucose. The absence of glucose deprives the cut flower of its energy supply, causing the flower cells to die and the flower to appear wilted (Nguyen & Lim, 2021).

Meanwhile, treatments of B-D showed a longer vase life, at 4.67 days, 6 days, and 7 days, respectively. Treatment E showed the longest vase life compared to the other treatments, namely at 14 days (about 2 weeks). These results indicate that a preservative solution with a composition consisting of

glucose, citric acid from lime, and sodium hypochlorite from bleach can increase vase life. This composition also contributes to the freshness of flowers. The presence of citric acid from lime creates a low pH that inhibits microbial growth, which is known to cause blockages in the stems, thus preventing the preservative solution from reaching the flower petals and leading to cell death and damage to color pigments (Simbawa *et al.*, 2023).

Besides acid citric from lime juice, glucose also plays a crucial role in maintaining the flower's condition. This is evident from the experimental results, where treatment E provided the longest shelf life compared to other treatments, while treatment A had the shortest vase life. The results also show that the vase life gradually increased along the increasing of glucose concentration. Glucose plays a role in providing energy that keeps flower cells alive (Susila & Jonni, 2021). Once energy reserves are depleted, cut flower cells require additional glucose from external sources. Cells that are no longer able to obtain glucose will experience disruption. This respiratory failure results in the inability to produce ATP. Consequently, cellular activities that require ATP are disrupted. This disruption causes the ionic conditions of the cytoplasm to become unstable and can trigger the activity of protease and nuclease genes. In addition to triggering the activity of protease and nuclease genes, the absence of glucose also causes mitochondria to produce Reactive Oxygen Species (ROS), leading to oxidative stress. This oxidative condition increases damage to cells, such as peroxidation of the lipid layer in the cell membrane, protein denaturation, and damage to genetic material. This condition causes cytoplasm to leak out of the cell, causing the cell to lose its turgidity. As a result, the cell dies and appears wilted (Rabiza-Świder *et al.*, 2025). Cut flowers need preservation solution with optimum concentration of glucose. The relatively shorter vase life of treatment B-D shows that Previous research by Zhang *et al.* (2022) showed that adding glucose as an additional sugar to cut flower preservative solutions induces the PsMBY2 gene, thereby promoting the accumulation of anthocyanin pigments, which impart color to flower petals. Anthocyanin accumulation prevents petal color from fading, so the petals still look fresh as long as the cells still alive.

Based on the water absorption results in

Table 5 and flower age in Table 9, it is known that the flower vase life is directly proportional to the level of preservative solution uptake. This is because the preservative solution becomes the sole source of nutrients and water for the physiological needs of cut flowers. The good absorption capacity of the preservative solution allows for a longer vase life for cut flowers.

4. CONCLUSION

Based on the observation results, it can be concluded that the glucose concentration in the preservative solution affects the durability of cut aster flowers. The 50 g L⁻¹ glucose treatment showed the best results in maintaining flower freshness until the 14th day, while the treatment without glucose experienced faster wilting. Although there was no statistically significant effect on solution absorption, treatment variation still showed differences in plant physiological responses. Treatment E gave the best response, indicating a more optimal osmotic balance in supporting plant resistance.

The combination of glucose, citric acid, and bleach in the preservative solution effectively maintains the condition of flowers and stems by increasing water absorption, suppressing the growth of microorganisms, and providing nutritional intake for the surviving cells of the cut flowers. The optimal glucose concentration (25-50 g L⁻¹) supports the process of water distribution through the xylem without causing cell damage, thus slowing the senescence process and maintaining flower freshness. In addition, the presence of glucose also induces the accumulation of anthocyanins, which prevents color fading in flower petals.

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