Adv. Hort. Sci., 2025 39(2): 83-92

DOI: 10.36253/ahsc-17201
https://oaj.fupress.net/index.php/ahs

AHS
Advances in Horticultural Science

Enhance the longevity and aesthetic appeal of *Anthurium andraeanum* cv. Fire cut leaves by using some natural components

M.F. Rida [(*)], **A.M. Taha**
Ornamental Plants Research and Landscape Gardening Department, Horticulture Research Institute, Agriculture Research Center, Alexandria, Egypt.

[(*)] **Corresponding author:**
magdeldinhamza2@yahoo.com

Citation:
RIDA M.F., TAHA A.M., 2025 - *Enhance the longevity and aesthetic appeal of Anthurium andraeanum cv. 'Fire' cut leaves by using some natural components.* - Adv. Hort. Sci., 39(2): 83-92.

ORCID:
RMF: 0000-0003-4122-0440
TAM: 0009-0009-8547-200X

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no conflict of interests.

Received for publication 19 January 2025
Accepted for publication 27 May 2025

Key words: *Anthurium,* Arabic gum, chitosan, glossiness, leaf postharvest, rosehip oil.

Abstract: This experiment was conducted to examine the effects of rosehip oil (Rh oil), Arabic gum (AG), and chitosan (CS) on the vase life and quality of *Anthurium andraeanum* cv. Fire under laboratory conditions. The experimental layout followed a completely randomized design. Seven treatments were applied: tap water (control), Rh oil (2% or 4%), Rh oil (2% or 4%) + AG (5%), and Rh oil (2% or 4%) + AG (5%) + CS (500 ppm). The leaves were sprayed using a hand sprayer until runoff occurred. Results showed that the highest increases in vase life, final water uptake, chlorophyll a and b content, and the degree of leaf health and glossiness were obtained after the application of 4% Rh oil. Scanning electron micrographs illustrated that stomata were open in untreated leaves, moderately open after application of 2% Rh oil, slightly open after spraying with 4% Rh oil, and completely closed after the application of Rh oil (2% or 4%) + AG (5%).

1. Introduction

Anthurium andraeanum (*Flamingo flower*) is a very popular plant which grows up to 60 cm tall. It features rich green, elongated, heart-shaped leaves and waxy white or coral-colored spathes, which are used in wedding arrangements (Jack, 1985). Its attractive foliage and showy cut flowers make it highly valuable in the global flower market (Anand *et al.*, 2017). When the plant is not in flower, the leaves harmonize with those of other tropical plants suitable for shady spots (Jane and Graham, 1997). In recent years several varieties of Anthuriums have been introduced into the Egyptian market. Most of these varieties have large, glossy leaves, making them suitable for use as cut foliage. Unfortunately, *Anthuriums andraeanum* cv. Fire has large, pale green leaves, which reduce its economic value.

AHS - Firenze University Press
ISSN 1592-1573 (on line) - 0394-6169 (print)

To optimize the commercial worth of cut flowers, researchers have concentrated on enhancing their longevity and quality through flower preservation; nevertheless, chemical flower preservation has negative environmental consequences. (Moussa *et al.,* 2024). Natural ingredients, such as plant extracts and essential oils, are utilized instead of chemicals in cut flower preserving solutions due to their negative impact on human health, particularly those with silver components. Numerous researchers have explored the impact of natural materials (Sarhan *et al*., 2023). In this respect Hashemabadi *et al.* (2021) found that adding dill essential oil to *Dianthus caryophyllus* L. cv. Yellow Candy solution improved vase life and solution uptake compared to pure water. Bañuelos-Hernández *et al.* (2017) found that applying 1.0 and 1.5% chitosan coating to Heliconia bihai flower stems increased vase life by 10.3 and 7 days, respectively, compared to the control. Also, Creel (2006) reported that soaking flowers in 10% or 20% Acacia gum can extend the vase life of snapdragon.

The fruit of *Rosa canina* L. is known as rosehip (Rh) or rose haw. It is red to orange in color. It consists of approx. 30-35% seeds and 65-70% pericarp (Uggla and Nybom*,* 1998). Rosehip oil is rich in polyunsaturated fatty acids, stearic acid (48.11%), linoleic acid (35.38%), palmitoleic acid (33.78%) and eicosadienoic acid (30.57%) (Vasić *et al.,* 2020). Due to its antioxidant properties, rosehip oli is widely used in pharmaceutical industry (Franco *et al.,* 2007; Machmudah *et al.,* 2007).

Acacia Senegal and *Acacia Seyal* trees are the primary sources of Arabic gum (AG), a natural polysaccharide polymer used in the biological industry. Recently, Arabic gum has gained considerable attention as a postharvest edible coating due to its ability to preserve the quality and extend the shelf life of fresh products. It's excellent emulsifying, stabilizing, binding, and shelf-life-extending properties make it an efficient food additive (Tiamiyu *et al.,* 2023). The shelf life of various fruits and vegetables, including tomatoes (Ali *et al.,* 2010), sweet cherries (Mahafaudi and Hamdi, 2014), green chilies (Chitravathi *et al.,* 2014) and mangoes (Khaliq *et al.,* 2015), has been successfully extended by Arabic gum coating.

Chitosan (CS) is a naturally occurring polymer with several advantageous properties, including non-toxicity, biocompatibility, biodegradability, and the ability to form chelates. These characteristics, along with its versatility, make chitosan a valuable material for various applications (Lingait *et al*., 2024). It can be processed into hydrogels, nanoparticles, pastes, nanofibers, films, membranes, microgranules, sponges, etc. Additionally, chitosan can be modified by grafting, crosslinking, ion templating, or blending with other materials to provide a variety of specific properties for new and targeted applications (Kluczka, 2024). It's excellent film-forming ability makes chitosan an effective edible surface coating for fruits and vegetables.

This study investigate the effects of rosehip oil, Arabic gum, and chitosan on the vase life and visual appeal of *Anthurium andraeanum* cv. Fire cut leaves.

2. Materials and Methods

This experiment was carried out at Antoniades Gardens, Ornamental Plants Research and Landscape Gardening Department, Horticulture Research Institute, Agriculture Research Center, Alexandria, Egypt, in the years of 2022 and 2023.

Plant materials and treatments

On March 29, 2022, and March 31, 2023, during the first and second seasons, *Anthurium andraeanum* leaves were sourced from a well-known commercial nursery. The leaves were transported to the laboratory under dry conditions, and the petioles were re-cut to a length of 27 cm before treatment.

Preliminary experiment was done by using several concentrations of rosehip (Rh) oil, Arabic gum (AG), chitosan (CS) and their combinations. Seven treatments with the higher vase life and best appeal beside control were chosen to do this experiment. Treatments included:

i. Tap water (control);
ii. Rh oil (2%);
iii. Rh oil (4%);
iv. Rh (2%) + AG (5%);
v. Rh oil (4%) + AG (5%);
vi. Rh oil (2%) (5%) + CS (500 ppm);
vii. Rh oil (4%) + AG (5%) + CS (500 ppm).

All treatments included the addition of Tween 80 (2%). The *Anthurium* leaves were sprayed with the different treatments using a hand sprayer until runoff occurred. Afterward, the leaves were placed in glass jars containing 500 ml of tap water to complete their shelf-life period.

The leaves were maintained at the average temperature of 19° to 23°, average humidity (59-65%) and 24 hours fluorescent light (about 550 -575 lux).

Data collection on postharvest characteristics

Vase life (VL) expressed in days. *Anthurium* leaf was excluded when about 20% of its surface was yellow. This stage was considered the end of the potential valuable longevity of the cut leaf.

Loss of leaf fresh weight percentage (LLFW). It was set at the end of vase life as expressed by the following formula:

$$\text{LLFW (\%)} = \frac{\text{(Initial leaf fresh weight - Final leaf fresh weight)}}{\text{(Initial leaf fresh weight)}} \times 100$$

Final water uptake (FWU) expressed in grams. Four evaporation control jars [jars which did not contain any leaves] were located between these containg leaves at different places. The evaporation of each jar was taken and the average of the four jars was calculated. It was calculated at the end of the experiment using the following formula:

$$\text{FWU (g)} = \quad \text{FWU (g)} = [\text{ASS -ASE}] - \text{ED}$$

Where ASS is the amount of solution at the start of the experiment, ASE is the amount of the solution remaining at the end of the experiment and ED is the average of evaporation data.

Leaf fresh weight/Leaf dry weight ratio (LWR). At the end of the experiment, the leaves were oven dried at 72°C for 48 hours for a constant weight to get the leaves dry weight. The fresh weight was then divided by the dry weight based on the following equation:

$$\text{LWR} = \frac{\text{Fresh weight per leaf (g)}}{\text{Dry weight per leaf (g)}} \times 100$$

The amount of transpired water from the leaf surface (TW) expressed in grams. After 2, 4 and 6 days from the beginning of experiment, the transpired water from the leaf surface was calculated as given by the formula below:

TW (g) = {WF + JW + WVS at (day n)} – {WF +JW+ WVS at day (n+1)})/(IFW)

Where WF is the weight of the leaf, JW is jar weight, WVS is the weight of vase solution, IFW is initial leaf fresh weight, n = 1, 3 and 5 days and n+1 is the next day.

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Relative fresh weight (RFW). Fresh weight of the leaves was set just before the immersion of the leaves into the solutions and recorded on the 2nd, 4th , 6th , 8th, 14th, 20th , 26th and 30th day from the beginning of the experiment. The fresh weight of each leaf was expressed relative to the initial weight to represent the water status of the leaf as follows:

$$\text{RFW} = \frac{\text{Wt}}{\text{W0}} \times 100$$

where (Wt) the weight of leaf (g) on the 2nd, 4th, 6th, 8th, 14th, 20th, 26th and 30th day from the beginning of the experiment, (W0) the initial fresh weight of the same leaf (g).

Vase Solution Uptake Rate (VSUR). It was measured according to the following formula:

$$\text{VSU rate} = \frac{\text{(St - 1) - St}}{\text{IFW of stem}} \times 100$$

where (St) is the weight of vase solution (g) after 2, 4, 6, 8 and 10 days from the beginning of experiment, (St-1) is weight of the vase solution (g) on the previous day and (IFW) is the initial fresh weight (g).

Chlorophyll content. Samples from each treatment were collected at the end of the vase life of the control treatment, and the amounts of chlorophyll a and b (mg/100 g fresh leaf weight) were determined according to Moran (1982).

Appearances and glossiness. On the 6th day from the experiment start. A jury of twenty members from different age groups evaluated the leaves visually for its glossiness and scored on a scale (not glossy, moderate glossy, glossy and high glossy) and its appearance and scored a scale (bad, good and very good).

Visualization of stomatal apparatus by Scanning Electron Microscope)SEM). At the end of the first experiment season, the treatments which led to the longest vase life were chosen to investigate its effect on stomata structure. *Anthurium* leaves were sprayed with these treatments beside tap water. After 24 hours of the treatment, small pieces of fresh specimens of *Anthurium* leaves were removed and fixed by immersing them immediately in 4F1G (Fixative, phosphate buffer solution) pH=7.4 at 4°C for 3 hours. Specimens were then post fixed in 2% Osmium tetroxide (OsO_4) in the buffer at 4°C for 2 hours. Samples were washed in the buffer and dehydrated at 4°C through a graded series of ethanol. Samples of *Anthurium* leaves were dried by means of critical point method , mounted using carbon paste on an Al- stub and coated with gold up to thickness in a sputter coating unit (JFC-1100E). Observation of stomata morphology in the coded specimens were performed in a JEOL JSM - 5300 scanning electron microscope operated between 15 and 20 Kev. The examination by electron microscope was done at the Electron Microscope Unit at the Faculty of Science, Alexandria University, Egypt (Tahmasebi *et al.,* 2015)

Experimental layout and statistical analysis

The experimental layout was a complete randomized design (CRD). It consisted of seven treatments with three replicates, and each replicate contained four cut leaves. The means of the different variables were compared using the "Least Significant Difference (LSD)" test at 5% level of probability. (Snedecor and Cochran, 1989).

3. Results

Post harvest parameters

The postharvest parameter results are summarized in Table 1. Vase life data show that all treatments outperformed the control. The most notable increase in vase life occurred with the application of 4% Rh oil in both seasons, with values of 33.22 days in 2022 and 33.28 days in 2023. In contrast, the lowest vase life was observed with the combination of 2% or 4% Rh oil + 5% AG + 500 ppm CS, which had a significance level value comparable to the control in both seasons.

The greatest reduction in LLWT percentage was achieved with 4% Rh oil, which resulted in 1.62% in 2022 and 1.88% in 2023. The highest increase in LFWT was found with the combination of 2% or 4% Rh oil + 5% AG + 500 ppm CS or 4% Rh oil + 5% AG, yielding similar significant results in both seasons.

The highest final water uptake was recorded with 2% or 4% Rh oil, with no significant difference between the two concentrations across both season. Additionally, the greatest increase in LWR was observed with 4% Rh oil, with values ranging between 5.36 in 2022 and 5.24 in 2023.

Table 2 revealed that during the first six days of the experiment the greatest significant increase in transpiration rate fluctuated between the control and application of either Rh oil (2%) + AG (5%) + CS (500 ppm) or Rh oil (4%) + AG (5%) + CS (500 ppm) in both experimental seasons. Two days after experiment started, in 2022 season, the application of Rh oil (4%) + AG (5%) + CS (500 ppm) resulted in the highest significant increase in transpiration rate, with a recorded value of 0.3391. In 2023 season, the highest significant increase in transpiration rate was obtained following control treatment, which recorded 0.3493, and Rh oil (4%) + AG (5%) + CS (500 ppm), which recorded 0.3411 with the same level of significance. Four days after the experiment began, the untreated control showed the largest significant rise, with results of 0.2469 and 0.3215 for 2022 and 2023 seasons , respectively. Furthermore, the application of Rh oil (4%) + AG (5%) + CS (500 ppm) in

Table 1 - Effect of foliar application of rosehip oil, Arabic gum, and chitosan on vase life, fresh weight loss, final water uptake, and fresh/dry weight ratio of *Anthurium* leaves during the 2022 and 2023 seasons

Treatment	VL (days)		LLFW (%)		FWU (g)		LWR (%)	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	10.55	10.78	4.90	4.64	19.95	23.51	4.43	4.51
Rh oil (2%)	26.10	23.00	6.07	6.01	47.06	49.95	4.80	4.77
Rh oil (4%)	33.22	33.28	1.62	1.88	50.79	57.61	5.36	5.24
Rh oil (2%) + AG (5%)	17.87	17.83	7.22	6.27	23.01	28.46	4.81	4.46
Rh oil (4%) + AG (5%)	17.89	18.67	10.88	10.77	22.28	26.50	4.89	4.69
Rh oil (2%) + AG (5%) + CS (500 ppm)	13.11	14.17	11.56	10.74	25.08	25.03	4.26	4.46
Rh oil (4%) + AG (5%) + CS (500 ppm)	12.89	12.00	13.71	12.48	26.97	18.82	4.17	4.37
LSD at 0.05	5.66	5.38	3.23	2.14	12.15	14.53	0.18	0.06

LSD at 0.05 = Least Significant Difference test at 5% level of probability. Rh oil = Rosehip oil; AG = Arabic gum; CS = Chitosan. VL = vase life; LLFW = Loss of leaf fresh weight percentage; FWU = Final water uptake; LWR = leaf fresh weight/leaf dry weight ratio.

Table 2 - Effect of foliar spray with rosehip oil, Arabic gum, and chitosan on the amount of water transpired from the surface of Anthurium leaves during the 2022 and 2023 seasons, measured at 2, 4, and 6 days after the start of the experiment

Treatment	TW (g)					
	2022			2023		
	2 days	4 days	6 days	2 days	4 days	6 days
Control	0.3320	0.2469	0.1437	0.3493	0.3215	0.1570
Rh oil (2%)	0.2173	0.1482	0.1350	0.2478	0.1690	0.1447
Rh oil (4%)	0.1928	0.1638	0.1075	0.2316	0.1659	0.1343
Rh oil (2%) + AG (5%)	0.2574	0.1677	0.1401	0.2781	0.1694	0.1146
Rh oil (4%) + AG (5%)	0.1705	0.1287	0.1042	0.1616	0.1190	0.1194
Rh oil (2%) + AG (5%) + CS (500 ppm)	0.3228	0.2302	0.1736	0.3343	0.1852	0.1822
Rh oil (4%) + AG (5%) + CS (500 ppm)	0.3391	0.1830	0.1425	0.3411	0.1648	0.1482
LSD at 0.05	0.0029	0.0004	0.0003	0.0033	0.0007	0.0002

LSD at 0.05 = Least Significant Difference test at 5% level of probability. Rh oil = Rosehip oil; AG = Arabic gum; CS = Chitosan. TW = Amount of transpired water from the leaf surface.

both seasons produced the greatest significant rise six days after the experiment began, with values of 0.1736 in 2022 season and 0.18822 in 2023 season.

Fig. 1 - Effect of foliar application of rosehip oil, Arabic gum, and chitosan on the relative fresh weight (RFW%) of *Anthurium* cut leaves during the 2022 and 2023 seasons, measured at 2, 4, 6, 14, 20, 26, and 30 days after the start of the experiment.

For RFW, figure 1 showed that the untreated leaves had the greatest rise in RFW% on the 2nd day after the experiment began. While the largest drop in RFW was recorded following application of Rh oil (4%), AG (5%), and CS (500 ppm). Also, figure 1 revealed a minor decline in RFW% following all treatments, with the exception of Rh oil (4%) which increased slightly in the season of 2022, but for 2023, all treatments caused a slight decrease in RFW% on the 4th day after the experiment began. The drop in RFW% persisted marginally on the 6th day after start of the experiment for all treatments except Rh oil (4%) + AG (5%) + CS (500 ppm), which declined considerably in both seasons. On the 14th day of the experiment, the Rh oil (2%) + AG (5%) + CS (500 ppm) and Rh oil (4%) + AG (5%) + CS (500 ppm) treatments ended, and the RFW% continued to decline marginally following the use of Rh oil (2%) in both experimental seasons. On the 20th day, all treatments were discontinued with the exception of Rh oil 2% and 4%, and RFW% decreased gradually in 2022 season and 2023 season. On the 26th and 30th days after the trial began, the reduction in RFW% persisted somewhat.

Figure 2 shows that the control treatment had the greatest rise in VSUR on the 2nd day of the experiment, and this increase persisted on the 4th day of the experiment when compared to the other treatments. The VSUR of control treatments declined dramatically on the 6th and reached its lowest point on the 10th of the experiment in the 2022 and 2023 seasons. While the lowest VSUR value was observed on the 2nd day following the application of Rh oil (4%) treatment, the drop in this value over the first 10

Fig. 2 - Effect of foliar application of rosehip oil, Arabic gum, and chitosan on vase solution uptake rate (VSUR) of *Anthurium* cut leaves during the 2022 and 2023 seasons, measured at 2, 4, 6, and 10 days after the start of the experiment.

days of the experiment persisted with a gradual rhythm in both experimental seasons.

Table 3 shows that the control treatment resulted in the lowest significant levels of leaf pigments. In contrast, the application of 4% Rh oil led to the most substantial increase in chlorophyll a and b levels in both seasons.

Leaves appearance and glossiness

Figure 3 shows that all jury members agreed the glossiness of *Anthurium* cut leaves was high when treated with Rh oil (2% or 4%) combined with AG

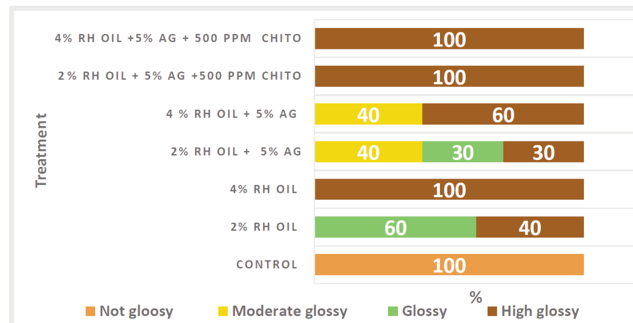

Fig. 3 - Percentage of jury evaluations for glossiness of *Anthurium* leaves following foliar application of rosehip oil, Arabic gum, and chitosan, compared to untreated (control) leaves.

(5%) and CS (500 ppm), as well as with 4% Rh oil alone. In contrast, untreated leaves were rated as not glossy. Additionally, figure 3 indicates that 60% of jury members rated the glossiness of leaves treated with 2% Rh oil alone as high.

Figure 4 shows that the overall opinion of the jury regarding the appearance quality of Anthurium cut leaves treated with Rh oil (2% or 4%) was very good. However, the application of Rh oil (2% or 4%) in combination with AG (5%) and CS (500 ppm) resulted in the development of brown patches on the leaves,

Table 3 - Effect of foliar spray with rosehip oil, Arabic gum, and chitosan on leaf pigment content in Anthurium leaves during the 2022 and 2023 seasons

Treatment	Chlorophyll (mg / 100 g FW)			
	a		b	
	2022	2023	2022	2023
Control	1.05	1.19	0.63	0.80
Rh oil (2%)	2.03	2.11	1.07	1.07
Rh oil (4%)	2.44	2.26	1.41	1.59
Rh oil (2%) + AG (5%)	2.17	1.96	1.20	1.02
Rh oil (4%) + AG (5%)	2.09	1.98	1.04	1.19
Rh oil (2%) + AG (5%) + CS (500 ppm)	1.78	2.10	0.91	1.04
Rh oil (4%) + AG (5%) + CS (500 ppm)	1.87	1.69	1.06	0.92
LSD at 0.05	0.10	0.11	0.03	0.04

LSD at 0.05 = Least Significant Difference test at 5% level of probability. Rh oil = Rosehip oil; AG = Arabic gum; CS = Chitosan. TW = Amount of transpired water from the leaf surface.

leading to a poor appearance rating for these treatments, as shown in Figures 4 and 5.

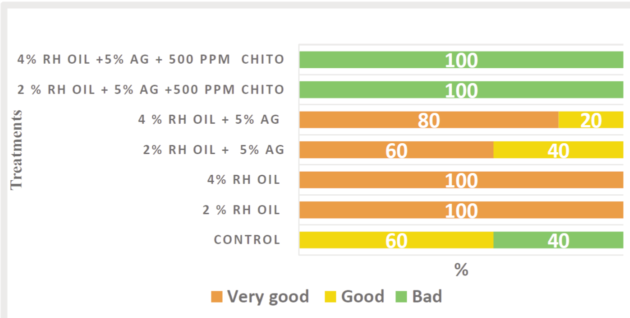

Fig. 4 - Jury evaluation percentages of *Anthurium* leaf appearance after foliar treatments with rosehip oil, Arabic gum, and chitosan, in comparison to control (untreated) leaves.

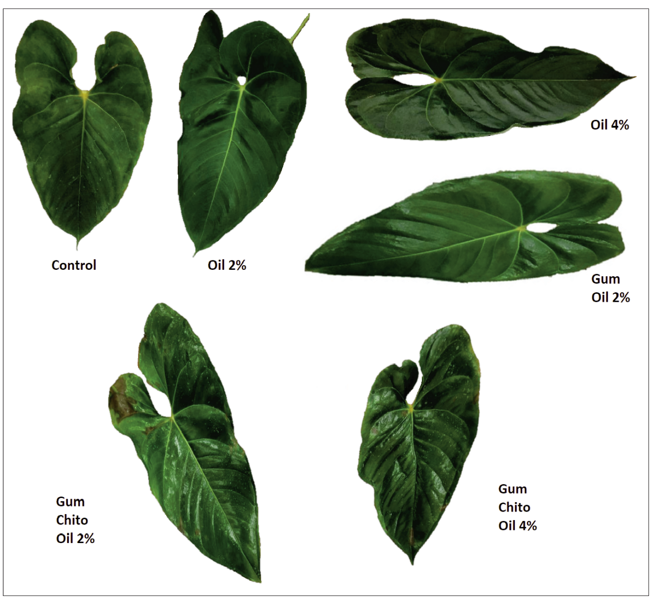

Fig. 5 - Effect of foliar application of rosehip oil, Arabic gum, and chitosan on the glossiness and appearance of *Anthurium* leaves on the 6th day after the start of the experiment, during the 2023 season.

Visualization of stomatal apparatus

Scanning electron micrographs of the abaxial surface of Anthurium leaves (Fig. 6) showed that fully open stomata were observed in untreated control leaves. Moderately open stomata were seen following application of 2% rosehip oil, while slightly open stomata appeared after spraying with 4% rosehip oil. In contrast, stomata were completely closed after treatment with rosehip oil at 2% or 4% combined with 5% Arabic gum.

Furthermore, close-up scanning electron

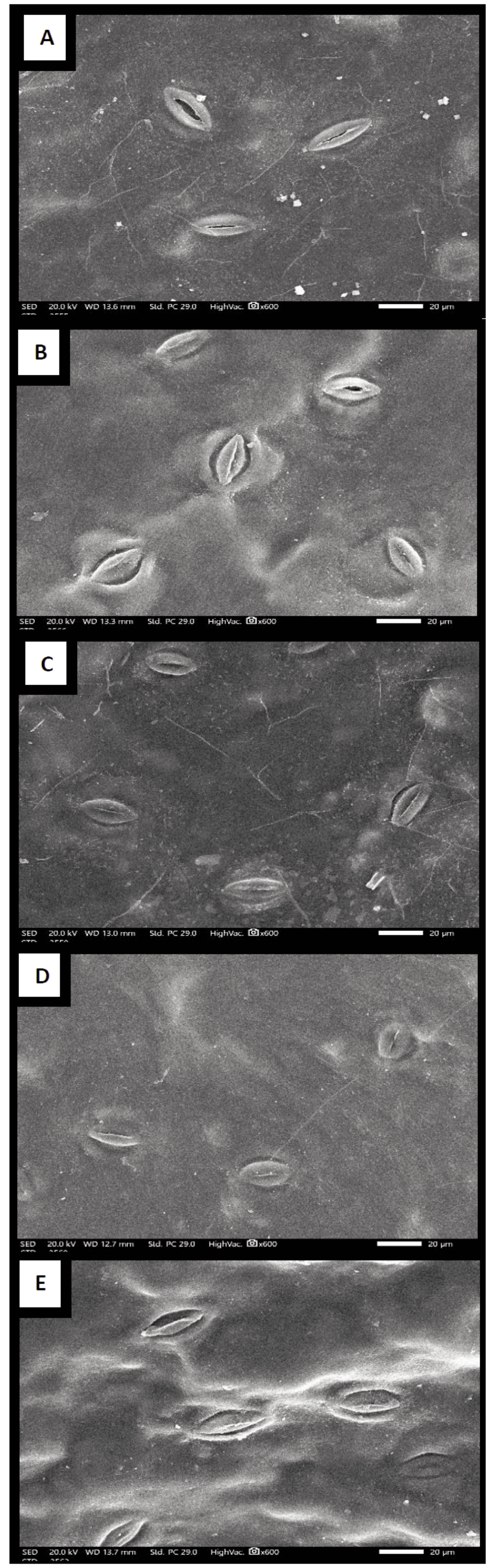

Fig. 6 - Scanning electron micrographs (SEM) of the abaxial surface of *Anthurium* leaves 24 hours after spraying with: (A) control; (B) 2% rosehip oil; (C) 4% rosehip oil; (D) 2% rosehip oil + 5% Arabic gum; (E) 4% rosehip oil + 5% Arabic gum. Micrographs were taken at 600× magnification; scale bar = 20 µm.

micrographs of individual stomata after different treatments (Fig. 7) revealed that the largest stomatal pore (width: 2.18 µm, height: 24.37 µm) was found in untreated leaves. A moderately sized pore (width: 1.438 µm, height: 12.87 µm) was recorded after treatment with 2% rosehip oil, while the smallest pore (width: 1.318 µm, height: 8.038 µm) was observed after treatment with 4% rosehip oil. Stomatal closure was evident following application of rosehip oil at 2% or 4% in combination with 5% Arabic gum.

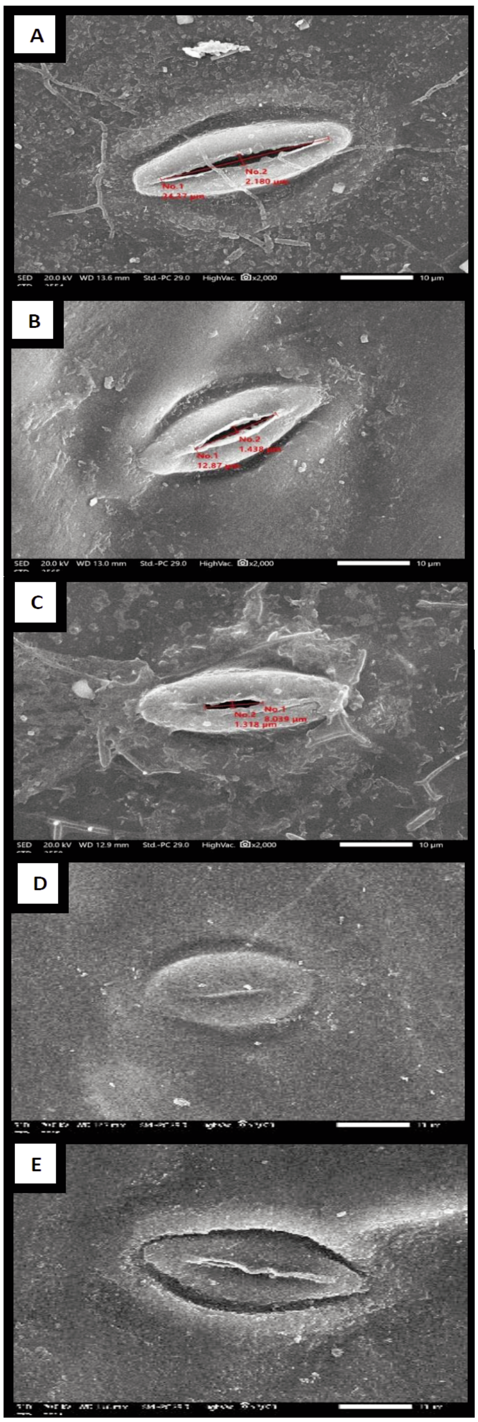

Fig. 7 - Scanning electron micrographs (SEM) of a single stoma on the abaxial surface of *Anthurium* leaves 24 hours after spraying with: (A) control; (B) 2% rosehip oil; (C) 4% rosehip oil; (D) 2% rosehip oil + 5% Arabic gum; (E) 4% rosehip oil + 5% Arabic gum. Micrographs were taken at 2000× magnification; scale bar = 10 µm.

4. Discussion and Conclusions

Stomata regulate the diffusive conductance of leaves, influencing both carbon assimilation and transpirational water loss. Their response is critical in maintaining the balance between water supply and atmospheric demand. Under low humidity conditions, for instance, reduced leaf water content triggers stomatal closure to limit transpiration and preserve internal water status (Thomas, 2005).

In the present study, foliar application of rosehip oil induced partial stomatal closure (Figs. 6 and 7), leading to decreased water loss through transpiration (Table 2). This effect contributed to improved water-use efficiency and leaf turgor maintenance, as reflected in the modest reduction in relative fresh weight during the experimental period (Fig. 1) and the gradual decline in vase solution uptake rate over the first 10 days (Fig. 2). The slight decrease in final fresh weight percentage (Table 1) may also be attributed to this stomatal behavior. These findings are consistent with previous reports identifying stomatal regulation as a key determinant of water loss in cut flowers (Fanourakis *et al.*, 2016; In *et al.*, 2016; Schroeder and Stimart, 2005). This stomatal response may be further explained by the chemical composition of rosehip oil, which contains a range of fatty acids - including myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, and arachidic acids (Paladines *et al.*, 2014). Arachidic acid, in particular, has been associated with the endogenous synthesis of salicylic acid (SA), a signaling molecule known to induce stomatal closure, enhance membrane stability, and reduce lipid peroxidation (Coquoz *et al.*, 1995; Hakimeh, 2012).

During the first six days, high water loss through transpiration led to a strong drop in relative fresh weight (Fig. 1), reduced water uptake, shorter vase life, and faster chlorophyll breakdown (Table 1). In untreated leaves, this continuous water loss after detachment caused the flowers to lose freshness earlier and wilt faster. These results confirm that keeping good stomatal control after detachment is important to reduce water loss and maintain vase life

(Salunkhe *et al*., 1990).

Treatment with 4% rosehip oil markedly improved leaf longevity and freshness, likely by limiting early transpiration (Table 2), sustaining vase solution uptake over time (Fig. 2), and reducing fresh weight loss (Table 1). The increased chlorophyll a and b contents further supported better color retention and extended vase life, aligning with the findings of Rida (2019) on Aster New York.

Application of 4% rosehip oil as a foliar spray on *Anthurium* leaves is recommended, as it enhanced vase life, final water uptake, and chlorophyll a and b levels, while also promoting healthier and glossier leaf appearance.

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