

ARTICLE

Derris elliptica leaf extract extends vase life of gerbera by suppressing bacterial growth and modulating oxidative stress

Extrato foliar de *Derris elliptica* prolonga a vida de vaso da gerbera suprimindo o crescimento bacteriano e modulando o estresse oxidativo

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Abstract

Gerbera is a high-value cut flower whose commercial longevity is frequently compromised by microbial-induced vascular occlusion and oxidative stress-driven senescence. This study evaluated the efficacy of *Derris elliptica* leaf extract as a natural, eco-friendly biopreservative for extending the vase life of cut gerberas. Results demonstrated that *D. elliptica* extract significantly improved postharvest performance in a dose-dependent manner, with 175 mg L⁻¹ identified as the optimal concentration. At this level, vase life was extended to 13.57 days, nearly double that of the distilled water control (6.93 days). The extract effectively suppressed microbial proliferation in the vase solution, maintaining a low optical density (0.15) compared to the control (0.72) at day 10. This reduction in bacterial load preserved xylem hydraulic conductivity, resulting in improved water balance, as reflected by relative fresh weight values exceeding 100%. Furthermore, the 175 mg L⁻¹ treatment significantly alleviated oxidative damage by reducing malondialdehyde content and electrolyte leakage. This was associated with enhanced antioxidant defense along with higher total phenolic and flavonoid contents (2.6–4.7-fold over the control). However, higher concentrations (200–250 mg L⁻¹) led to a decline in physiological performance, suggesting an optimal threshold at 175 mg L⁻¹. *Derris elliptica* extract extended vase life through dual mechanisms involving microbial suppression and oxidative stress regulation.

Keywords: Cut flowers, microbial inhibition, plant extract, postharvest physiology.

Resumo

A gébera é uma flor de corte de alto valor cuja longevidade comercial é frequentemente comprometida pela oclusão vascular induzida por microrganismos e pela senescência associada ao estresse oxidativo. Este estudo avaliou a eficácia do extrato foliar de *Derris elliptica* como um bioconservante natural e ecológico para prolongar a vida de vaso de géberas de corte. Os resultados demonstraram que o extrato de *D. elliptica* melhorou significativamente o desempenho pós-colheita de forma dose-dependente, sendo 175 mg L⁻¹ identificado como a concentração ótima. Nesse nível, a vida de vaso foi estendida para 13,57 dias, quase o dobro em comparação ao controle com água destilada (6,93 dias). O extrato suprimiu efetivamente a proliferação microbiana na solução de vaso, mantendo uma baixa densidade óptica (0,15) em comparação ao controle (0,72) no dia 10. Essa redução da carga bacteriana preservou a condutividade hidráulica do xilema, resultando em melhor balanço hídrico, conforme evidenciado por valores de peso fresco relativo superiores a 100%. Além disso, o tratamento com 175 mg L⁻¹ reduziu significativamente os danos oxidativos, diminuindo o teor de malondialdeído e o extravasamento de eletrólitos. Esse efeito esteve associado ao aumento das defesas antioxidantes, bem como a maiores teores de compostos fenólicos totais e flavonoides (2,6 a 4,7 vezes superiores ao controle). No entanto, concentrações mais elevadas (200–250 mg L⁻¹) resultaram em redução do desempenho fisiológico, indicando um limiar ótimo em 175 mg L⁻¹. De modo geral, o extrato de *Derris elliptica* prolongou a vida de vaso por meio de um mecanismo duplo, envolvendo a supressão microbiana e a regulação do estresse oxidativo.

Palavras-chave: Flores de corte, inibição microbiana, extrato vegetal, fisiologia pós-colheita.

Introduction

Cut flowers represent a high-value segment of ornamental horticulture, but their commercial value is strongly limited by rapid postharvest deterioration. Among them, gerbera is highly susceptible to postharvest losses due to its short vase life, which typically ranges from only a few days under ambient conditions (Oliveira et al., 2024; Salgado et al., 2025). A primary factor responsible for this decline is the rapid blockage of xylem vessels caused by microbial proliferation in vase solutions, leading to reduced hydraulic conductivity, impaired water uptake, and consequent floral wilting (Manzoor et al., 2024).

Microorganisms in vase water originate mainly from stem ends and external contamination, and their rapid multiplication is promoted by the presence of organic substrates such as sugars in commercial holding solutions (Chen et al., 2023). The formation of bacterial aggregates and biofilms further exacerbates vascular occlusion, which is widely recognized as one of the most critical physiological constraints in cut flower longevity (Soliman and El-Sayed, 2023; Chen et al., 2025). In addition to microbial-induced dysfunction, oxidative stress plays a central role in postharvest senescence. The excessive accumulation of reactive

oxygen species (ROS) disrupts membrane integrity, accelerates lipid peroxidation, and triggers programmed senescence pathways, ultimately shortening vase life (Jhanji et al., 2025).

To mitigate these problems, synthetic biocides and preservatives are commonly applied in vase solutions to suppress microbial growth. However, increasing concerns regarding environmental safety, microbial resistance, and consumer preference for eco-friendly products have driven the search for natural alternatives (Salgado et al., 2025). In this context, plant-derived extracts have gained attention due to their multifunctional properties, particularly their ability to combine antimicrobial activity with antioxidant defense modulation (Sahraie et al., 2025).

Derris elliptica is a tropical leguminous species widely recognized for its rich repertoire of secondary metabolites, particularly rotenoids and flavonoids, which exhibit potent antimicrobial and antioxidant properties (Trang et al., 2023). Despite the well-established bioactivity of *D. elliptica*, a comprehensive review of the current literature revealed no prior reports investigating its application as a floral preservative. While its phytochemical profile is distinct, the logic for its use in this study is supported by findings from analogous botanical extracts. Extracts from

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Moringa oleifera (Hassan and Fetouh, 2019) and *Azadirachta indica* (Callejas-Utrera et al., 2025) have been shown to significantly extend the vase life of various cut flowers by inhibiting bacterial biofilms and enhancing the antioxidant defense system.

Therefore, the present study aims to evaluate the efficacy of *Derris elliptica* leaf extract in improving the postharvest performance of gerbera. Specifically, this study focuses on suppression of microbial growth in vase solutions, and modulation of oxidative stress responses, in order to clarify its potential as a natural postharvest preservative for extending vase life.

Materials and Methods

Plant material and treatments

Red cut gerbera ‘Goliath’ flowers were sourced from a commercial greenhouse at the Agricultural Hi-Tech Park, Ho Chi Minh City, Vietnam (10.973° N, 106.458° E), situated at an altitude of approximately 10 m above sea level. Flowers were harvested at 5:00 AM during the spring season (February 2026) at the commercial harvest stage, defined by the

two outermost rows of disc florets being perpendicular to the scape. Uniform flowers were selected based on flower diameter (8.0 ± 0.5 cm) and scape length (50.0 ± 2.0 cm). After harvest, flowers were transported to the laboratory within 2-h under dry, ambient conditions. Upon arrival, stem bases were re-cut under distilled water to prevent xylem embolism and immediately assigned to the experimental treatments.

The powdered leaf material of *Derris elliptica* was extracted using 70% (v/v) ethanol at a solid-to-solvent ratio of 1:25 (w/v). The extraction was performed in an ultrasonic bath (40 kHz) at 50 °C for 3-h to enhance the release of bioactive compounds. After extraction, the mixture was filtered through filter paper to remove plant residues, and the filtrate was concentrated under reduced pressure using a rotary evaporator at an appropriate temperature until ethanol was completely removed. The concentrated extract was then dried to a constant weight and stored at 4 °C in amber bottles until further analysis. Preliminary qualitative phytochemical screening of the extract was conducted according to Gul et al. (2017), and the major classes of secondary metabolites detected are summarized in Table 1.

Table 1. Preliminary qualitative phytochemical screening of the ethanolic leaf extract of *Derris elliptica*

Phytochemical group	Qualitative test	Result
Alkaloids	Dragendorff's test	+
Flavonoids	Alkaline reagent test	+++
Total phenolics	Ferric chloride test	+++
Tannins	Ferric chloride test	++
Saponins	Frothing test	+
Terpenoids	Salkowski test	++
Steroids	Liebermann–Burchard test	+
Glycosides	Keller–Killiani test	+
Coumarins	Fluorescence test	+
Quinones	Bornträger's test	–

Note: (+++) strongly detected; (++) moderately detected; (+) detected; (–) not detected

Ten concentrations of *Derris elliptica* leaf extract were evaluated: 0 (control), 25, 50, 75, 100, 125, 150, 175, 200, and 250 mg L⁻¹. Each stem was placed individually in a graduated cylinder containing 250 mL of the respective treatment solution. The vase solutions were characterized by a pH range of 6.5–7.0 and an electrical conductivity (EC) of 0.5–0.5 mS cm⁻¹. Notably, the solutions were not renewed throughout the entire experimental period; this static immersion approach was specifically designed to evaluate the sustained preservative efficacy and long-term bioactivity of the *Derris elliptica* extract under continuous exposure.

The experimental setup was maintained under strictly controlled environmental conditions at 22 ± 2 °C, 85% relative humidity, and a 12 h photoperiod provided by cool-white fluorescent lamps (photosynthetic photon flux density: 15–20 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Postharvest performance was monitored using both non-destructive and destructive approaches. Non-destructive parameters, including vase life, daily water uptake, and visual quality index, were recorded systematically using the same set of samples. For biochemical characterization, petal and stem tissues were harvested on day 10 of vase life, a sampling interval predetermined as the critical physiological transition stage in preliminary experiments. Samples were immediately flash-frozen in liquid nitrogen and stored at -80 °C until further analysis.

Physiological and biochemical measurements

Water uptake was determined gravimetrically by recording the daily decrease in vase solution volume and expressed as mL day⁻¹ per stem. Relative fresh weight was determined to assess changes in water status during vase life. The initial fresh weight (W_0) of each stem was recorded at the beginning of the experiment, and subsequent fresh weights (W_t) were measured on the 10th day of the vase life, coinciding with the predefined biochemical sampling interval. Relative fresh weight was calculated as $(W_t/W_0) \times 100$ and expressed as a percentage of the initial weight. Membrane integrity was assessed via electrolyte leakage (EL). Leaf

discs were incubated in deionized water at room temperature, and initial electrical conductivity (EC_1) was measured. Samples were then boiled for 20 min to obtain total conductivity (EC_2). Electrolyte leakage was expressed as $EC_1/EC_2 \times 100$. Microbial proliferation in the vase solution was estimated by measuring the optical density at 600 nm (OD_{600}) with a spectrophotometer (Campbell et al., 2010). OD_{600} was used as an indirect indicator of total microbial growth. To reduce potential interference from the intrinsic color of *Derris elliptica* leaf extract, the spectrophotometer was calibrated using the corresponding freshly prepared extract solution as the blank for each treatment. Vase solutions were filtered prior to measurement to remove large suspended particles. Lipid peroxidation was evaluated by quantifying malondialdehyde (MDA) content following the thiobarbituric acid method (Gasparovic et al., 2012). Fresh tissue (0.5 g) was homogenized in 0.1% trichloroacetic acid and centrifuged at $10,000 \times g$ for 15 min. The supernatant was mixed with thiobarbituric acid reagent and heated at 95 °C for 30 min, then rapidly cooled and centrifuged. Absorbance was measured at 532 and 600 nm, and MDA content was calculated and expressed as nmol g⁻¹ fresh weight (FW).

For antioxidant enzyme assays, fresh samples (0.5 g) were homogenized in ice-cold phosphate buffer (50 mM, pH 7.0) and centrifuged at 4 °C (Elavarthi and Martin, 2010). The supernatant was used for enzymatic analyses. Superoxide dismutase (SOD) activity was determined based on its ability to inhibit the photochemical reduction of nitroblue tetrazolium. Catalase (CAT) activity was assayed by monitoring the decomposition of hydrogen peroxide at 240 nm. Peroxidase (POD) activity was measured using guaiacol as a substrate by recording the increase in absorbance at 470 nm. Enzyme activities were expressed as U g⁻¹ FW (U g⁻¹). Total phenolic content (TPC) was determined using the Folin–Ciocalteu method, and results were expressed as mg gallic acid equivalents g⁻¹ FW (mg GAE g⁻¹). Total flavonoid content (TFC) was measured using the aluminum chloride colorimetric method and expressed as mg quercetin equivalents g⁻¹ FW (mg QE g⁻¹) (Thang and Linh., 2023).

Statistical analysis

The study was conducted using a completely randomized design with three biological replicates per treatment, each replicate consisting of five flowers. Data were processed using Jamovi software (version 2.7) and expressed as mean $\pm$ standard deviation based on three replicates. Statistical differences among treatments were evaluated by one-way analysis of variance, and mean comparisons were performed using Tukey's test at a significance level of $p < 0.05$.

Results

Effects of *Derris elliptica* extract on vase life, water relations and microbial growth

The application of *Derris elliptica* leaf extract significantly influenced the vase life and physiological parameters of cut gerbera flowers (Table 2). The vase life increased progressively with increasing extract concentrations, reaching a peak of 13.57 days at 175 mg L⁻¹, which represented a nearly twofold increase compared to the control (6.93 days). Concentrations of 125 and 175 mg L⁻¹ also resulted in significantly extended vase life (12.58 and 13.42 days, respectively) compared to the control and lower-dose treatments ($p < 0.05$). However, a relative decline in longevity was observed at higher concentrations of 200 and 250 mg L⁻¹ (11.34 and 11.26 days) compared to the 175 mg L⁻¹ optimum. At day 10, water relations followed a similar dose-dependent trend. Water uptake in the control group dropped to 0.38 mL day⁻¹,

while the 175 mg L⁻¹ treatment maintained the highest uptake rate at 3.52 mL day⁻¹. Correspondingly, the relative fresh weight at day 10 was lowest in the control (62.41%) and highest in the 175 mg L⁻¹ treatment (106.85%). Notably, treatments ranging from 125 to 175 mg L⁻¹ were able to maintain relative fresh weight values above 100% at the 10-day mark, whereas flowers treated with 0–100 mg L⁻¹ fell significantly below their initial fresh weight.

The bacterial density in the vase solution, measured as OD600 at day 10, showed a strong inverse correlation with the concentration of *Derris elliptica* extract (Table 2). The control solution exhibited the highest microbial turbidity (OD600 = 0.72). In contrast, the addition of the extract significantly suppressed bacterial proliferation. The OD600 values decreased sharply as the concentration rose, reaching the lowest levels in the 175–250 mg L⁻¹ treatments (0.15 and 0.13, respectively).

The visual appearance of the flowers after 10 days of vase life corroborated the quantitative data (Fig. 1). Control flowers and those treated with 25–50 mg L⁻¹ showed advanced symptoms of senescence, characterized by severe petal wilting, shriveling, and loss of structural integrity. In contrast, flowers receiving 125–175 mg L⁻¹ maintained superior aesthetic quality with fully expanded, vibrant ray florets and firm, upright stems. At the highest concentrations (200–250 mg L⁻¹), although the flowers remained upright, slight curling of the petal margins and minor discoloration were observed in comparison to the 150 mg L⁻¹ treatment group.

Table 2. Effects of *Derris elliptica* leaf extract on vase life, water relations and microbial growth in cut gerbera at day 10

Treatment (mg L ⁻¹)	Vase life (days)	Water uptake (mL day ⁻¹)	Relative fresh weight (%)	OD600
Control	6.93 $\pm$ 0.35 d	0.38 $\pm$ 0.16 e	62.41 $\pm$ 4.25 e	0.72 $\pm$ 0.05 a
25	7.87 $\pm$ 0.42 d	0.42 $\pm$ 0.22 e	72.85 $\pm$ 3.12 d	0.69 $\pm$ 0.04 a
50	8.31 $\pm$ 0.38 d	0.85 $\pm$ 0.18 d	76.56 $\pm$ 2.95 d	0.52 $\pm$ 0.03 b
75	9.63 $\pm$ 0.15 c	1.34 $\pm$ 0.25 c	83.26 $\pm$ 3.48 c	0.43 $\pm$ 0.04 c
100	10.25 $\pm$ 0.41 bc	1.95 $\pm$ 0.38 b	90.87 $\pm$ 4.15 bc	0.29 $\pm$ 0.04 d
125	12.58 $\pm$ 0.79 ab	2.85 $\pm$ 0.45 ab	103.42 $\pm$ 3.68 a	0.21 $\pm$ 0.03 e
150	13.42 $\pm$ 0.47 a	3.12 $\pm$ 0.22 a	104.51 $\pm$ 4.22 a	0.19 $\pm$ 0.02 e
175	13.57 $\pm$ 0.34 a	3.52 $\pm$ 0.35 a	106.85 $\pm$ 3.85 a	0.15 $\pm$ 0.02 f
200	11.34 $\pm$ 0.61 b	2.35 $\pm$ 0.31 b	95.86 $\pm$ 3.24 b	0.13 $\pm$ 0.02 f
250	11.26 $\pm$ 0.48 b	2.05 $\pm$ 0.28 b	96.67 $\pm$ 2.92 b	0.13 $\pm$ 0.01 f

Means labeled with the same letter in the column are not significantly different at the 5% level

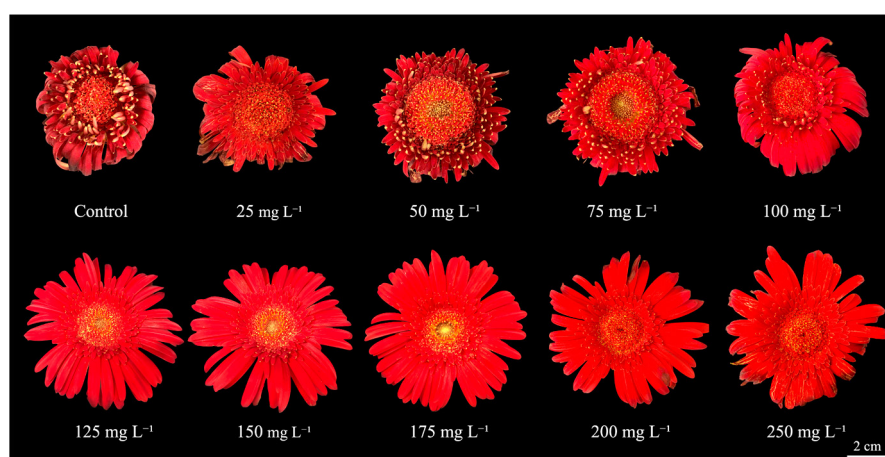


Fig. 1. Effects of *Derris elliptica* leaf extract on the visual quality of cut gerbera after 10 days of vase life under different concentrations.

To further characterize the dose-dependent response of cut gerbera flowers to *Derris elliptica* leaf extract, a quadratic regression analysis was performed between extract concentration and vase life (Fig. 2). The fitted model was highly significant ($F_{2,7} = 21.2$, $p = 0.001$), explaining 85.8% of the total variation in vase life ($R^2 = 0.858$; adjusted $R^2 = 0.818$). Residual diagnostics indicated that the assumptions of the regression model were satisfied, with normally distributed residuals (Shapiro-Wilk test, $p = 0.120$)

and no significant autocorrelation (Durbin-Watson = 1.41, $p = 0.076$). The fitted equation, $Y = 6.155 + 0.0704X - 1.96 \times 10^{-4}X^2$, where Y is vase life (days) and X is the extract concentration (mg L⁻¹), revealed significant positive linear ($p = 0.002$) and negative quadratic ($p = 0.010$) effects. These results indicate that vase life increased progressively with increasing extract concentration until reaching an optimum, after which it declined slightly at higher concentrations. Based on the fitted model, the optimum extract

concentration was predicted to be approximately 180 mg L⁻¹, corresponding to a maximum predicted vase life of 12.47 days. This predicted optimum closely agreed with the experimental observation, where the longest vase

life (13.57 ± 0.34 days) was obtained at 175 mg L⁻¹, confirming that *Derris elliptica* leaf extract exhibits a concentration-dependent preservative effect with an optimal application range between 175 and 180 mg L⁻¹.

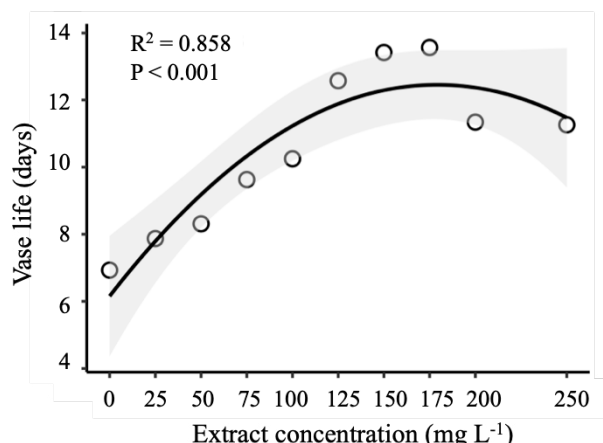


Fig. 2. Quadratic regression illustrating the relationship between *Derris elliptica* leaf extract concentration and the vase life of cut gerbera flowers. The shaded area represents the 95% confidence interval of the fitted regression model ($R^2 = 0.858$, $p < 0.001$).

Effects of *Derris elliptica* extract on membrane damage and lipid peroxidation

The physiological damage to gerbera tissues was assessed by measuring MDA content and electrolyte leakage at day 10 (Table 3). In both petal and stem tissues, a clear dose-dependent reduction in membrane damage was observed as the *Derris elliptica* extract concentration increased up to 175 mg L⁻¹. In petal tissues, the control group exhibited the highest levels of MDA (61.42 nmol g⁻¹ FW) and EL (75.84%), indicating severe membrane degradation at the end of its vase life. The application of 175 mg

L⁻¹ extract effectively mitigated this damage, reducing MDA and EL values by 65.6% and 64.2%, respectively, compared to the control. A similar trend was recorded in stem tissues, where the 175 mg L⁻¹ treatment maintained the lowest membrane permeability (24.32% EL) and lipid peroxidation (18.24 nmol g⁻¹ FW), significantly outperforming the control and lower-dose treatments ($p < 0.05$). However, increasing the extract concentration beyond the optimal level (200–250 mg L⁻¹) led to a notable resurgence in membrane damage markers. In petals, the MDA content rose from 21.12 nmol g⁻¹ FW (at 175 mg L⁻¹) to 36.42 nmol g⁻¹ FW (at 250 mg L⁻¹).

Table 3. Effects of *Derris elliptica* leaf extract on membrane integrity of gerbera at day 10

Treatment (mg L ⁻¹)	Petal Tissues		Stem Tissues	
	Malondialdehyde (nmol g ⁻¹ FW)	Electrolyte leakage (%)	Malondialdehyde (nmol g ⁻¹ FW)	Electrolyte leakage (%)
Control	61.42 ± 3.85 a	75.84 ± 4.12 a	54.26 ± 3.15 a	68.42 ± 3.55 a
25	55.18 ± 2.92 b	68.25 ± 3.85 b	48.55 ± 2.84 b	61.15 ± 3.12 b
50	48.64 ± 3.12 c	62.14 ± 3.42 c	42.18 ± 2.65 c	54.36 ± 2.85 c
75	40.25 ± 2.55 d	54.36 ± 3.15 d	36.42 ± 2.12 d	46.18 ± 2.64 d
100	33.15 ± 2.18 e	45.82 ± 2.85 e	28.56 ± 1.95 e	38.52 ± 2.15 e
125	26.42 ± 1.95 f	36.15 ± 2.24 f	22.14 ± 1.45 f	30.25 ± 1.95 f
150	22.85 ± 1.64 fg	29.42 ± 1.85 g	19.35 ± 1.25 g	26.54 ± 1.64 g
175	21.12 ± 1.52 g	27.15 ± 1.92 g	18.24 ± 1.18 g	24.32 ± 1.55 g
200	29.56 ± 2.12 ef	38.64 ± 2.34 f	25.18 ± 1.84 f	32.18 ± 2.12 f
250	36.42 ± 2.48 de	48.72 ± 2.85 d	32.45 ± 2.25 d	42.56 ± 2.45 d

Means labeled with the same letter in the column are not significantly different at the 5% level

Effects of *Derris elliptica* extract on antioxidant enzyme activities and secondary metabolite content

At day 10, *Derris elliptica* extract significantly upregulated antioxidant enzyme activities (SOD, CAT, POD) and secondary metabolite accumulation (TPC, TFC) in both petals and stems (Table 4 and 5). Across all treatments, petal tissues consistently exhibited higher levels of these parameters compared to stems. All measured indicators followed a similar dose-dependent trend, peaking at the 175 mg L⁻¹ concentration. In petals, peak SOD, CAT, and POD activities reached 345.8, 238.4, and 152.2 U g⁻¹ FW, respectively,

representing a 2.6 to 3.5-fold increase over the control. Similarly, TPC and TFC in petals were maximized at 10.12 mg GAE g⁻¹ FW and 3.84 mg QE g⁻¹ FW, respectively. Stem tissues mirrored this trend, with maximum enzyme and metabolite levels recorded at 175 mg L⁻¹ (e.g., TPC at 8.62 mg GAE g⁻¹ FW and TFC at 2.75 mg QE g⁻¹ FW), significantly outperforming the control ($p < 0.05$). However, a marked decline in both enzymatic performance and bioactive compound content was observed at supra-optimal concentrations (200–250 mg L⁻¹) relative to the 175 mg L⁻¹ group, although these values remained significantly higher than those of the control.

Table 4. Effects of *Derris elliptica* leaf on antioxidant enzyme activities of gerbera at day 10

Treatment (mg L ⁻¹)	Petal Tissues			Stem Tissues		
	SOD (U g ⁻¹)	CAT (U g ⁻¹)	POD (U g ⁻¹)	SOD (U g ⁻¹)	CAT (U g ⁻¹)	POD (U g ⁻¹)
Control	132.4 h	68.5 g	45.2 g	112.5 g	52.4 f	38.6 f
25	154.6 g	82.4 f	58.6 f	128.4 f	64.8 e	48.2 e
50	178.5 f	96.7 e	72.4 e	145.8 e	78.5 d	62.4 d
75	210.2 e	124.5 d	86.8 d	172.6 d	102.4 c	75.8 c
100	242.8 d	158.2 c	102.5 c	198.4 c	128.6 b	88.5 b
125	275.4 c	186.4 b	118.4 b	234.2 b	154.2 a	104.2 a
150	312.5 ab	215.6 a	135.8 a	268.5 a	182.5 a	122.4 a
175	345.8 a	238.4 a	152.2 a	295.4 a	208.6 a	138.5 a
200	284.2 b	185.8 b	115.6 b	242.8 b	145.8 b	95.4 b
250	242.6 d	152.5 c	92.5 c	208.4 c	122.4 c	80.6 c

Means labeled with the same letter in the column are not significantly different at the 5% level

Table 5. Effects of *Derris elliptica* leaf extract on TPC and TFC of gerbera at day 10

Treatment (mg L ⁻¹)	Petal Tissues		Stem Tissues	
	Total phenolic (mg GAE g ⁻¹)	Total flavonoid (mg QE g ⁻¹)	Total phenolic (mg GAE g ⁻¹)	Total flavonoid (mg QE g ⁻¹)
Control	3.12 ± 0.25 g	0.82 ± 0.06 f	2.54 ± 0.18 f	0.48 ± 0.04 f
25	3.85 ± 0.31 fg	1.15 ± 0.09 ef	3.12 ± 0.22 ef	0.65 ± 0.05 ef
50	4.42 ± 0.28 f	1.48 ± 0.12 e	3.68 ± 0.25 e	0.82 ± 0.07 e
75	5.26 ± 0.42 e	1.92 ± 0.15 d	4.45 ± 0.31 d	1.12 ± 0.09 d
100	6.58 ± 0.35 d	2.34 ± 0.18 c	5.62 ± 0.38 c	1.45 ± 0.12 c
125	7.92 ± 0.54 c	2.85 ± 0.22 b	6.84 ± 0.45 b	1.94 ± 0.15 b
150	9.15 ± 0.48 ab	3.25 ± 0.25 ab	7.95 ± 0.52 ab	2.32 ± 0.18 ab
175	10.12 ± 0.62 a	3.84 ± 0.28 a	8.62 ± 0.58 a	2.75 ± 0.22 a
200	8.24 ± 0.51 bc	2.92 ± 0.21 b	6.92 ± 0.42 b	2.12 ± 0.16 b
250	7.15 ± 0.45 d	2.45 ± 0.18 c	5.85 ± 0.35 c	1.68 ± 0.14 c

Means labeled with the same letter in the column are not significantly different at the 5% level

Discussion

The significant extension of vase life in gerbera observed in this study highlights the strong potential of *Derris elliptica* leaf extract as a multifunctional, plant-based biopreservative. Unlike conventional synthetic preservatives such as silver nitrate, which act primarily through broad-spectrum antimicrobial activity but raise concerns regarding environmental persistence and heavy metal accumulation, the botanical extract demonstrated a dual-functional mode of action that integrates microbial suppression with the regulation of postharvest physiological stability (Nxumalo et al., 2021; Kumar et al., 2024; Bhattacharya et al., 2025). A central mechanism underlying this effect appears to be the preservation of xylem hydraulic conductivity. In cut gerbera stems, vascular blockage caused by microbial proliferation and biofilm formation is a primary trigger of the bent neck disorder, leading to impaired water uptake and rapid wilting (Le and Pham, 2025). The presence of rotenoids and flavonoids in *D. elliptica* extract likely disrupts bacterial cell integrity and interferes with quorum sensing pathways, thereby limiting biofilm development within xylem vessels (Trang et al., 2022; Ferrati et al., 2023). This microbial control maintains functional water transport, as reflected in improved water uptake and sustained water balance, ultimately delaying turgor loss and visible senescence symptoms. The superior performance of *D. elliptica* compared to control treatments aligns with the growing body of evidence regarding plant-derived secondary metabolites, such as those found in tea tree oil, pumpkin seed oil, moringa seed essential oils, and eucalyptus oils, which have demonstrated similar capacities to delay senescence in ornamental species by balancing water relations and metabolic stability (Soliman and El-Sayed, 2023).

Beyond external vascular protection, the extract also exerts a significant influence on internal oxidative metabolism. Postharvest senescence is typically associated with an overproduction of ROS, which accelerates lipid peroxidation and membrane destabilization (Ziogas and Corpas, 2023). The observed reductions in MDA content and electrolyte leakage suggest that *D. elliptica* not only acts as an antimicrobial agent but also enhances cellular redox stability (Table 3). Polyphenolic constituents may function as direct ROS scavengers, while also acting as signaling molecules that upregulate endogenous antioxidant enzymes, including SOD, CAT, and POD (Altyar et al., 2026). This enzymatic reinforcement indicates a priming-like effect similar to that induced by known senescence-delaying regulators such as salicylic acid and melatonin (Abd et al., 2026). Importantly, these two mechanisms, vascular protection and oxidative stress mitigation, appear to be functionally interconnected. By maintaining continuous water uptake, the extract indirectly reduces dehydration-induced ROS accumulation, while enhanced antioxidant capacity further stabilizes cellular membranes, creating a feedback loop that collectively delays senescence progression (Manzoor et al., 2024). This integrated response supports the interpretation of *D. elliptica* extract as a coordinated physiological regulator rather than a single-target preservative. From an environmental perspective, the use of rotenone-containing extracts warrants careful consideration. Although rotenone is toxic to aquatic organisms at high concentrations, it is also readily biodegradable, undergoing rapid degradation under light and oxidative conditions within days (Cavoski et al., 2007; Redman et al., 2021). At the relatively low concentrations applied in this study, the environmental burden is expected to be minimal, particularly when compared with persistent heavy-metal-

based preservatives such as AgNO₃ or nano-silver formulations, which accumulate in soil and aquatic systems (Krishnamoorthi et al., 2025). The observed U-shaped dose response further emphasizes the importance of concentration optimization. While intermediate concentrations (175 mg L⁻¹) maximized vase life extension, higher doses (200–250 mg L⁻¹) induced physiological stress, as evidenced by reduced antioxidant enzyme activity and increased membrane damage. This hormetic response suggests that excessive levels of bioactive rotenoids may shift from regulatory to phytotoxic effects, disrupting cellular homeostasis. Similar biphasic responses have been reported for essential oil-based preservatives, where optimal doses enhance postharvest performance, whereas supra-optimal levels impair metabolic stability (Soliman and El-Sayed, 2023).

Conclusion

Derris elliptica leaf extract at an optimal concentration of 175 mg L⁻¹ significantly extends the vase life of cut gerberas to 13.57 days, nearly doubling that of the control. This effect is achieved through a dual mechanism: potent suppression of microbial proliferation to maintain vascular conductivity and modulation of the antioxidant defense system. By effectively mitigating oxidative stress and membrane damage, this botanical extract offers a sustainable and eco-friendly alternative to synthetic postharvest preservatives in the ornamental industry.

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Author Contribution

TTT: Conceptualization, Formal Analysis, Methodology, Visualization, Writing – Review & Editing. **TXHV:** Methodology, Supervision, Validation. **HPN:** Investigation, Methodology. **TTTL:** Conceptualization, Data Curation, Methodology, Project Administration, Supervision, Validation, Writing – Original Draft, Writing – Review & Editing.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

Data will be made available upon request to the authors.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that the use of AI and AI-assisted technologies was not applied in the writing process.

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