Phytochemical Characterization of *Cleome droserifolia* Biomass and its Application as *in vitro* Antioxidant, Anti-Inflammatory, Anti-Diabetic, and Anti-Yeast Agents

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This study investigated the anti-inflammatory, anti-diabetic, anti-yeast, and antioxidant properties of the ethanolic extract of *Cleome droserifolia* shoot (CDE). Thirteen phenolic compounds were shown in the CDE ethanolic extract using high-performance liquid chromatography (HPLC), with rutin and syringic acid being the predominant components. Rutin and syringic acid were found at elevated levels of 15,900 and 5320 µg//g of extract, respectively, in association with CDE. Additionally, gallic acid, chlorogenic acid, ellagic acid, and vanillin were quantified at 1150, 987, 2830, and 1425 µg/g of extract, respectively. The ethanolic extract of CDE exhibited detrimental impacts on the species of pathogenic yeast. The CDE demonstrated scavenging activity for 2,2-diphenyl-1-picrylhydrazyl to visualize an antioxidant action with IC_{50} 8.95±1.023 µg/mL. CDE inhibited COX-1 and COX-2 to document its anti-inflammatory potential with IC_{50} 12.91±0.5a µg/mL and 21.63±0.8 µg/mL, respectively. CDE inhibited amylase activity as a marker of diabetic management with $IC_{50\ of}$ 14.93±1.87µg/mL. The pathogenic yeasts including *C. albicans, C. tropicalis,* and *C. glabrata* were suppressed by CDE with inhibition zones 25±0.2, 20±0.1, and 25±0.1 mm, respectively. The findings suggest the utilization of CDE for the management of numerous health issues.

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INTRODUCTION

The health of humans and animals can be enhanced by using nutraceuticals (food supplements) and medicinal plants as an alternative form of therapeutic medications (Alawlaqi *et al*. 2023; Al-Rajhi *et al*. 2025). In recent decades, there has been increased interest in looking at plants as potential sources of various medications, particularly antimicrobials, to combat bacteria that are resistant to numerous therapies (Hashem *et al* 2019; Almehayawi *et al*. 2024; Qanash *et al*. 2024). *Cleome* is one of the largest genera in the medicinal plant family Cleomaceae. Approximately 180 to 200 species of this genus

can be found in arid and semi-arid regions like Egypt, Libya, Palestine, and Syria (Moustafa and Mahmoud 2023). They feature complexly branching stems, three-nerved leaves with enlarged glandular hairs, and are low, fragrant perennial shrubs that range in length from 25 to 60 cm. They also resemble cushions (El-Askary *et al*. 2019). Its remarkable array of naturally occurring phenolic compounds appears to be responsible for the strong antioxidant, antibacterial, and immunomodulatory properties of the aerial parts of the *Cleome droserifolia* shrub, which can enhance general health (Hashem and Shehata 2021). A substance known as 3-ethylsulfonyl-2,3-dimethoxypropyl was successfully isolated and identified from the methanolic extract of *Cleome africana*. Molecular docking studies indicate that this molecule exhibits promising activity and may serve as an effective antidiabetic agent by inhibiting glucosidase. Several extracts demonstrated hepato-protective and anti-inflammatory actions (Abdullah *et al*. 2021). Due to its antioxidative potential and antidiabetic properties, it can be concluded that *C. droserifolia* extract medication possesses a therapeutic protective role in diabetes by mitigating oxidative stress and damage to pancreatic β-cells (Helal *et al.* 2015). *C. droserifolia*, containing bioactive compounds, serves as a significant therapeutic plant capable of inducing apoptosis in human cancer cells (Panicker *et al.* 2020). This study focused on assessing the activity of *C. droserifolia* shoot extract against different species of pathogenic yeast, as well as the vital role of this extract versus COX-1 and COX-2 inhibitors. Also, the antioxidant and anti-amylase action of this extract was studied.

EXPERIMENTAL

Collecting and Preparing of *Cleome droserifolia* Shoot Extract (CDE)

In November 2023, *C. droserifolia* were collected from Saint Katrine in the South Sinai Governorate of Egypt. The plant shoots were cleaned under tap water, allowed to air dry at room temperature in the shade, and then ground into a finer consistency. For 72 h at 22 °C, a sealed bottle containing 25 g of pulverized *C. droserifolia* extract (CDE) was submerged in 0.25 L of 100% ethanol. After that, the extract was sonicated at 50 °C for 50 minutes. After filtration to create the crude CDE, the extracted materials were vacuum-concentrated in a rotary evaporator at 45 °C (Khowdiary *et al.* 2024).

HPLC Conditions

The phenolic and flavonoid profile was assessed by high-performance liquid chromatography using an Agilent 1260 series equipment. The separation process made use of a Zorbax Eclipse Plus C8 column that measured 4.6 mm by 250 mm i.d., and had a particle size of 5 µm. 0.9 mL/min of water (A) and 0.05% trifluoroacetic acid in acetonitrile (B) made up the mobile phase. The following describes the sequential programming of the mobile phase in an even gradient: 82% A for 0 min; 82% A for 0 to 1 minute; 75% A for 1 to 11 min; 60% A for 11 to 18 minutes; 82% A for 18 to 22 min; and 82% A for 22 to 24 min. At 280 nm, the multi-wavelength detector showed observation. Each specimen had an injection volume of 5 µL. The temperature of the column was maintained at 40 °C.

Antioxidant Activity

CDE's capacity to scavenge DPPH was evaluated. Different double-fold dosages of the compounds under investigation, varying at different concentrations (1.95, 3.90, 7.81, 15.63, 31.25, 62.50, 125, 250, 500, and 1000 µg/mL), were combined with high-purity H_2O (Milli Q H_2O) while the DPPH was dissolution in methanol. In a test tube, 450 µL of Tris-HCl buffer (pH = 7.4), 1.0 mL of each concentration, and 1.0 mL of DPPH were mixed. After thoroughly mixing the contents of each tube, they were shaken (150 rpm) for 30 min at 37 °C in a dark environment. A test tube with all components except the tested compounds (ascorbic acid or extract) served as the negative control, while ascorbic acid served as the positive control at the same concentrations (Selim *et al.* 2025b). The scavenging activity was measured spectrophotometrically at 517 nm, and the percentage was computed as follows.

$$\text{Scavenging percentages} = \frac{\text{Control absorbance} - \text{treatment absorbance}}{\text{Control absorbance}} \text{ x } 100 \quad (1)$$

The IC_{50} value (the concentration of extract required to inhibit 50% of DPPH radicals) was determined from a dose–response curve plotted using the inhibition percentages.

In vitro COX-1 and COX-1 Inhibition Assay

Catalog number k548, Biovision, USA Kits were utilized to assess the test extract's *in vitro* capacity for inhibiting COX-1 isoenzymes according to the manufacturer's instructions. In an overall amount of 1 mL of the test, CDE were submerged in DMSO 1.0% and analyzed at doses ranging from 1000 to 0.5 µg/mL. Catalog number k547, Biovision, USA, kits were used to assess the efficiency of the extract to block the COX-2 isoenzyme. A final amount of 1 mL of the CDE was dissolved in DMSO 1.0% and analyzed at concentrations ranging from 1000 to 0.5 µg/mL. For the COX-1 and COX-2 inhibition test, celecoxib served as a positive control. The specimens were examined in duplicate at twelve distinct concentrations. Using GraphPad PRISM, a dose of the test CDE 50% inhibition (IC50) of COX-1 and COX-2 was determined from the concentration response curve (Selim *et al.* 2025a). The IC_{50} values (concentration causing 50% inhibition) for COX-1 and COX-2 were calculated from the dose–response curves.

α-Amylase Inhibition Activity

Extract and acarbose, which had been prepared in various test tubes with 0.02 M phosphate buffer (pH=6.9), 500 µL of α-amylase (from *Bacillus subtilis,* Sigma-Aldrich, USA) was added, and the test components had been incubated for 10 min at 37 °C at various amounts (1000 to 1.95 µg/mL). After that, every tube received 500 µL of 1% a solution of starch, which was allowed to incubate for 10 min. To halt the reaction, 1 mL of 3,5-dinitrosalicylic acid was then added to each tube. The tubes were then incubated for 15 min at 60 °C in a water bath before being cooled and finished with 10 mL of dH_2O (Amin *et al*. 2025). The development color was measured at 540 nm, which indicates α-amylase % as follows,

$$\text{Inhibition percentages} = \frac{Ac - At}{Ac} \; x \; 100 \quad (2)$$

where Ac and At are the control and treatment absorbance, respectively.

The half-maximal inhibitory concentration (IC_{50}) of the extract was calculated based on dose-dependent inhibition. The IC_{50} value, defined as the concentration of extract required to inhibit 50% of α-amylase activity, was determined using nonlinear regression analysis.

Anti-Yeast Activity

A well-plate agar diffusion experiment was used for assessing CDE's yeast suppression versus three distinct kinds of *Candida*: *C. glabrata* (RCMB 027016), *C. albicans* (ATCC 10231), and *C. tropicalis* (ATCC 10243). *Candida* strains were collected from the culture collection of the microbiological lab at the Faculty of Science, Al-Azhar University, Egypt. Uncontaminated, melted Sabouraud dextrose medium was used to plant the plates containing yeasts. A sterilized cork borer was used to eliminate cups (6 mm radius) of the agar layer once the mixture had hardened. 100 µL from every CDE (20 µg/mL) was added to each cup using an automated microliter pipette. At 27 °C, the inoculation plates was incubated for 48 h. Fluconazole-containing wells were the control. After the incubation period, the inhibition zones were assessed (Abdelghany *et al.* 2021).

Minimum Concentration of CDE for Yeast Inhibition and as a Fungicidal Agent

The minimal inhibitory concentration (MIC) and minimal fungicidal concentration (MFC) were determined using the twofold broth dilution method, as described by French (2006), with slight modifications. Sabouraud dextrose broth (SDB) was used as the culture medium. The extract was serially twofold diluted in SDB, starting from 125 µg/mL in a final volume of 2 mL. A negative control tube containing only sterile broth without extract was included. Yeast inocula were prepared by suspending 18-hour-old cultures in sterile saline and adjusting the turbidity to match the 0.5 McFarland standard (~1×10^6 CFU/mL), using a densitometer. Each tube was inoculated with 0.5 mL of the standardized yeast suspension and mixed thoroughly. Tubes were incubated at 35 °C for 24 h. The MIC was defined as the lowest extract concentration with no visible turbidity (growth) observed by the unaided eye. To determine the MFC, 100 µL from tubes showing no visible growth were spread onto Sabouraud dextrose agar (SDA) plates and incubated at 35 °C for another 24 h. The MFC was the lowest concentration showing no colony growth.

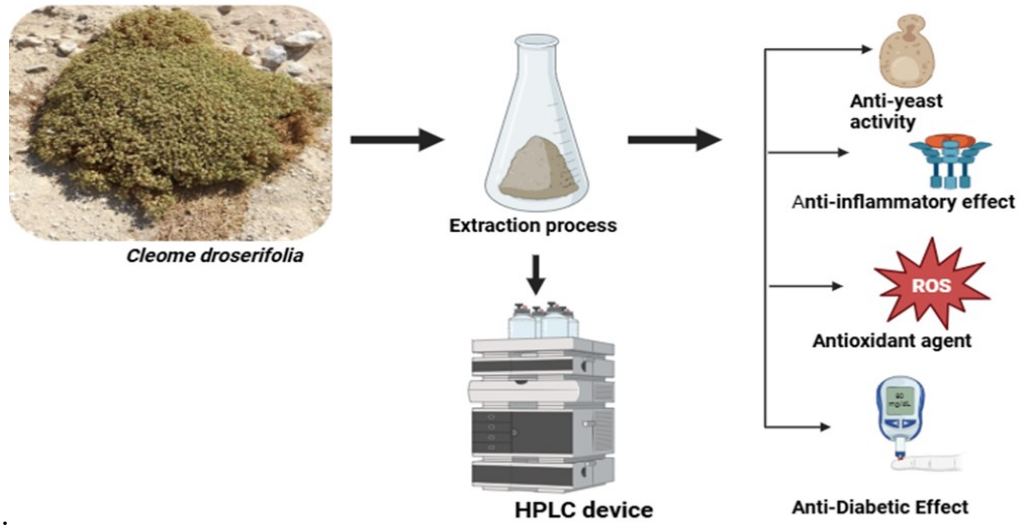

Fig. 1. Biological functions and extraction of *C. droserifolia*

Statistical Analysis

Results were analyzed using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). To calculate the ± standard deviation (SD) and mean values, tests were repeated three times.

RESULTS AND DISCUSSION

Assessment of Phenolic and Flavonoid Compounds of *Cleome droserifolia* Shoot Extract (CDE) by HPLC

The *Cleome droserifolia* shoot was extracted with ethanol, and HPLC was used to track the phytoconstituents, antioxidants, anti-yeast, anti-inflammatory, and anti-diabetic properties (Fig. 1). The wide range of secondary compounds present in plants of the *Cleome* genus is linked to the biological consequences. Shrubs belonging to the *Cleome* species have yielded a variety of flavonoids, alkaloids, and polyphenols (Moustafa and Mahmoud 2023). The examination of phenols and flavonoids in the shoot extract of *Cleome droserifolia* (CDE) is shown in Table 1 and the HPLC chromatogram (Fig. 2). Elevated levels of rutin and syringic acid (15854.59 and 5319.18 µg/g, respectively) were linked to CDE. There are numerous medicinal uses for syringic acid (SA), including the prevention of diabetes, cancer, and cerebral ischemia. It also has antioxidant, antibacterial, and anti-inflammatory properties. It reduces oxidative stress indicators and is an efficient free radical scavenger. Methoxy groups attached to the aromatic ring at positions 3 and 5 are responsible for SA's medicinal properties. SA's potent antioxidant activity might be the source of its positive health effects (Srinivasulu *et al.* 2018).

Also, gallic acid, chlorogenic acid, ellagic acid, and vanillin were identified at quantities of 1150, 987, 2830, and 1420 µg/g, respectively. Conversely, a minimal concentration of coumaric acid (19.4 µg/g), succeeded by rosmarinic acid (21.0 µg/g), methyl gallate (22.1 µg/g), and ferulic acid (125 µg/g) was identified in CDE. Other chemicals were observed in moderate concentrations, such as caffeic acid, catechin, and naringenin (Table 1).

Table 1. HPLC Analysis of *Cleome droserifolia* Shoot Extract (which Area [mAU*s]: milli-absorbance unit and RT: retention time)

Detected Constituent	RT	Area (mAU*s)	Area (%)	Conc. (µg/g)
Gallic acid	3.540	314.34	5.07	1150.76
Chlorogenic acid	4.181	141.73	2.28	987.47
Catechin	4.445	43.55	0.70	467.80
Methyl gallate	5.425	7.89	0.12	22.09
Caffeic acid	5.694	79.04	1.27	202.75
Syringic acid	6.379	1808.65	29.19	5319.18
Rutin	6.784	2118.28	34.18	15854.59
Ellagic acid	7.432	557.49	8.99	2831.70
Coumaric acid	8.510	10.77	0.17	19.36
Vanillin	8.841	785.53	12.67	1424.53
Ferulic acid	9.690	43.24	0.69	125.49
Naringenin	10.542	84.36	1.36	389.28
Rosmarinic acid	11.608	4.32	0.06	20.99
Daidzein	16.141	44.21	0.71	126.56
Quercetin	17.038	60.27	0.97	375.34
Cinnamic acid	18.962	23.06	0.37	22.34
Kaempferol	20.787	7.93	0.12	9.97
Hesperetin	21.035	61.16	0.98	143.18

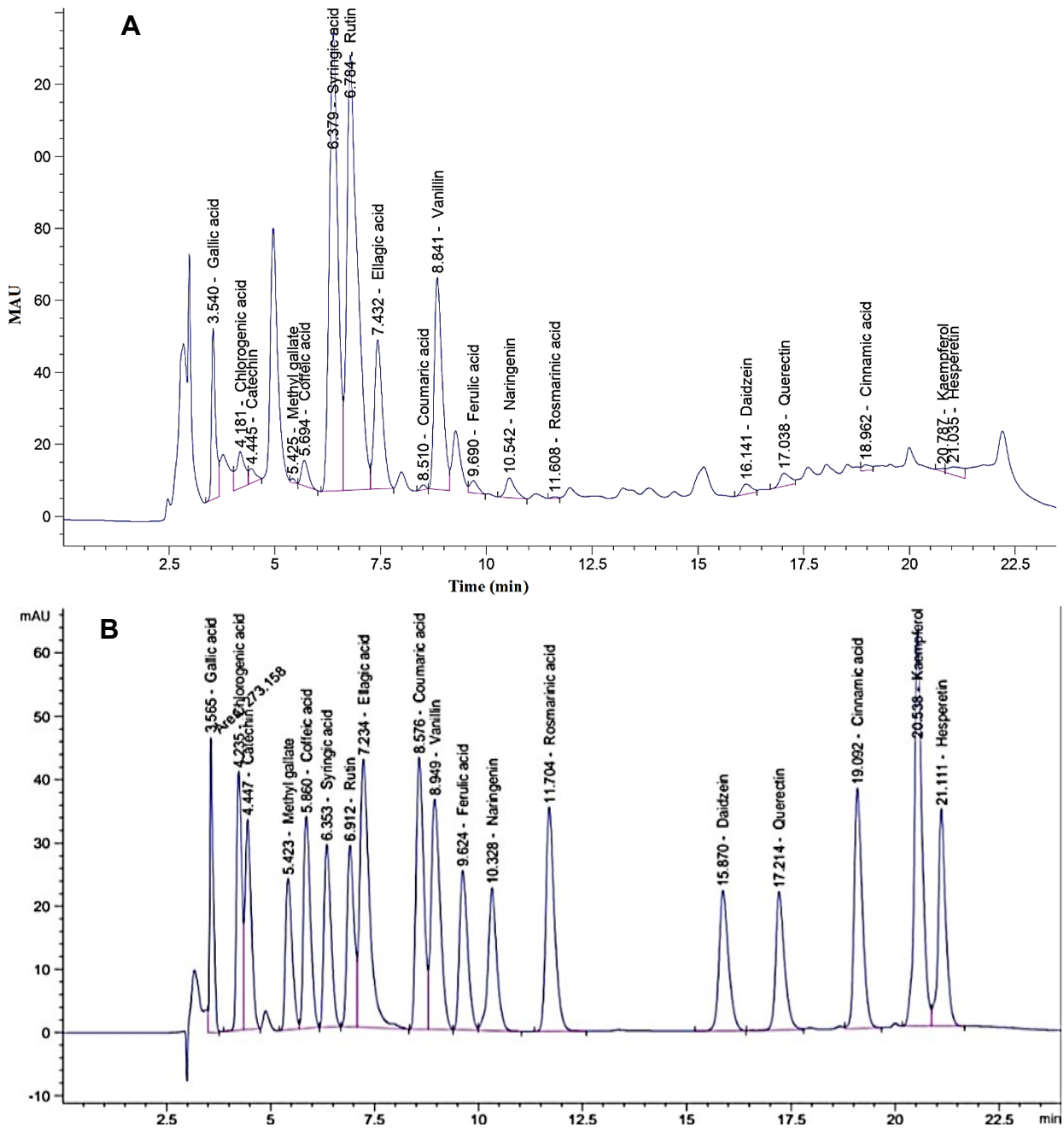

Fig. 2. HPLC diagram for detection of phenolic compounds in *Cleome droserifolia* shoot extract (A) and HPLC chromatograms of the standard for the phenolic and flavonoids compounds (B)

Gallic acid has been shown to have a number of positive effects, such as anti-inflammatory, antioxidant, and anti-cancer effects. It has been reported that this chemical has therapeutic properties for metabolic and cardiovascular diseases (Kahkeshani *et al*. 2019). Also, chlorogenic acid has many benefits, including anti-oxidant, anti-bacterial, anti-tumor, lipid and glucose metabolism management, anti-inflammatory, nervous system protection, and blood vessel activity.

Phenolic and flavonoid components in *C. droserifolia* extract play a crucial role in

its medicinal effects. These chemicals enhance their antibacterial, anti-inflammatory, and antioxidant properties (Joshi *et al.* 2023, Amin *et al*. 2024, and Khowdiary *et al*. 2024). The principal constituents in the methanolic extract of *C. droserifolia* shoot extract are benzoic acid, rutin, ellagic acid, naringenin, and o-coumaric acid (Hashem and Shehata 2021). Figure 2B shows an HPLC chromatogram of the standard for the phenolic and flavonoids compounds.

Antioxidant Activity of CDE

Many therapeutic chemicals that can be used safely to treat a variety of human and animal ailments can be found naturally in medicinal plants (Abdel Ghany and Hakamy 2014; Abdelghany *et al*. 2019; Al-Rajhi *et al*. 2023). Clarifying plants as a significant source of many medications has received more attention in recent decades (Bakri *et al*. 2024; Bazaid *et al*. 2025). CDE exhibited antioxidant activity, which increased with its concentration increase from 1.95 to 1000 µg/mL. Compared with the standard ascorbic acid, the DPPH scavenging % by CDE differed significantly at concentrations from 1.95 to 250 µg/mL, while the difference was not significant at 500 and 1000 µg/mL. The obtained IC_{50} dose of CDE (8.95±1.023 µg/mL) indicated its potential as an antioxidant agent if compared with the ascorbic acid IC_{50} dose (3.07±1.08 µg/mL) (Table 2). In another investigation, the IC_{50} methanolic CDE was 470.27 ± 2.24 µg/mL compared to IC_{50} 14.03 ± 0.67 µg/mL of ascorbic acid, respectively, *via* DPPH (Hashem *et al*. 2021). Elevated level of rutin (15854.59 µg/g) in *C. droserifolia* extract, which acts as an antioxidant agent by enhancing catalase and superoxidase dismutase enzymes, which also possesses anti-inflammatory properties. Rutin can also dramatically reduce lipid peroxidation in a variety of tissues, including the liver and brain (Bakhtiari *et al.* 2017).

Table 2. *Cleome droserifolia* Shoot Extract's Antioxidant Activity (µg/mL) as Determined by the DPPH Free Radical Scavenging Assay

Concentration (µg/mL)	DPPH scavenging%		HSD
	Extract	Ascorbic acid	
1000	95.9±0.65a	98.0±0.51a	2.21
500	93.2±0.42a	94.6±0.21a	1.62
250	89.3±0.32b	92.3±0.41a	2.30
125	82.9±1.09b	88.5±1.03a	2.65
62.50	74.0±0.65b	80.6±1.16a	2.54
31.25	65.3±1.07b	73.6±1.32a	3.54
15.63	57.2±0.95b	65.5±1.25a	2.15
7.81	47.7±0.42b	56.8±0.32a	2.32
3.90	39.7±0.36b	51.5±2.02a	4.19
1.95	30.5±1.36b	43.2±2.36a	5.12
IC_{50}	8.95±1.023a	3.07±1.08b	2.65

Note: HSD is Tukey's Honestly Significant Difference (HSD)

Anti-Inflammatory Activity of CDE

The anti-inflammatory effects of CDE were represented by the inhibition of COX-1 and COX-2 (Table 3). From the results, COX-1 was more sensitive to CDE than COX-2 at all tested concentrations, where their inhibitions were 47.6±0.4 and 37.2±1.1 % at 7.8 µg/mL: 60.1±1.0 and 54±0.4 at 31.25 µg/mL, respectively. Inhibition of COX-1 and COX-2 was compared to Celecoxib as standard drug which reflected high inhibition levels against both enzymes if compared to CDE, however the IC_{50} dose of CDE is considered

good against COX-1 (12.91±0.5a µg/mL) and COX-2 (21.63 ±0.8 µg/mL) compared celecoxib against COX-1 (6.41 ± 0.7 µg/mL) and COX-2 (3.44 ±0.8 µg/mL). in vivo study, the inflammatory markers were decreased by CDE (Alqahtani *et al*. 2024).

Table 3. Anti-inflammatory of CDE *via* Inhibition of COX-1 and COX-2 Compared to Celecoxib

Concentration (µg/mL)	Inhibition (%)					
	COX-1		HSD	COX-2		HSD
	Plant extract	Celecoxib		Plant extract	Celecoxib	
0.00	0	0		0	0	
0.5	9.0±1.2b	19.6±1.2a	3.21	8.5±0.22b	21.3±0.2a	1.96
1.0	18.3±0.6b	25.9±0.4a	2.45	15.4±0.91b	30.7±0.4a	4.36
2.0	29.6±0.9b	34.6±0.86a	1.96	20.2±0.8b	47.5±0.86a	3.25
3.9	39.1±0.9b	45.2±1.2a	3.21	28.9±1.6b	55.3±1.2a	2.65
7.8	47.6±0.4b	55.3±1.6a	1.58	37.2±1.1b	64.8±1.6a	3.96
15.6	55.2±0.8b	67.5±1.2a	2.96	48.3±0.9b	71.3±1.2a	5.32
31.25	60.1±1.0b	69.7±0.9a	2.20	54±0.4b	79.4±0.9a	2.36
62.5	68±1.10b	77.9±0.2a	1.02	66.7±1.4b	83.1±0.2a	4.20
125	77.9±0.8b	84.6±0.33a	2.41	72.3±1.2b	86.8±0.33a	289
250	84.5±0.6b	88.7±0.36a	2.89	79.1±0.3b	90.2±0.36a	3.65
500	89.1±0.4a	91.6±0.7a	2.65	84.2±0.6b	95.3±0.7a	2.15
1000	95.2±0.8a	97.2±0.4a	2.25	88.9±0.4b	97.9±0.4a	6.32
IC_{50} (µg/mL)	12.91± 0.5a	6.41 ± 0.7 b	2.01	21.63 ± 0.8 a	3.44 ± 0.8b	4.63

Note: HSD is Tukey's Honestly Significant Difference (HSD)

Anti-amylase Activity of CDE

CDE exhibited anti-diabetic activity *via* inhibition of amylase compared to acarbose as a standard drug. Amylase inhibition by CDE and acarbose was 50.9±4.32 and 64.3±2.32 % at 15.62 µg/mL and reached to 93.9±2.36 µg/mL and 97.4±2.36 µg/mL at1000 µg/mL, respectively (Fig. 3).

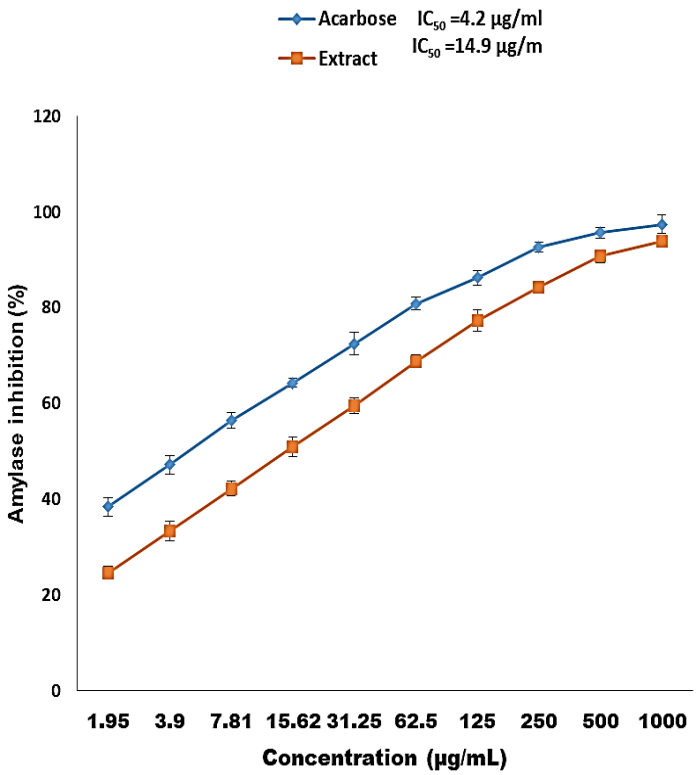

Fig. 3. Anti-amylase activity of *Cleome droserifolia* shoot extract, with Acarbose as positive control

The obtained IC_{50} dose of CDE (14.93±1.87µg/mL) indicated its potential as an anti-diabetic agent, which documented with the aid of acarbose acid IC_{50} dose (4.2±2.32µg/mL). The present results were agreement with in vivo study (El Naggar *et al*. 2005) which indicated that CDE possess anti-diabetic potential due to the presence of quercetin, kaempferol, and isorhamnetin quercetin, kaempferol, ferulic acid, 4-coumaric acid, isorhamnetin and syringic acid, these active compound may change the dynamics of proteins, enzymes, and other transcription factors linked to cancer, inflammation, and diabetes (Srinivasulu *et al.* 2018).

In another investigation, Helal *et al*. (2015) found that CDE reflected therapeutic protective against diabetes via declining oxidative stress as well as pancreatic β-cells' injury which is due to its anti-diabetic and antioxidative properties.

Anti-yeast Activity of CDE

The recorded and apparent inhibition zone indicated the efficacy of CDE against tested yeasts *C. albicans* (25±0.2mm), *C. tropicalis* (20±0.1mm), and *C. glabrata* (25±0.1mm) (Table 4 and Fig. 4). The standard antifungal agent showed better inhibition zones against *C. albicans* and *C. tropicalis* but lower against *C. glabrata* than CDE. Moreover, promising values of MIC and MFC were attributed to CDE against the examined yeasts. Various bacteria and *Candida albicans* were previously shown to be inhibited by CDE (Hashem *et al*. 2021). The antifungal activity of was documented by El-Alem *et al*. (2024), where the growth of the fungus *C. albicans* was suppressed with zone of inhibition 10 mm.

Overall, these findings recommend the possibility of utilizing CDE as a therapeutic agent. Prospective experiments are required to separate the bioactive constituents of the CDE and their specific activities *in vitro* and *in vivo*.

Table 4. Anti-yeast Activity of *Cleome droserifolia* Shoot Extract, with Fluconazole as a Positive Control

Tested Microorganisms	Inhibition Zones (mm)		HSD	MIC	MFC
	Extract	Control			
C. albicans	25±0.2a	27±0.1a	3.35	15.62±0.62	15.62±0.41
C. tropicalis	20±0.1b	27±0.2a	2.65	31.25±1.36	62.5±1.32
C. glabrata	25±0.1a	17±0.1b	4.32	15.62±2.02	31.25±1.52

Note: HSD is Tukey's Honestly Significant Difference (HSD)

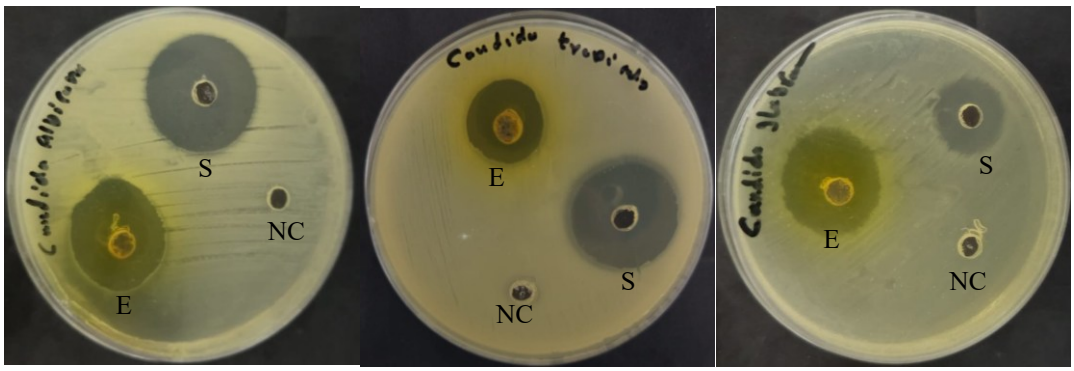

Fig. 4. Anti-yeast Activity of *Cleome droserifolia* Shoot Extract (E), with Fluconazole as a Positive Control (S), and ethanol as negative control (NC)

CONCLUSIONS

1. The findings of the current investigation point to the remarkable range of flavonoids and phenols ingredients of the CDE with several biological functions.
2. The CDE demonstrated antioxidant, anti-inflammatory, anti-diabetic, and anti-yeast activities *in vitro*, suggesting its potential—pending further modification such as purification or fractionation, stability enhancement, and targeted delivery—for evaluation in *in vivo* studies.

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REFERENCES CITED

Abdel Ghany, T. M., and Hakamy, O. M. (2014). "*Juniperus procera* as food safe additive, their antioxidant, anticancer and antimicrobial activity against some food-borne bacteria," *Journal of Biological and Chemical Research* 31, 668-677.

Abdelghany, T. M., Ganash, M., Alawlaqi, M. M., Alawlaqi, M. M., and Al-Rajhi, A. M. (2019). "Antioxidant, antitumor, antimicrobial activities evaluation of *Musa*

paradisiaca L. pseudostem exudate cultivated in Saudi Arabia," *BioNanoScience* 9, 172-178. DOI: 10.1007/s12668-018-0580-x

Abdelghany, T. M., Reham, Y., Bakri, M. M., Ganash, M., Basma, H. A., and Qanash, H. (2021). "Effect of *Thevetia peruviana* seeds extract for microbial pathogens and cancer control," *International Journal of Pharmacology* 17, 643-655.

Abdullah, W., Elsayed, W. M., Abdelshafeek, K. A., Nazif, N. M., Ismail, N. S., Ismail, S. I., Singab, A. N. B., and Nada, S. A. (2021). "Biological activity and investigation of some active constituents with molecular docking from two species," *Egyptian Pharmaceutical Journal* 20(2), 115-125. DOI: 10.4103/epj.epj_47_18

Alawlaqi, M. M., Al-Rajhi, A. M., Abdelghany, T. M., Ganash, M., and Moawad, H. (2023). "Evaluation of biomedical applications for linseed extract: Antimicrobial, antioxidant, anti-diabetic, and anti-inflammatory activities *in vitro*," *Journal of Functional Biomaterials* 14(6), article 300. DOI: 10.3390/jfb14060300

Almehayawi, M. S., Almuhayawi, M. S., El-Fadl, S. R. A., Nagshabandi, M. K., Tarabulsi, M. K., Selim, S., Alruwaili, Y. S., Mostafa, E. M., Al Jaouni, S. K., and Abdelghany, T. M. (2024). "Evaluating the anti-yeast, anti-diabetic, wound healing activities of *Moringa oleifera* extracted at different conditions of pressure via super-critical fluid extraction," *BioResources* 19(3), 5961-5977. DOI: 10.15376/biores.19.3.5961-5977

Alqahtani, J., Negm, W. A., Elekhnawy, E., Hussein, I. A., Hassan, H. S., Alanzi, A. R., Moglad, E., Ahmed, R., Ibrahim, S., and El-Sherbeni, S. A. (2024). "Potential surviving effect of *Cleome droserifolia* extract against Systemic *Staphylococcus aureus* infection: Investigation of the chemical content of the plant," *Antibiotics* 13(5), article 450. DOI: 10.3390/antibiotics13050450

Al-Rajhi, A. M. H., Abdelghany, T. M., Almuhayawi, M. S., Alruhaili, M. H., Saddiq, A. A., Baghdadi, A. M., Al Jaouni, S. K., Albasri, H. M., Waznah, M. S., Alraddadi, F. A., and Selim, S. (2025). "Effect of ozonation on the phytochemicals of black seed oil and its anti-microbial, anti-oxidant, anti-inflammatory, and anti-neoplastic activities *in vitro*," *Sci Rep.* 15(1), article 3840. DOI: 10.1038/s41598-025-88223-w

Al-Rajhi, A. M. H., Qanash, H., Bazaid, A. S., Binsaleh, N. K., and Abdelghany, T. M. (2023). "Pharmacological evaluation of *Acacia nilotica* flower extract against *Helicobacter pylori* and human hepatocellular carcinoma *in vitro* and *in silico*," *Journal of Functional Biomaterials* 14(4), article 237. DOI: 10.3390/jfb14040237

Amin, M. A. A., Abu-Elsaoud, A. M., Nowwar, A. I., Abdelwahab, A. T., Awad, M. A., Hassan, S. E. D., and Elkelish, A. (2024). "Green synthesis of magnesium oxide nanoparticles using endophytic fungal strain to improve the growth, metabolic activities, yield traits, and phenolic compounds content of *Nigella sativa* L," *Green Processing and Synthesis* 13(1), article 20230215. DOI: 10.1515/gps-2023-0215

Amin, M. A., Algamdi, N. A., Waznah, M. S., Bukhari, D. A., Alsharif, S. M., Alkhayri, F., and Fouda, A. (2025). "An insight into antimicrobial, antioxidant, anticancer, and antidiabetic activities of trimetallic Se/ZnO/CuO nanoalloys fabricated by aqueous extract of *Nitraria retusa*," *Journal of Cluster Science* 36(1), 1-15.

Bakhtiari, M., Panahi, Y., Ameli, J., and Darvishi, B. (2017). "Protective effects of flavonoids against Alzheimer's disease-related neural dysfunctions," *Biomedicine and Pharmacotherapy 93*, 218-229.

Bakri, M. M., Alghonaim, M. I., and Alsalamah, S.A. (2024). "Impact of moist heat on phytochemical constituents, anti-helicobacter pylori, antioxidant, anti-diabetic, hemolytic and healing properties of rosemary plant extract in vitro," *Waste Biomass*

Valor 15, 4965-4979. DOI: 10.1007/s12649-024-02490-8

Bazaid, A.S., Binsaleh, N.K., Barnawi, H., Alharbi, B., Alsolami, A., Selim, S., Al Jaouni, S. K., Saddiq, A.A., Ganash, M., Abdelghany, T. M., and Qanash, H. (2025). "Unveiling the *in vitro* activity of extracted *Euphorbia trigona via* supercritical fluid extraction against pathogenic yeasts, obesity, cancer, and its wound healing properties," *Bioresour. Bioproc.* 12(1), 28. DOI:10.1186/s40643-025-00855-y

El Naggar, E. M. B., Bartošíková, L., Žemlička, M., Švajdlenka, E., Rabišková, M., Strnadova, V., and Nečas, J. (2005). "Antidiabetic effect of *Cleome droserifolia* aerial parts: Lipid peroxidation-induced oxidative stress in diabetic rats," *Acta Veterinaria Brno*, 74(3), 347-352. DOI: 10.2754/avb200574030347

El-Alem, W. A., El-Swaify, Z. A. S., Mohamed, A. A., Bedair, R. I., and Khafagi, O. M. A. (2024). "Anticancer; antiviral activities and phytochemical studies on *Cleome droserifolia* (Forssk.) Delile in Nabq Protectorate, South Sinai, Egypt," *Egyptian Journal of Botany* 64(3), 369-380. DOI: 10.21608/ejbo.2024.292645.2863

El-Askary, H., Handoussa, H., Badria, F., El-Khatib, A. H., Alsayari, A., Linscheid, M. W., and Motaal, A. A. (2019). "Characterization of hepatoprotective metabolites from *Artemisia annua* and *Cleome droserifolia* using HPLC/PDA/ESI/MS–MS," *Revista Brasileira de Farmacognosia* 29(2), 213-220.

French, G. L. (2006). "Bactericidal agents in the treatment of MRSA infections-the potential role of daptomycin," *J. Antimicrob. Chemother.* 58(6), 1107-1117. DOI: 10.1093/jac/dkl393

Hashem, N. M., and Shehata, M. G. (2021). "Antioxidant and antimicrobial activity of *Cleome droserifolia* (Forssk.) Del., and its biological effects on redox status, immunity, and gut microflora," *Animals* 11(7), article 1929. DOI: 10.3390/ani11071929

Hashem, N. M., Soltan, Y. A., El-Desoky, N. I., Morsy, A. S., and Sallam, S. M. A. (2019). "Effects of *Moringa oleifera* extracts and monensin on performance of growing rabbits," *Livestock Science* 228, 136-143.

Helal, E. G., Khattab, A. M., Abou Aouf, N., and Abdallah, I. Z. (2015). "Hypoglycemic and antioxidant effects of *Cleome droserifolia* (Samwah) in alloxan-induced diabetic rats," *The Egyptian Journal of Hospital Medicine* 58(1), 39-47.

Joshi, A., Richard, T. H., and Gohil, V. M. (2023). "Mitochondrial phospholipid metabolism in health and disease," *Journal of Cell Science* 136(17), jcs260857.

Kahkeshani, N., Farzaei, F., Fotouhi, M., Alavi, S. S., Bahramsoltani, R., Naseri, R., Momtaz , S., Abbasabadi, Z., Rahimi, R., Farzaei, M. H., Bishayee, A., and Bishayee, A. (2019). "Pharmacological effects of gallic acid in health and diseases: A mechanistic review," *Iranian Journal of Basic Medical Sciences* 22(3), article 225.

Khowdiary, M. M., Alatawi, Z., Alhowiti, A., Amin, M. A., Daghistani, H., Albaqami, F. M. K., and Fouda, A. (2024). "Phytochemical analysis and multifaceted biomedical activities of *Nitraria retusa* extract as natural product-based therapies," *Life* 14(12), article 1629.

Moustafa, A. A., and Mahmoud, M. A. K. (2023). "Importance of *Cleome droserifolia* as an endangered medicinal plant species in the Sinai Peninsula and the need for its conservation. An Egyptian natural heritage facing extinction," *Adv. Med. Plant Res* 11, 43-51. DOI: 10.1016/j.plana.2025.100158

Panicker, N. G., Balhamar, S. O. M. S., Akhlaq, S., Qureshi, M. M., Rehman, N. U., Al-Harrasi, A., and Mustafa, F. (2020). "Organic extracts from *Cleome droserifolia* exhibit effective caspase-dependent anticancer activity," *BMC Complementary Medicine and Therapies* 20, 1-13.

Qanash, H., El-Fadl, S. R. A., Binsaleh, N. K., Aljahdali, I. A., Altayar, M. A., Khalel, A. F., and Abdelghany, T. M. (2024). "Ecofriendly extraction approach of *Moringa peregrina* biomass and their biological activities *in vitro*," *Biomass Conversion and Biorefinery* 1-11. DOI: 10.1007/s13399-024-05916-4

Selim, S., Abdelghany, T. M., Almuhayawi, M. S., Nagshabandi, M. K., Tarabulsi, M. K., Elamir, M. Y. M., and Al Jaouni, S. K. (2025a). "Biosynthesis and activity of Zn-MnO nanocomposite in vitro with molecular docking studies against multidrug resistance bacteria and inflammatory activators," *Sci. Rep.* 15, article 2032. DOI: 10.1038/s41598-024-85005-8

Selim, S., Saddiq, A. A., Ashy, R. A., Baghdadi, A. M., Alzahrani, A. J., Mostafa, E. M., Al Jaouni, S. K., Elamir, M. Y. M., Amin, M. A., Salah, A. M., and Hagagy, N. (2025b). "Bimetallic selenium/zinc oxide nanoparticles: Biological activity and plant biostimulant properties," *AMB Express* 15(1), 1-11.

Srinivasulu, C., Ramgopal, M., Ramanjaneyulu, G., Anuradha, C. M., and Kumar, C. S. (2018). "Syringic acid (SA) – A review of its occurrence, biosynthesis, pharmacological and industrial importance," *Biomed. Pharmacother.* 108, 547-557.

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