

Antioxidant and Anti-Inflammatory Activities of *Suaeda vera*

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Abstract

Medicinal plants have been used for centuries to alleviate inflammation and related ailments. In traditional medicine, *Suaeda* species is important because it has medicinal uses. Several investigations have shown that they possess anticancer, antioxidant, and antibacterial properties. The aim of this study was to evaluate the anti-inflammatory and antioxidant properties of *Suaeda vera*'s ethanolic leaf extract in a carrageenan inflammatory model. The extract was administered orally at three different doses (100, 200 and 400 mg/kg) for a 5-hour treatment period in rats. According to findings, the extract contains high antioxidant content and significant level of radical scavenging ability, quenching DPPH (1, 1-diphenyl-2-picrylhydrazyl) and H₂O₂ radicals. Additionally, the extract contains flavonoids and phenolics, as determined by the phytochemical screening. During the *in vivo* anti-inflammatory study, the ethanolic extract exhibited inhibitory effects of 13.39%, 28.75%, and 39.65% at doses of 100, 200 & 400 mg/kg, respectively; compared to the positive control (10 mg diclofenac sodium /kg) which showed 57.45 inhibition percentage. These findings show that, *S. vera* has the capacity to alleviate inflammation, supporting the plant's ethanomedical claim.

Keywords: Medicinal plants; antioxidant; *Suaeda vera* ethanolic extract; HPLC; Anti-inflammatory.

Introduction

Inflammation is a defensive response of mammalian tissues triggered by foreign chemicals, often occurring to eliminate or halt

the expansion of harmful stuffs (Zhao *et al.*, 2021).

Inflammation serves as a protective mechanism via dilution and destruction of toxic microorganisms and other dangerous substances,

prior to restorative & repairing process (Chu et al., 2020). Inflammation, particularly at the cellular level, is linked to numerous disease conditions, including diabetes, arthritis, anaphylaxis, prostatitis, chronic kidney disease, bacterial infections, digestive disorders, novel coronavirus infections, and Alzheimer's disease. Usually, these disorders cause major health drawbacks (Bandyopadhyay et al., 2021; Junejo et al., 2021).

According to the U.S. Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 2015), the estimated number of Americans affected by Inflammatory Bowel Disease (IBD) exceeds 3 million. The Crohn's and Colitis Foundation of America reports that around 1.6 million individuals in the United States are afflicted with IBD (Kumar, 2021).

Corticosteroids and non-steroidal anti-inflammatory medications (NSAIDs) are being used as treatments for inflammation. However, both of these drugs have negative side effects, including a higher risk of heart attacks and gastrointestinal ulcers (Rogler, 2010 and Park et al., 2012). Because of these risks, new sources of anti-inflammatory compounds are quite interesting. It has been suggested that the development of natural source-based anti-inflammatory pharmaceuticals is a

sensible and effective approach towards the treatment of inflammatory diseases. Meanwhile, a number of naturally occurring compounds from plants have been shown to block particular inflammatory mediators (Lahare et al., 2021). Compared to pharmaceutical drugs, medicinal plants are now more necessary as they are less expensive, safe with less side effects. They are accessible and can be regarded as the main source of healthcare for indigenous people living in poverty and in rural areas (WHO 2001).

Genus *Suaeda*, known as sea-blites or seep weeds, contains succulent salt-accumulating herbs and shrubs with continuous stem and fleshy, linear leaves in the family *Amaranthaceae* (formerly classified under the *Chenopodiaceae*) (Jochen and Ferren, 2001). The genus comprises over 100 species found in various locations, primarily thriving in saline-alkaline environments such as salt marshes, saline-alkali lands, grasslands, seaboards, wastelands along coastlines, inland deserts, and other challenging conditions characterized by intense light, high temperatures, drought, high salinity, and low oxygen levels. According to Riadh et al. (2012) and Thatoi et al. (2014), they have the capacity to respond to a variety of environmental challenges in terms of morphology, anatomy, physiology, and molecular

mechanism, which causes plants to create oxidative stress.

Therefore, researchers' attention has turned to the antioxidant as well as anti-inflammatory properties of *Suaeda* extracts.

In traditional medicine, genus *Suaeda* has been utilized therapeutically. Different species of *Suaeda* genus have been traditionally used to treat ulcers (Ali et al., 2014; Al-Said et al., 2017), and gastrointestinal disorders such as diarrhea and as a carminative (Ali et al., 2014; Al-Said et al., 2017). Additionally, it is used as an antimicrobial for skin conditions, gout, conjunctivitis, the flu, and cough (Ahmed et al., 2014; Saleh et al., 2020). The plant has been shown to have antioxidant, anti-inflammatory, hepatoprotective, hypolipidemic, hypoglycemic, and anti-cancer properties (Oueslati et al., 2012; Elsharabasy et al., 2019). (Saleh et al., 2020). It has also applied medically as an antibacterial for gout, rheumatism, flu, conjunctivitis, skin diseases and cough (Ahmed et al., 2014; Saleh et al., 2020). Studies have demonstrated that the plant exhibits anti-inflammatory effects (Pisoschi et al., 2012) as well as antioxidant properties (Ksouri et al., 2012; Oueslati et al., 2012; Elsharabasy et al., 2019). It has also been found to possess hepatoprotective, hypoglycemic, hypolipidemic effects (Benwahhoud et al., 2001),

and considered as a potential anti-cancer agent (Saleh et al., 2020).

In light of this background, we assessed the antioxidant and anti-inflammatory effects of *S. vera* leaf ethanolic extract.

Materials and Methods

Plant sampling and preparation of extract

The plant leaf samples of *Suaeda vera* were collected in August 2021 from Ashtoum El Gameel Protected Area (N 31°18'60.11", E 32°10'27.45"), packed into plastic bags then immediately transported right away in an ice-filled box with ice to the Central Lab., Faculty of Science, Suez Canal University for further analysis. The samples were cleaned in the lab using running tap water and distilled water to get rid of any dust, and then they were dried in the shade. The air-dried plant material was ground and extracted with ethanol (70%). The extraction process was accelerated by periodic shaking. A rotary evaporator (Buchi Rotavapor, R-114) was used to evaporate the entire ethanolic extract, producing 2g of dry residue. For further uses, the residue was kept in a freezer at -20° C (Mau et al., 2001).

Evaluation of free-radical scavenging activity

Hydrogen peroxide scavenging assess

The extract capacity to hunt hydrogen peroxide (H₂O₂) was evaluated following Ruchet al.

(1989) technique. The positive control used was ascorbic acid. The next formula was applied to assess the H₂O₂ scavenging ability of the extracts:

$$\text{Percentage (\% of inhibition)} = (A_{\text{Control}} - A_{\text{Sample}}) / A_{\text{Control}} \times 100$$

The results were plotted as the percentage of scavenging activity versus the sample concentration.

DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radical hunting assess

The ability of the *S. vera* extract to scavenge the free radical was determined following the procedure of Kulisic (*Kulisic et al., 2004*). Using a UV-visible spectrophotometer, the absorbance of the reaction product was considered at 517 nm. The positive control used in this experiment was a solution of rutin. The DPPH scavenging capacity was determined using the following equation:

$$\text{Percentage (\% of inhibition)} = (A_{\text{Control}} - A_{\text{Sample}}) / A_{\text{Control}} \times 100$$

Total flavonoid content (TFC) assess

The TFC was calculated following *Saeed et al. (2012)* procedures based on colorimetric property of aluminum chloride. As a standard solution, rutin was consumed and the calibration curve was created using the absorbance measurement at 506 nm. The extract content of flavonoids was represented as milligrams of rutin / gram of samples (mg. g⁻¹ DWT).

Total phenolic content assess

Following Folin-Ciocalteu phenol technique recommended by *Iqbal et al. (2016)*, total phenolic acid was measured. The total phenolic acids were reported as gallic acid (milligrams) / gram of samples (mg. g⁻¹ DWT).

Determination of CAT, SOD and GPX enzymes activities assay

To quantify the activity of catalase (EC: 1.11.1.6), superoxide dismutase (EC: 1.15.1.1), and glutathione peroxidase (GPX; EC: 1.11.1.9), the method described by *Grace and Logan (1996)* was employed. Frozen leaf powder weighing 100 mg was homogenized with 1 ml of ice-cold potassium phosphate (KP) buffer extraction buffer (50 mM, pH 7.0). The extraction buffer consisted of 1 mM ascorbate, 0.1 mM EDTA, 4% (w/v) polyvinylpyrrolidone (pvp), and 2% (v/v) glycerol. For the enzyme assay, centrifugation of the homogenate was conducted for 10 min at 10,000 x g and 4 °C.

CAT activity was measured by observing the rate of H₂O₂ decay at 240 nm wavelength in a solution containing 3 mL KP buffer (pH 7.0) plus H₂O₂ (25 mM) plus 100 µL of basic enzyme (*Aebi, 1984*). Millimole H₂O₂ / mg protein / min was the unit to display the CAT activity.

Estimation of Superoxide Dismutase (SOD)

The SOD activity was calculated in accordance with *Dhindsa et al. (1981)*, based on the reality that half of nitro blue

tetrazolium (NBT) photo reduction would be blocked by one unit of SOD.

Estimation of Glutathione Peroxidase (GPX)

For measuring GPX activity, a 50 μ l portion of the crude enzyme was combined with 950 μ l of a solution comprising 50 mM potassium phosphate buffer (pH 7.0) plus NaCl (0.114 M), EDTA (1 mM) plus reduced glutathione (GSH, 1 mM) plus H₂O₂ (0.25 mM) plus NADPH (0.2 mM) and 1 U of GR (*Nagalakshmi and Prasad, 2001*). The reduction in absorbance at 340 nm was monitored for 1 minute at 30 °C to determine the enzyme activity. The extinction coefficient of 6.22 mM⁻¹ cm⁻¹ (*Anderson and Davis, 2004*) was used to calculate the GPX activity.

HPLC-DAD analysis

By using a high-performance liquid chromatography (HPLC) equipped with a diode array detector (DAD, Thermoscientific), the methanolic fraction of *S. vera* leaves was chromatographically analyzed. The four resultant compounds were each identified by direct comparison with pure standard (Quercetin, Naringenin, Rutin, and Ascorbic Acid) (Sigma-Aldrich), using absorbance spectrum (at 280 or 340 nm), retention duration and chromatographic peak area as the criteria. With a thermal hypersil C18 column (3 mm 4.6 mm 150 mm), formic acid 1 percent (phase A), and methanol (phase B) as

solvents, the analysis was performed. The column was kept at 30 °C, while the injection volume was 15 μ l. The elution gradient is set as follows: t₀ min (A 85 percent, B 15 percent); t₂₀ min (A 65 percent, B 35 percent); t₅₅ min (A 10 percent, B 90 percent); t₆₈ min (A 85 percent, B 15 percent); and t₇₀ min (end run).

Fourier Transform Infrared Spectrophotometer (FTIR)

The types of functional groups (or chemical bonds) presented in compounds were identified using Fourier Transform Infrared Spectrophotometer (FTIR). The chemical bond was characterized by the wavelength of light that was absorbed. Dried powder of *S. vera* extract was loaded into Bruker Alpha II FTIR spectroscopewith 400 to 4000 cm⁻¹ scan range and cm⁻¹ resolution.

Determination of anti-inflammatory activity of *S. vera* ethanolic extract

Animals and ethical approval

For the experiment, twenty-five male Wistar rats, aged (eight to ten) weeks and weighed between (160 and 185 g) were used. The pharmacological protocols for our animal experiment were approved by the institutional ethical committee, Faculty of Veterinary Medicine, Suez Canal University, with approval number SCU 2023065. Every possible effort was made to minimize animal suffering and reduce the number of animals used while obtaining reliable data.

Before the experiment began, the rats were given a two-week period to acclimate to the laboratory conditions. They were housed in a controlled environment with a temperature of 25 ± 1 °C, humidity of $60\pm 10\%$, and a 12-hour light/dark cycle. The rats were kept in polypropylene cages, with five rats per cage. They had unrestricted access to a standard rodent pellet diet and tap water for drinking. The handling of the animals followed the guidelines outlined in the National Research Council's "Guide for the Care and Use of Laboratory Animals" (2011).

Assessment of anti-inflammatory activities using carrageenan-induced paw edema

Following the procedure outlined by *Ia et al. (2005)*, the anti-inflammatory efficacy of *S. vera* ethanolic extracts was examined in rat's paw edema (acute inflammation).

In all rat groups, the footpad of the right hind paw was injected sub-plantar with 0.1 ml of 1% freshly made carrageenan suspension. To determine the change in paw thickness, the left hind paw was left un-injected and used as a control. After three hours of carrageenan injection, there was well-defined swelling and redness that continued until the experiment's ended. Using a Vernier digital caliper, the development of paw edema was

recorded at intervals of 0, 1, 2, 3, and 5 hours.

The reacclimatized rats were isolated into five groups, each of five rats (5×5). One hour prior to injection of carrageenan, the rats received either Voltaren® (Diclofenac sodium injected i.p in a dose of 10 mg/kg as a standard anti-inflammatory drug, control positive group) or *S. vera* ethanolic extract (100, 200 or 400 mg/kg). The first group of rats received only saline (5 ml/kg) instead of extracts and kept as control negative.

The variance between the left and right paw diameters was used to calculate changes in paw thickness, and the formula below was used to calculate the % of edema inhibition in comparing to the control negative group:

$$\text{(\% Edema inhibition)} = \frac{\text{Control value} - \text{Sample value}}{\text{Control value}} \times 100.$$

Statistical analysis

Our data were analyzed using one-way ANOVA and presented as mean \pm SEM. All experimental groups' results, including those created by the standard medication (diclofenac sodium), were compared to control groups' results, and their significance was assessed results considered statistically significance at $P < 0.05$.

Results

Antioxidant Activity of S. vera

Antioxidant activities of the leaves in terms of H_2O_2 , DPPH, total

flavonoid and total phenolic as well as enzyme activities displayed in Figures (1 & 2) and tables

1–3. Highly reactive hydroxyl radicals are produced in our bodies and quickly broken down into oxygen and water, producing hydroxyl radicals (OH), which can start lipid peroxidation and harm DNA. The results showed that scavenging effect of *S. vera* extract on H_2O_2 was concentration-dependent (25–400 $\mu\text{g/mL}$) showing a maximum effect at 400 $\mu\text{g/mL}$ of concentration (91.3 %) comparable to that of the reference compound ascorbic acid (Fig. 1). With higher extract concentrations, the extract's capacity to scavenge hydroxyl radicals increased. Based on the concentration of the extract, the H_2O_2 IC_{50} (half-maximal inhibitory concentration) was estimated. IC_{50} value was determined in *S. vera* extract (53.4 $\mu\text{g/ml}$) while the IC_{50} value for ascorbic acid was measured as (47.7 $\mu\text{g/ml}$) (Table 1). According to the IC_{50} values, plant extracts are excellent radical scavengers and are relatively equivalent to ascorbic acid in general.

DPPH radical scavenging activity of ethanol extract of *Suaeda vera* leaves was depicted in figure 2. As standard and sample concentrations increase, the scavenging effect also increases. At 400 $\mu\text{g/mL}$ concentration ethanol extract of *Suaeda vera* possessed 92.7 % scavenging activity on DPPH. The IC_{50} values (extract

concentration that scavenge 50% of the DPPH radicals) are inversely proportional to its antioxidant components richness (lower IC_{50} values suggest greater antioxidant activity). IC_{50} values of ethanol extract of *Suaeda vera* leaves and standard rutin for DPPH, were found to be 51.3 $\mu\text{g/mL}$ and 48.7 $\mu\text{g/mL}$ respectively (Table 1).

Total phenolic and flavonoid contents in *S. vera* extract were calculated using the calibration curves for gallic acid and rutin, respectively. Table 2 lists the total amounts of phenolic and flavonoid compounds found in *S. vera* leaves. The content of phenolic components (mg/g) in gallic acid equivalent was found to be 15.96 ± 0.095 mg GAE g^{-1} dry weights (DW) in the ethanolic extract of *S. vera*. The total flavonoid content (mg/g) in rutin equivalent was found to be 41.94 ± 0.179 mg R g^{-1} dry weights (DW) in ethanolic leaves extract of *S. vera*.

To assess the mechanisms behind the antioxidant functions in *S. vera*, we evaluated the activity of antioxidant enzymes. Table 3 displays the *S. vera* leaves antioxidant enzymes activity. Of all the antioxidant enzymes tested, GPX activity exhibited the greatest increase. The findings showed that, respectively, $GPX > CAT > SOD$ by (398.84, 100.08, and 90.36).

HPLC-DAD analysis

The HPLC-DAD chromatograms of the ethanolic fraction of *Suaeda vera* leaves are

shown in Figure 4. At 250 nm, signals were captured. It indicates the retention time for the sample and real standards (20 μ L). Only 4 compounds out of the 8 that have been demonstrated for the leaf ethanolic fraction have been effectively identified. All four of these chemicals have been identified based on their peak spectral features and retention times in comparison to standards (Fig. 3). They are ascorbic acid, naringenin, rutin and quercetin. Out of the eight compounds, those with Rt values 1.6, 1.8, 2.09 and 3.18, were found to be more prevalent since their percentage areas were higher with 6.56%, 8.78%, 17.62% and 5.63% respectively. The other components were discovered to be extremely few because the total percent area for all the spots was less than 5.50.

Infrared Fourier Transform Spectroscopy Analysis (FTIR)

To identify the functional groups found in the leaves, FTIR analysis of *S. vera* leaf extract was performed. The prominent peaks in the extract's FTIR spectrum (Fig. 5) were at cm^{-1} 3337.2, 2970.5, 1755, 1643.8, 1353, 1318, 1289.4 and 566.5. The broad peak at 3337.2 cm^{-1} is accountable for O-H stretching of polyphenolic substances including triterpenoids, flavonoids and non-flavonoids. A possible cause of the broad peak at 1643.8 is C=O stretching of proteins. A peak of 2970.5 cm^{-1} was detected, indicating the presence of C-H stretching. While

1755 cm^{-1} corresponds to C-O. The peak around 1643.8 cm^{-1} is caused by C=O stretching, while the peak at 1353 cm^{-1} most likely relates to C-N stretch vibration. S-O, C-O, and C-halogen, respectively, are responsible for the peaks at 1318 cm^{-1} , 1289.4 cm^{-1} , and 566.5 cm^{-1} . The remaining peaks are quite thin, which indicated the presence of additional substances such as esters, carboxylic acids and anhydrides in trace levels.

Anti-inflammatory activities

Table 5 displays the effect of *S. vera* extracts and diclofenac sodium on carrageenan-stimulated paw edema over time. For each fraction, the dose effect is based on measuring the meaningful difference between doses. Fig. 6 indicates the degree at which the extracts and diclofenac sodium reduce the established carrageenan-resulted inflammation. The rate and degree to which the related extract suppresses inflammation are determined by the steepness of each plot. The amount of paw edema was rising every hour, reaching a larger level at the fifth hour (Figure 6). In comparison to carrageenan-induced paw edema, the various dosages of *S. vera* and diclofenac sodium treated rats demonstrated a suppression of carrageenan-stimulated paw edema in all observed time intervals. The inhibition of paw edema was noted to be greater in rats treated with diclofenac (57.45%) followed by *S. vera* at high dose (39.65%), mid

dose (28.75%) and low dose (13.39%) at 5th hour observation (Table 5 and Figure 6).

Table 1: IC_{50} values of H_2O_2 & DPPH free radicals with *S. vera* extract, ascorbic acid and rutin.

Antioxidant assays		
IC ₅₀ (µg/mL)		
Extract	H ₂ O ₂ free radical	DPPH free radical
<i>S. vera</i>	53.4	51.3 ± 0.17
Ascorbic Acid	47.7	----
Rutin	----	48.7 ± 0.23

Table 2: Total phenolic and flavonoid contents of *S. vera* extract.

<i>Suaeda vera</i> extract	Total Phenolic content	Total Flavonoid content
	15.96 ± 0.095	41.94 ± 0.179

Table 3: CAT, SOD and GPx activities of *S. vera* extract.

Enzyme	CAT	SOD	GPx
<i>Suaeda vera</i> extract	100.08 ± 1.026	90.36 ± 0.67	389.84 ± 1.89

Table 4: FTIR peak values of *S. vera* extract.

S. No	Peak Values	Functional Groups
1	3337.2	O-H
2	2970.5	C-H
3	1755	C-O
4	1643.8	C=O
5	1353	C-N
6	1318	S-O
7	1289.4	C-O
8	566.5	C-halogen

Table 5: Rats' paw thickness in carrageenan induced inflammation with and without *S. vera* ethanolic extract injected in 3 doses. Each value is the mean"

Group	Dose	Paw thickness mm (Hours post treatment)						Average inhibition %
		0	1 st	2 nd	3 rd	4 th	5 th	
Saline	5 ml/kg	4.06±0.10 ^a	6.25±0.27 ^a	6.85±0.39 ^a	7.38±0.43 ^a	7.08±0.29 ^a	6.98±0.67 ^a	-
Diclofenac sod.	10mg/kg	3.94±0.06 ^a	5.25±0.26 ^b	5.18±0.25 ^c	5.18±0.18 ^d	5.08±0.22 ^d	4.95±0.27 ^c	57.45
<i>S. vera</i> ethanolic extract	100mg/kg	4.04±0.13 ^a	6.08±0.13 ^a	6.70±0.38 ^{ab}	7.05±0.22 ^{ab}	6.55±0.27 ^{ab}	6.10±0.28 ^{ab}	13.39
	200mg/kg	4.01±0.06 ^a	5.70±0.24 ^{ab}	6.23±0.42 ^{ab}	6.48±0.23 ^{bc}	6.08±0.13 ^{bc}	5.68±0.25 ^{bc}	28.75
	400mg/kg	3.98±0.09 ^a	5.40±0.17 ^b	5.70±0.23 ^{bc}	6.03±0.11 ^c	5.88±0.05 ^c	5.48±0.11 ^{bc}	39.65

S.E.M for 5 rats. Different letters within the same column mean statistical significance at P<0.05.

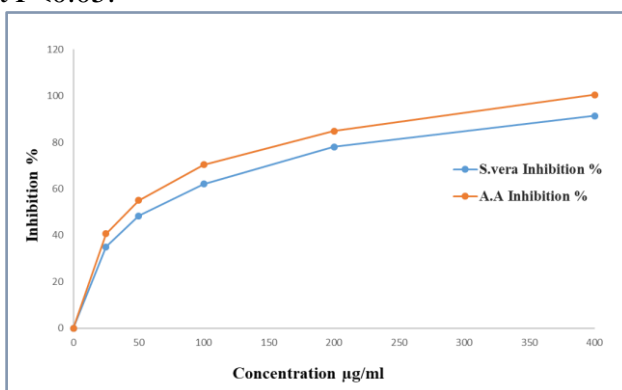


Figure 1: Hydrogen peroxide free radical scavenging activity of *S. vera* extract at different concentrations (25–400 µg/ml) compared to ascorbic acid.

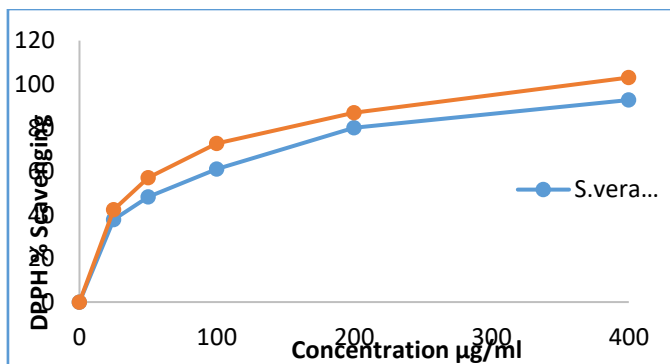


Figure 2: DPPH free radical scavenging activity of *S. vera* extract at different concentrations (25–400 µg/ml) compared to rutin.

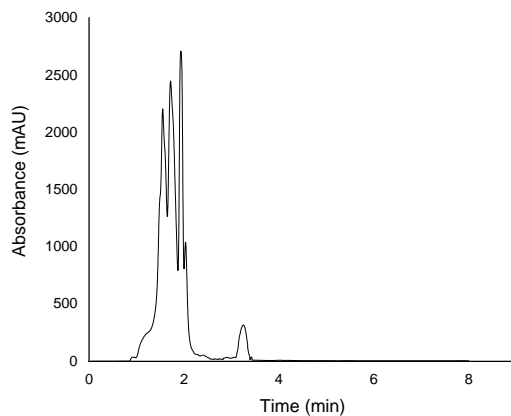


Figure 3: HPLC chromatogram of four standards mixture (quercetin, naringenin, rutin and ascorbic acid) at 272 nm.

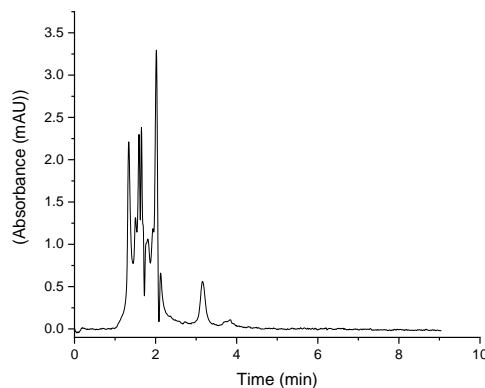


Figure 4: HPLC chromatogram of four *S. vera* at 272 nm.

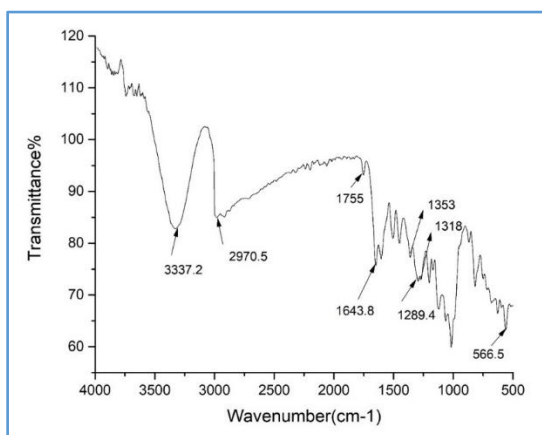


Figure 5: FTIR spectral profiles of *S. vera* extract.

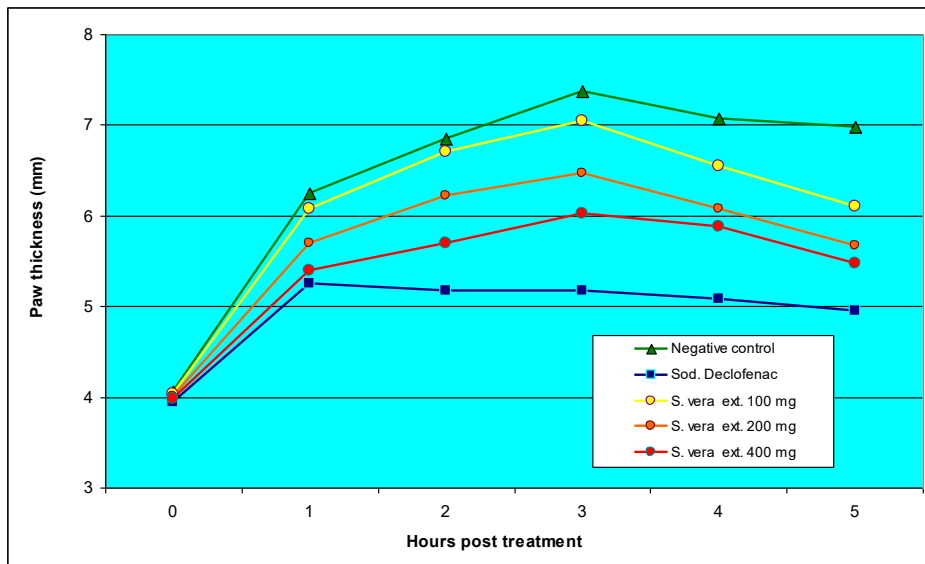


Figure 6: The Anti-inflammatory effects of various doses of *S. vera* extracts and diclofenac sodium on carrageenan-induced paw edema over time.

Discussion

The potentiality for antioxidant activity in plant tissues is connected with the concentration of cell-reinforcing components, like phenolic compounds, carotenoids, flavonoids, tocopherol, ascorbic acid, and substances that can catalyze the scavenging of free radicals (including super oxidase, glutathione peroxidase and catalase) (Kasote et al., 2015; Parcheta et al., 2021). Plant phenolics are one of the most important classes of compounds that function as principal antioxidants or free radical scavengers (Shahidi and Ambigaipalan, 2015). In accordance with numerous studies (Matanjun et al., 2008; Sushant et al., 2019; Chen et al., 2020; Gaber, et al., 2023), have suggested that the antioxidant activity of phenolic

compounds is accredited to their capacity to donate hydrogen atoms to free radical. Additionally, they possess the ideal structural qualities for free radical scavenging capacities (Sulaiman et al., 2011). Plant phenols have potent anti-inflammatory, anti-tumor, and antioxidant effects. They can also be utilized to control the metabolism of arachidonic acid (Wang et al., 2022). So, it is important to ascertain the total concentration of phenols and flavonoids in the plant extract chosen for the study.

According to studies, antioxidants actively protect cells from ROS-caused cellular damage through scavenging free radicals. According to our findings, *S. vera* extract contained significant levels of TPC and TFC when phenolic and

flavonoid contents were quantified. The presence of these substances in *Suaeda vera* extract may support its use locally for the treatment of diseases brought on by oxidative stress. Additionally, the *S. vera* extract demonstrated notable antioxidant activity when tested using H₂O₂ and DPPH free radical scavenging techniques. The development of inflammatory disorders is largely caused by reactive oxygen species (ROS) and free radicals (Liu et al., 2018; Vona et al., 2021). Thereby, antioxidants and radical scavengers can lessen inflammation by neutralizing free radicals.

H₂O₂ naturally occurs in a little concentration in plants, water, air, animal/human bodies, food, and bacteria (Haida and Hakim, 2019). It breaks down fast into oxygen plus water, and it may also generate hydroxyl radicals (OH[•]), which can start lipid peroxidation and damage DNA (Vimbert et al., 2020; Abbas et al., 2023). Figures 1 and 2 showed that *S. vera* extract has strong reducing and free radical scavenging abilities as demonstrated by H₂O₂ and DPPH tests. The ability of *S. vera*'s extract to effectively scavenge hydrogen peroxide may be explicated by the presence of phenolic groups, which could transfer electrons to hydrogen peroxide and deactivate it into water (H₂O).

The HPLC profile of *S. vera* extract detected the presence of quercetin, naringenin, rutin and

ascorbic acid. These four components are chemicals from the flavonoid and phenolic classes that have previously been found in the *Suaeda* species; *S. monoica* and *S. aegyptiaca* (Qasim et al., 2017; Elsharabasy et al., 2019). But none of the examined halophyte species contained large amounts of hesperetin, quercetin, or kaempferol (Lopes et al., 2021). The existence of quercetin in high concentrations can be directly correlated with the smallest values of IC₅₀ obtained for ethanolic extract in the DPPH experiment.

The results of FTIR spectroscopy on a variety of solvent extracts allowed for the identification of several chemical bonds and functional groups that supported the presence of various phytochemical groups that had been biochemically characterized. It has been demonstrated that FTIR spectroscopy is an accurate and sensitive approach for detecting biomolecular composition. The presence of O-H stretching (3337.2 cm⁻¹, strong, broad) and O-H bending (1,353 cm⁻¹, medium) demonstrated the presence of alcohol, proteins, polyphenols, polysaccharides and/or enzymes (Susanto et al., 2009). Other significant groups detected by FTIR in the various solvent extracts included C-H stretching (2,970.5 cm⁻¹, medium, sharp) for carboxylic acid (Li et al., 2007). The peak at 1353 cm⁻¹ most likely correlates to the amide I bands of

proteins and also C-N stretch vibration (*Gurunathan et al., 2015*). The band at 1643.8 cm^{-1} is caused by C=O stretching of alcohols, nitro and amide 1 group. S-O stretching ($1,318\text{ cm}^{-1}$) and C-halogen bond stretching (566.5 cm^{-1}) indicated the existence of alkyl halide compounds and organic sulfur (*Zhang et al., 2016*).

Understanding the phytochemical components and their concentrations in these plant species may strengthen the foundation for future phytochemical research and food applications.

Additionally, this halophytic plant's crude extract and fractions have notable cytotoxic and antioxidant properties; as a result, coupling the chemical structure of this plant with its biological activities could provide a more successful isolation process that concentrates on their predicted bioactive principles, improving drug development.

To confirm that *S. vera* extract decreases inflammation, we evaluated its effectiveness in treating carrageenan-induced paw edema. In earlier studies, the anti-inflammatory mechanism of the three species of *Suaeda* was examined, with a particular emphasis on the mechanism of lipopolysaccharide (LPS) induced BV-2 cell strains and RAW264.7 as well as rat foot swelling model (*Jong et al., 2007; Samia et al., 2012; Zeineb et al., 2018*).

Carrageenan-induced paw edema is frequently used to evaluate the anti-inflammatory efficacy of both natural and synthetic substances (*Cordaro et al., 2020*). It is known that the carrageenan-induced edema is caused by cell migration, fluid exudation, and the fast release of inflammatory mediators such as bradykinin, histamine and serotonin (*Arulmozhi et al., 2005*). Nitric oxide or prostaglandin (PGs) synthesis may be triggered in the late stages. The synthesis of nitric oxide and prostaglandins (PGs) can be activated by the nitric oxide synthase (iNOS) and inducible COX, which then keep the acute inflammatory response (*Arulmozhi et al., 2005; Musa et al., 2016; Fayez, et al., 2024*). In the present investigation, the suppression of carrageenan-induced edema by *S. vera* ethanolic extract may be related to inhibiting the synthesis of serotonin, bradykinin, and histamine mediators, which in turn inhibits the production of inducible nitric oxide and PGs. This result is comparable to that of the non-steroidal anti-inflammatory medicine diclofenac sodium. These findings were in line with a recent study (*Musa, 2019*) on *Suaeda vera*, which is a halophyte that grows in Saudi Arabia and exhibits promising anti-inflammatory properties in animal models. The phytochemical screening of this halophyte also revealed the presence of tannins and flavonoids.

Based on the findings, it can be concluded that the *Suaeda vera* plant possesses anti-inflammatory properties, highlighting its medicinal significance in reducing inflammation.

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الأنشطة المضادة للأكسدة والمضادة للالتهاب لنبات السويداء الحقيقية

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الملخص العربي

مع مرور الوقت، تم استخدام النباتات الطبية لعلاج الالتهابات والحالات ذات الصلة. في الطب التقليدي، يعتبر جنس السويداء مهمًا لأنه يستخدم علاجيًا. وفقا لعدة دراسات، فإنها تمتلك تأثيرات مضادة للأكسدة، ومضادة للسرطان، ومضادة للبكتيريا. قيمت هذه الدراسة القدرة المضادة للأكسدة والمضادة للالتهابات ونشاط المستخلص الإيثانولي لأوراق نبات سويداء فيرا في نموذج الفئران المستحث بالكاراجينان بجرعات مختلفة (جرعات 100 و 400 ملغم / كغم، عن طريق الفم) لمدة 5 ساعات من العلاج. وفقا للنتائج، يحتوي المستخلص على نسبة عالية من مضادات الأكسدة وقدرة كبيرة على التخلص من الجذور الحرة، مما يؤدي إلى إخماد جذور DPPH (1،1-ثنائي فينيل-2-بيكريل هيدرازيل)، وكذلك جذور فوق أكسيد الهيدروجين. بالإضافة إلى ذلك، يحتوي المستخلص على مركبات الفلافونويد والفينولات، كما تبين من الفحص الكيميائي للنبات. كشفت الدراسة المضادة للالتهابات في الجسم الحي عن تثبيط الالتهاب باستخدام المستخلص بجرعات 100، 200 و 400 ملغم/كغم بقيم 13.39%، و28.75%، و39.65% على التوالي. أظهر ديكلوفيناك الصوديوم، الضابط الايجابي، قيمة تثبيط بلغت 57.45 بالمائة عند جرعة 10 ملغم / كغم. تظهر النتائج أن نبات السويداء الحقيقية لديه القدرة على تقليل الالتهاب، وهو ما يدعم الأهمية الطبية للنبات.