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The Remedial Effect of *Ziziphus lotus* Extract against Oxidative Stress Induced by Deltamethrin Pesticide in Rats

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ABSTRACT

This study investigated the antioxidant properties of natural compounds derived from the medicinal plant *Ziziphus lotus*, traditionally used for treating liver disorders. The research focused on its potential to mitigate biochemical alterations induced by the pesticide Deltamethrin in rats. Thirty male Wistar albino rats were exposed to Deltamethrin (7 µl/kg/day), after which they received aqueous extract of *Ziziphus lotus* at three different doses (100, 200, and 400 mg/kg/day) via oral gavage. After 33 days of treatment, the animals were sacrificed, and blood samples were collected for serum biochemical analysis. Liver tissues were preserved for assessment of antioxidant activity. The extraction process yielded 20%, with a high polyphenol content of 12.04 ± 0.142 mg AGE/mL (Gallic Acid Equivalents per millilitre of extract). The DPPH assay confirmed strong antioxidant potential of the extract, with an IC_{50} value of 0.62 ± 0.146 µg/mL. In vivo results showed that Deltamethrin exposure led to significant reductions in body weight and increases in serum levels of Aspartate Transaminase (AST), Alanine Transaminase (ALT), Alkaline Phosphatase (ALP), alpha-amylase, cholesterol, creatinine, and urea ($p < 0.05$ vs. control), indicating hepatotoxicity and nephrotoxicity. Additionally, antioxidant defence markers such as reduced glutathione (GSH) were diminished, while malondialdehyde (MDA) levels increased, reflecting enhanced lipid peroxidation. Treatment with *Ziziphus lotus* extract at all three doses ameliorated several liver and kidney function markers and restored body weight. The presence of bioactive secondary metabolites in the extract contributed to its significant biological activities, notably its potent antioxidant effects demonstrated both in vitro and in vivo.

Keywords: Natural products, *Ziziphus lotus*, Biochemical alterations, Deltamethrin, Oxidative stress.

INTRODUCTION

Deltamethrin is a modern insecticide that protects vegetables, fruits, and crops from pests such as ants, mites, beetles, and weevils. Its applications include nurseries, golf courses, urban landscaping, residential homes, construction sites, and garden pest management. Additionally, it is utilized as an ectoparasiticide in veterinary practice to reduce vector-borne infections by eliminating mites, flies, fleas, and ticks. Deltamethrin belongs to the synthetic pyrethroid group and is promoted as an alternative to organophosphate chemicals due to its persistent and effective properties [1,2].

However, excessive use, improper application, and mishandling in various fields have accumulated significant amounts of Deltamethrin in water sources and soil [3]. This accumulation results in toxic contamination and causes harm to non-target organisms, including humans. Acute Deltamethrin poisoning manifests with

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clinical symptoms similar to those observed in organophosphorus insecticide poisoning, such as abdominal pain, dizziness, headache, nausea, pulmonary oedema, bronchospasm, fatigue, increased secretions in body tissues, muscle twitching, and vomiting [4].

The toxicity of Deltamethrin is attributed to various mechanisms, including the generation of free radicals. Research predominantly indicates that oxidative stress is a central factor in the toxic effects of Deltamethrin [5]. One study revealed that Deltamethrin exposure significantly increases hepatic lipid peroxidation and weakens the antioxidant defense system, producing oxygen-free radicals and subsequent liver injury [6]. Another study found that Deltamethrin exposure causes kidney damage by modulating apoptotic activity and oxidative stress response [7].

Natural products, particularly those of plant origin, have long been regarded as a significant source of medicinal compounds. Currently, between 25% and 30% of medications used to treat illnesses are derived from natural sources (plants, animals, microbes, and fungi) or are obtained from these sources [8]. Furthermore, current data from the drug industry show that natural products remain an essential source for developing new chemical entities to treat complex diseases, as their structures have been refined over millions of years of evolution to be highly effective [9].

Among these potentially promising natural products, antioxidants like polyphenols have been extensively studied due to their applications in various pharmaceutical fields, such as antibacterial [10], antifungal [11], antidiabetic [12], hepatoprotective [13], and hematoprotective [14], uses as well as in cosmetics and food for their health benefits [15]. Recently, there has been growing interest in the potential of antioxidants to enhance food preservation due to concerns that certain synthetic antioxidants may pose carcinogenic risks [16]. Numerous plants, whether used as food or medicine, contain antioxidant components. Regular consumption of phytonutrients with significant antioxidant properties is associated with a lower incidence of disorders linked to oxidative stress, such as cancers, cardiovascular diseases, and atherosclerosis [17] as well as reduced mortality rates [18].

Considering these beneficial properties of natural products, this study aimed to investigate the remedial effect of **Ziziphus lotus** extract against oxidative stress induced by the Deltamethrin pesticide in rats.

MATERIAL AND METHODS

Reagents and chemicals:

Sigma-Aldrich from the USA was used to purchase all chemicals and was of analytical quality. Deltamethrin pesticide was obtained from Bayer laboratory, and a commercial kit from Spinreact, Spain, was used for biochemical parameter determinations.

Plant material:

Aerial parts (Branches, Leaves, Thorns) of **Ziziphus lotus** were collected from Hamraya, El-Oued state, Algeria, and the plant was identified by Prof. Dr. Atef Chouikh (Faculty of Natural and Life Sciences, El-Oued University, Algeria). The aerial parts of the medicinal herb Ziziphus lotus were cleaned, dried, and powdered, then kept at ambient temperature.

Plant extract preparation:

Two hundred grams of Ziziphus lotus were macerated in 2000 mL of distilled water for 24 hours with continuous agitation at room temperature and protected from light. The solvent was then removed using a rotary evaporator, and the remaining extract was incubated at 40°C until completely dry. The dried extract was weighed and stored at 4°C for subsequent analyses [19]. The extraction yield was 20% w/w based on the initial raw plant material.

Total phenolic content estimation:

The total phenolic content was determined using the Folin–Ciocalteu method. Briefly, 0.1 mL of Ziziphus lotus extract was mixed with 0.2 mL of Folin–Ciocalteu reagent and diluted with 3.16 mL of distilled water. Then, 0.6 mL of

20% sodium carbonate solution was added. After incubating the mixture for 120 minutes at room temperature, the absorbance was measured at 765 nm. The assay was performed in triplicate to ensure data consistency. The phenolic content was expressed as milligrams of gallic acid equivalents per milliliter of extract [20].

DPPH free radical scavenging assay:

2.4 mg of DPPH• is dissolved in 100 ml of methanol to make the 1,1-diphenyl-2-picrylhydrazyl solution. 50 µl of extract (or ascorbic acid as a control) is added to 1.950 ml of the DPPH• solution previously produced. The reaction mixture is quickly agitated and then maintained at ambient temperature for 30 minutes in the dark to complete the reaction. The absorbance of the reaction medium is measured at 515 nm [21].

Liver protective effect of Ziziphus lotus **extract estimation:**

Acute toxicity of Ziziphus lotus extract:

The median lethal dose (LD_{50}) of *Ziziphus lotus* extract was determined following the procedure described by Litchfield and Wilcoxon (1949) [22]. Thirty male Albino rats were divided into five groups of six animals each and administered different oral doses of the extract (25, 250, 500, 1000, and 2000 mg/kg). A control group received distilled water only. The rats were monitored for signs of toxicity and mortality over a 14-day period.

Animals and experiment design:

Thirty adult Wistar albino rats, weighing 352.44 ± 8.77 g, were obtained from the Pasteur Institute of Algiers. They were housed in the Department of Molecular and Cellular Biology at El-Oued University, Algeria, under controlled conditions: temperature 24 ± 1 °C, a 12-hour light/12-hour dark photoperiod, with free access to standard food and water throughout the study. The rats were acclimated to these laboratory conditions for 15 days prior to the experiment. All animal experiments and protocols were approved by the Institutional Animal Ethical Committee (IAEC) of El-Oued University. The rats were then randomly divided into five groups of six animals each and subjected to the following treatments for 33 days:

Group 1: Control group.

Group 2: Received daily Deltamethrin (7 µl/kg/J in oral gavage). [23]

Group 3: Received daily Deltamethrin (7 µl/kg/J in oral gavage) than **Ziziphus lotus** extract (100 µl/kg/J in oral gavage).

Group 4: Received daily Deltamethrin (7 µl/kg/J in oral gavage) than **Ziziphus lotus** extract (200 µl/kg/J in oral gavage).

Group 5: Received daily Deltamethrin (7 µl/kg/J in oral gavage) than **Ziziphus lotus** extract (200 µl/kg/J in oral gavage).

Throughout the weeks of the study, body weight was frequently monitored.

Relative liver weight estimation:

After the rats were sacrificed, the liver was removed, cleaned with physiological saline, and weighed to calculate the relative liver weight using the formula: Relative liver weight = (Liver weight / Body weight) * 100% [24].

Blood collection for biochemical parameters analyses:

After 16 hours of feeding, the rats were sacrificed by decapitation following anaesthesia with chloroform. Blood was then drawn, and the samples were placed into serum-separating tubes and centrifuged for 10 minutes at 3000 rpm to prepare them for biochemical analysis.

Biochemical parameters analyses:

(AST): Serum Aspartate Transaminase (ALT): Alanine Transaminase (ALP): Alkaline Phosphatase, Alpha-amylase, Protein, Glycaemia, Cholesterol, Triglycerides, Creatinine, and Urea.

Liver homogenate parameters:

- Post mitochondrial supernatant preparation

To reduce nuclear debris, 0.5 g of liver from the sacrificed animals was homogenized in a cold phosphate buffer solution (0.1 M, pH 7.4) containing potassium

chloride (1.17%). The resulting homogenate was centrifuged at 9600 rpm for 45 minutes at 4°C to produce a post-mitochondrial supernatant (PMS), which served as the enzyme source.

- Total protein, Glutathione (GSH), and Malondialdehyde (MDA) estimation

Total protein content in liver homogenates was measured using the Coomassie Brilliant Blue G-250 assay, with bovine serum albumin as the standard reference (Bradford, 1976) [25]. Glutathione (GSH) and malondialdehyde (MDA) levels were determined following the methods described by Weckbecker and Cory (1988) [26] and Quintanilha (1981) [27], respectively.

Statistical analysis:

To analyze the obtained data, a student t-test (using Minitab® 13 software) was conducted. P-values of 0.05 or below were considered significant. The results of each experiment were presented as the mean and standard deviation (SD).

Total phenol content:

The total phenol content of **Ziziphus lotus** extract was estimated using the equation (y = 0.00116 x + 0.0375, r2 = 0.09985) and expressed as Gallic Acid Equivalents (GAE). It was 12.04 ± 0.142 mg GAE/ml of the **Ziziphus lotus** aerial part extract.

DPPH free radical scavenging assay:

The antioxidant activity of **Ziziphus lotus aerial** parts extract was tested using the DPPH free radical scavenging assay. The results are summarized in Table 1. The DPPH free radical scavenging activity of the plant extract was compared to that of the standard (ascorbic acid).

Table 01: DPPH free radical scavenging of *Ziziphus lotus* aerial parts extract.

IC_{50}	Ascorbic acid (µg/mL)	*Ziziphus lotus* extract (µg/mL)
	0.43 ±0.102	0.62 ±0.146

Data are expressed as mean±SE (Standard Error), (n=3).

Liver protective effect of Ziziphus lotus extract:

Acute toxicity of Ziziphus lotus extract:

The acute toxicity study, based on the method of Litchfield and Wilcoxon (1949) [22], is a standard preliminary screening test for evaluating new chemical substances. After administering Ziziphus lotus extract at five different doses over a 14-day period, none of the rats in any group showed clinical or behavioral changes, and no mortality was observed (Table 2).

Table 02: Rat's acute toxicity analyses treated by *Ziziphus lotus* aerial parts extract.

Group	Doses (mg/kg)	Mortality rate	Mortality ratio	Mortality (%)
Group 1	25	0	0/5	0
Group 2	250	0	0/5	0
Group 3	500	0	0/5	0
Group 4	1000	0	0/5	0
Group 5	2000	0	0/5	0

Relative liver weight:

The results of relative liver weight show that body weight was affected by the Deltamethrin pesticide and the plant extract. Additionally, Group 2 (treated with Deltamethrin) showed liver hypertrophy. In contrast, the extract of **Ziziphus lotus**, when administered at different doses in combination with Deltamethrin pesticide, reduced the elevated liver weight. The results of relative liver weight are summarized in Table 3.

Table 03: Rats' relative liver weight treated by *Ziziphus lotus* aerial parts extract.

Groups	Body weight (g)	Liver weight (g)	Relative liver weight (%)
Group 1	367.35 ± 3.9	12.1±0.74	2.600 ±0.1
Group 2	351.66□± □□□□ ***	10.38 ±0.75***	□□□□□± □□□□□***
Group 3	354.5□□± □□□*	9.35 ±0.44**	2.500 ±0.0816***
Group 4	361.90 ±3.8**	9.97 ±0.12*	2.650 ±0.191***
Group 5	365.4□□±□□□□□□□	10.32 ±0.58Ns	2.725 ±0.097**

Results are presented as the mean ± S.E. (Standard Error) (n = 5). (*) p≤0.05, (**)p≤0.01 and (***)p≤0.001. (NS)p > 0.05 as compared with Deltamethrin pesticide. Model group. bp < 0.05 as compared with a normal control group.

Biochemical parameters analyses:

- Serum enzyme activity

Figure 1 illustrates the effect of Ziziphus lotus aerial parts extract on serum enzyme activities (ALT, AST, ALP, and alpha-amylase). Exposure to the pesticide Deltamethrin caused a significant increase in serum enzyme activities. However, rats pretreated with Ziziphus lotus extract at various doses showed a notable reduction in these enzyme levels.

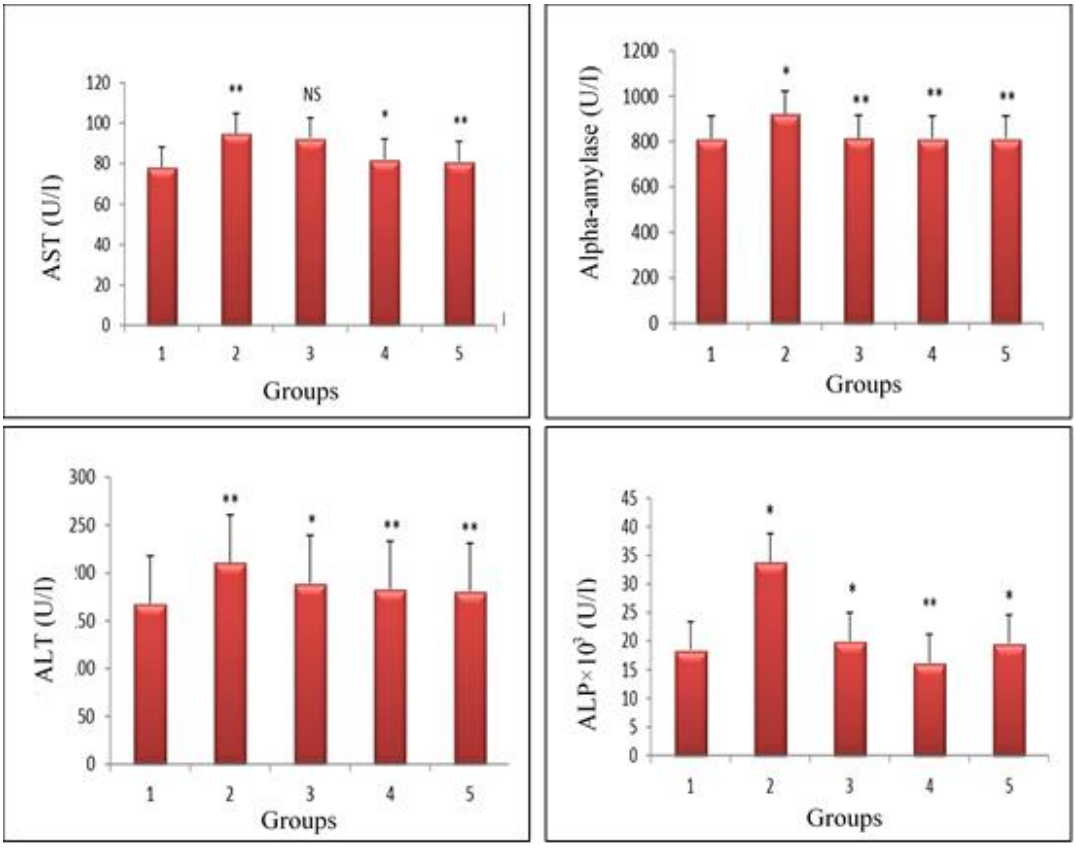

Figure 1: Effect of *Ziziphus lotus* aerial parts extract on serum enzyme activity.

(AST): Serum Aspartate Transaminase, (ALT): Alanine Transaminase, (ALP): Alkaline Phosphatase, Results are presented as the mean ± S.E. (Standard Error) (n = 5). (*) p≤0.05, (**) p≤0.01 and (***) p≤0.001. (NS) p > 0.05 as compared with Deltamethrin pesticide. Model group. bp < 0.05 as compared with a normal control group.

- Serum biochemical parameters

Administration of the pesticide Deltamethrin caused a significant increase in the analyzed serum biochemical parameters. The mitigating effects of Ziziphus lotus aerial parts against Deltamethrin-induced damage are shown in Figure 2.

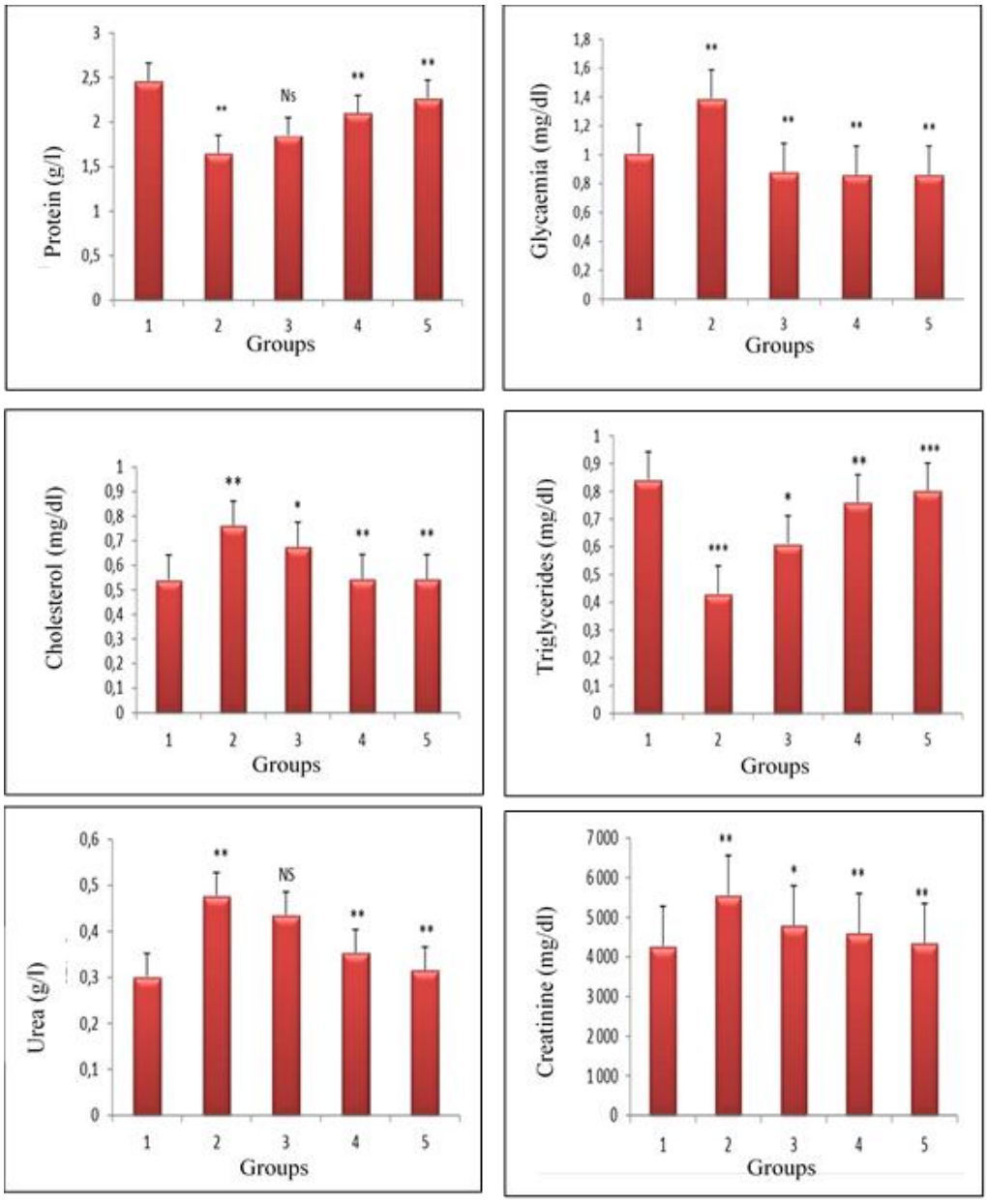

Figure 2: Effect of *Ziziphus lotus* aerial parts extract on biochemical parameters.

Results are presented as the mean ± S.E. (Standard Error) (n = 5). (*) p≤0.05, (**) p≤0.01 and (***) p≤0.001. (NS) p > 0.05 as compared with Deltamethrin pesticide. Model group. bp < 0.05 as compared with a normal control group.

-Liver enzyme activity (GSH and MDA):

The administration of the pesticide Deltamethrin caused alterations in liver oxidative stress markers, specifically Glutathione (GSH) and Malondialdehyde (MDA) levels. Figure 3 summarizes the protective effects of *Ziziphus lotus* aerial parts against Deltamethrin-induced liver damage.

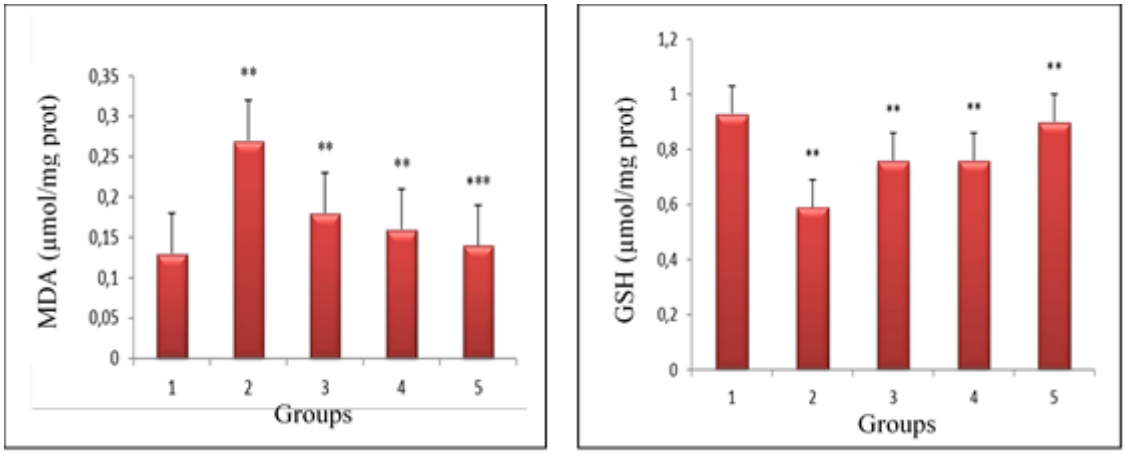

Figure 3: Effect of *Ziziphus lotus* aerial parts extract on liver enzymes activity.

(GSH): Glutathione. (MDA): Malondialdehyde. Results are presented as the mean ± S.E. (Standard Error) (n = 5). (*) $p \leq 0.05$, (**) $p \leq 0.01$ and (***) $p \leq 0.001$. (NS) $p > 0.05$ as compared with Deltamethrin pesticide. Model group. bp < 0.05 as compared with a normal control group.

DISCUSSION

This series of tests was conducted to evaluate the antioxidant capacity of *Ziziphus lotus* extract both in vitro, using the DPPH assay, and in vivo against Deltamethrin pesticide poisoning. The results are, in several respects, quite promising. Overall, the tests demonstrated consistency for extracts of similar nature, with plant extracts consistently exhibiting strong antioxidant potency. Based on these findings, a strong correlation can be established between the abundance of secondary metabolites (polyphenolics) in the aerial parts of *Ziziphus lotus*, including its aqueous extract, and the high level of antioxidant activity observed.

In this study, the maceration method with agitation accelerated the extraction process by minimizing the contact time between solvent and plant material while preserving the bioactivity of the constituents. Furthermore, extracting at room temperature and removing the solvent under reduced pressure enabled maximum recovery of compounds and prevented potential denaturation or modification due to high temperatures [28]. Approximately 4 g of aqueous extract was obtained from the water extraction of *Ziziphus lotus* aerial parts, corresponding to a 20% yield. Generally, concentrations in crude extracts vary among plants within the same family, depending on factors such as solid-liquid extraction conditions, extraction solvent, particle size, and solvent diffusion coefficient [29].

According to the results, the aqueous extract of *Ziziphus lotus* aerial parts contained a remarkably high amount of total polyphenols, measured at 12.04 ± 0.142 mg GAE/ml. In contrast, our findings differ from those of Djemai Zoughlache (2009) [30], who reported lower total polyphenol levels in raw extracts prepared with polar solvents (methanolic and aqueous) from *Ziziphus lotus* fruits collected in the Batna region of Algeria. In

Zoughlache's study, the total polyphenol content was 5.8 ± 1.24 µg GAE/mg.

The DPPH free radical scavenging assay results demonstrate the promising effect of polyphenolic substances in plant extracts, which act as primary antioxidants [31,32]. Generally, our results indicate that the aqueous extract of Ziziphus lotus exhibits strong activity in scavenging DPPH free radicals, with an IC50 of 0.43 ± 0.102 µg/mL. The efficacy of these antioxidants is attributed to their ability to donate hydrogen atoms or electrons, primarily from hydroxyl groups in flavonoids [20]. Indeed, polyphenolic compounds, especially flavonoids, are recognized as potent antioxidants capable of scavenging radical species and reactive forms of oxygen [33]. The scavenging effect of flavonoids is due to their low redox potential, which enables them to reduce free radicals by transferring hydrogen atoms from hydroxyl groups [34].

Male rats were orally administered different doses (25, 250, 500, 1000, and 2000 mg/kg) of Ziziphus lotus aerial parts extract and observed for 14 days in the acute toxicity study. These findings are consistent with earlier research demonstrating that extracts from medicinal plants can be safe even at high doses, such as Marrubium vulgare (2000 mg/kg) [23], Euphorbia hirta (5000 mg/kg) [35], and Lactuca serriola (6000 mg/kg) [56]. Moreover, to ensure greater confidence in the safety of natural products intended for human use—especially in pharmaceutical applications—data from acute toxicity studies of medicinal plants should be thoroughly evaluated [36].

Many xenobiotics, especially pesticides, are believed to produce reactive oxygen species (ROS) or even free radicals that cause oxidative stress in biological systems [37]. A significant reduction in mean body weight indicates general health deterioration in rats, which a decrease in daily food intake could explain. Previous studies on adult rats treated with pesticides also showed decreased body weight [38,39]. Moreover, rats given pesticide treatments exhibited a significant increase in their relative organ weights, particularly in the liver, showing hepatic hypertrophy (hepatomegaly). Numerous authors have described this anomaly as a consequence of the aggressive effects of various chemicals and pesticides [40].

Similarly, Prieto-Simón et al. (2006) [41] observed that a biomarker of pesticide cytotoxicity is a decrease in the relative weights of several animal organs. In contrast, the relative liver weights of intoxicated rats decreased following the oral administration of **Ziziphus lotus** plant extract. This improvement is attributed to the protective effects of the bioactive components in the plant extract against Deltamethrin pesticide toxicity.

Decreased levels of serum enzymes AST, ALT, ALP, and alpha-amylase were observed in rats treated with different doses of Ziziphus lotus plant extract following intoxication with Deltamethrin pesticide. Serum enzymes TGO (AST) and TGP (ALT) are synthesized in the cytoplasm of cells and are released into circulation when cellular damage occurs [42,43]. These enzymes serve as reliable indicators of liver cytolysis. Additionally, ALP reflects pathological changes in biliary flow [44]. Conversely, elevated levels of the pancreatic enzyme alpha-amylase were observed. The results showed that Deltamethrin pesticide increased alpha-amylase levels (Group 2), potentially impairing pancreatic function and reducing insulin secretion [45]. In contrast, rats treated with Ziziphus lotus extract demonstrated improved pancreatic function, as indicated by normalized alpha-amylase levels, which play a role in glucose regulation [46].

Results for biochemical metabolites such as triglycerides and cholesterol, along with renal indicators including creatinine and urea, demonstrate that these parameters are adversely affected by cytotoxic agents like the Deltamethrin pesticide. Elevated levels of renal markers, lipids (cholesterol), and proteins were observed. Since the kidneys are responsible for excreting harmful by-products of protein metabolism—such as creatinine and urea—[47], the

increased blood levels of these substances in this study suggest impaired kidney function. This impairment was also accompanied by a significant decrease in serum protein levels [48]. Additionally, some studies propose that synthetic chemicals, including pesticides, may negatively impact thyroid function [49,50,51]. Hyperlipidemia has been linked by some researchers to hypothyroidism or reduced lipase activity [52]. Treatment with various doses of *Ziziphus lotus* extract helped restore these metabolite levels to normal.

Toxic effects often originate from alterations in the endoplasmic reticulum, resulting in the loss of intracellular components such as metabolic enzymes [53]. A healthy organism possesses a robust defense system to prevent and neutralize damage caused by free radicals. Endogenous antioxidant enzymes, including glutathione (GSH) and malondialdehyde (MDA), play vital roles in protecting cells against reactive oxygen species [54]. In this study, the intoxicated group exhibited decreased GSH levels alongside excessive hepatic MDA production. Similar findings were reported by Djahra et al. (2020b) [13], who observed these changes following oral exposure to the insecticide Lambda-cyhalothrin at 62.5 mg/L per day. The normalization of hepatic function after administration of *Ziziphus lotus* extract underscores the extract's beneficial antioxidant properties, consistent with findings by Zeghib and Djahra (2019) [55].

CONCLUSION

This study reaffirmed the protective potential of natural compounds, particularly polyphenolics, present in Ziziphus lotus extract. The extract exhibited a significant modulatory effect on biochemical parameters commonly disrupted by oxidative damage following intoxication with the Deltamethrin pesticide.

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Conflicts of interest

The authors declare no conflicts of interest.

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الأثر العلاجي لمستخلص نبات *Ziziphus lotus* ضد الاجهاد التأكسدي الناتج عن مبيد Deltamethrin على الفئران

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ملخص

اختبرت هذه الدراسة الخصائص المضادة للأكسدة للمركبات الطبيعية المستخلصة من نبات السدر (Ziziphus lotus) الطبي، الذي استُخدم تقليديًا لعلاج اضطرابات الكبد ومقاومة التغيرات البيوكيميائية التي يُحدثها مبيد الحشرات دلتامثرين في الجرذان. شملت التجربة 30 جرذًا ذكرًا من نوع ويستر ألبينو، تم تعريضهم لمبيد دلتامثرين (7 ميكرولتر/كغ/يوم). بعد ذلك، تم إعطاء الجرذان مستخلصًا مائيًا من نبات السدر بثلاث جرعات مختلفة (100، 200، و400 مغ/كغ/يوم) عبر التغذية الأنبوبية. بعد 33 يومًا من العلاج، تم التضحية بالجرذان وجمع عينات الدم لتحليل المصل البيوكيميائي. كما تم حفظ أنسجة الكبد لتقييم التأثيرات مضادات الأكسدة. أظهرت النتائج أن عملية الاستخلاص المائي أنتجت 20%، مع تركيز عالٍ من البوليفينولات بلغ 0.142± 12.04 مغ مكافئ حمض الجاليك لكل ملليلتر من المستخلص. علاوة على ذلك، أظهر اختبار DPPH أن مستخلص السدر أبدى نشاطًا مضادًا للأكسدة بشكل كبير، حيث بلغت قيمة 0.146 ± IC50=0.62 ميكروغرام/ملل. أظهرت نتائج النشاط المضاد للأكسدة في الجسم الحي أنه في المجموعة المعرضة لدلتامثرين، انخفض وزن الجسم، بينما زادت مستويات أنزيمات الأسبارتات ترانساميناز (AST) والألانين ترانساميناز (ALT) والفوسفاتاز القلوي (ALP) والأميليز ألفا والكوليسترول والكرياتينين واليوريا ($p < 0.05$ مقابل مجموعة الشاهد)، مما يشير إلى وجود سمية كلوية وكبدية. كما انخفضت مستويات بيروكسيد الدهون (GSH) للدفاعات المضادة للأكسدة وزادت تركيزات المالونديالديهيد (MDA). أدى العلاج بمستخلص السدر بجرعاته الثلاثة إلى تحسين بعض وظائف الكبد والكلى وزيادة وزن الجسم. كما أثبتت وجود المركبات الثانوية في مستخلص السدر أن لها أنشطة بيولوجية كبيرة ومثيرة للاهتمام، بما في ذلك خصائص مضادة للأكسدة قوية في الاختبارات المخبرية وفي الجسم الحي.

الكلمات الدالة: المنتجات الطبيعية، *Ziziphus lotus* ، التغيرات البيوكيميائية، دلتامثرين، الإجهاد التأكسدي.

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