

The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 2026

Volume 42, Pages 76-84

ICBASET 2026: International Conference on Basic Sciences, Engineering and Technology

Assessment of *Thymus numidicus* and *Lavandula stoechas* Essential Oils Effects on Deltamethrin-Induced Toxicity in Female Rabbits

Farida Fernane

Mouloud Mammer's University

Nacira Daoudi-Zerrouki

Mouloud Mammer's University

Ouardia Chaouchii

Mouloud Mammer's University

Hakima Aitissad

Mouloud Mammer's University

Abstract: *Thymus numidicus* and *Lavandula stoechas* are aromatic and medicinal plants belonging to the Lamiaceae family. They are widespread in Algeria and used in traditional medicine and in the culinary arts. Deltamethrin is a chemical compound belonging to the pyrethroid family. It is mainly used as an insecticide and repellent for insects or snakes due to its neurotoxic properties. This study aims to evaluate the protective effects of *Thymus numidicus* (TNEO) and *Lavandula stoechas* (LSEO) essential oils against deltamethrin-induced toxicity in female rabbits. The chemical composition and biological activities of these two essential oils were assessed beforehand. The GC/MS analysis revealed that both essential oils are rich in monoterpene hydrocarbons and oxygenated monoterpenes. In TNEO, the major compounds identified were thymol and carvacrol, whereas in LSEO, fenchone and camphor. The antibacterial activity results showed that TNEO exhibited strong inhibitory effects against Gram-positive bacteria, while its activity was lower against Gram-negative strains. On the other hand, LSEO demonstrated moderate antibacterial activity against both Gram+ and Gram- bacteria. The administration of deltamethrin at 1.28mg/kg/day for 14 days induced significant hematological, biochemical, and histopathological damage in both the liver and kidneys of female rabbits. The combination of *Thymus numidicus* and *Lavandula stoechas* essential oils exhibited a remarkable protective effect against the biochemical and histopathological alterations caused by deltamethrin exposure.

Keywords: *Thymus numidicus*, *Lavandula stoechas*, Essential oils, Deltamethrin, Toxicity

Introduction

Over recent decades, essential oils (EOs) have attracted growing interest as promising agents for protecting against oxidative damage (Gupta et al. 2023). Essential oils have long been recognized for their medicinal value; they are a rich source of bioactive compounds with a wide range of therapeutic, industrial and environmental applications. They are increasingly regarded as valuable alternatives for mitigating the harmful effects of toxic agents, as well as for the prevention and treatment of various diseases (Borromeo et al., 2024; Küçükler et al., 2021; Domingues et al., 2021). Among these, the essential oils of *Thymus numidicus* (TN) and *Lavandula stoechas* are important in both traditional medicine and culinary practices (Messara et al., 2018; Boukhatem et al., 2021; Yildizhan et al., 2023). These two species of the Lamiaceae family are distinguished by their remarkable pharmaceutical properties, and their antioxidant, anti-inflammatory, and antibacterial activities (Messara et al., 2018; Kaki et al., 2021; Rasheed et al., 2023).

- This is an Open Access article distributed under the terms of the Creative Commons Attribution-Noncommercial 4.0 Unported License, permitting all non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

© 2026 Published by ISRES Publishing: www.isres.org

Pesticides are chemical substances used to control pests such as insects, pathogens, and weeds (Alokail et al., 2024; Yadav & Devi, 2017). Their widespread use poses a major threat to both public health and the environment due to their accumulated toxic effects (Makhlouf et al., 2025). According to WHO data prolonged exposure to pesticides is associated with adverse health effects, including endocrine disruption, neurological disorders, and an increased risk of cancer (Alokail et al., 2024; Bellala et al., 2022; Chargui et al., 2012). Depending on their chemical properties, pesticides may accumulate in the food chain and in various biological fluids such as blood, urine, and cerebrospinal fluid (Benedetti et al., 2018; Carvalho et al. 2017; and Mohammed et al., 2022). Among the organs most affected by pesticide toxicity, the liver and kidneys play a central role. The liver is the organ responsible for metabolism and detoxification, ensuring the biotransformation of endogenous and exogenous compounds (Mohammed et al., 2022). The kidneys, for their part, are essential for the elimination of metabolic waste and the maintenance of homeostasis (Sharma et al., 2014; Saoudi et al., 2017; Küçükler et al., 2021).

Deltamethrin is a synthetic pyrethroid insecticide widely used for controlling pests in agriculture and public health programs (Basak et al., 2021; Bellala et al., 2022; Ilyas et al., 2023; Kangyuan Qu et al., 2024; Sharma et al., 2014). Its popularity is due to its effectiveness, low mammalian toxicity, and rapid degradation in the environment (WHO, 2011). However, the use of deltamethrin has raised concerns over its potential toxicity towards non-target organisms, including humans, pets, and wildlife.

Therefore, understanding the toxicity of deltamethrin is critical for its safe use and protecting the environment and human health. The WHO has set a maximum residue limit (MRL) of 5 mg/kg, but exposure to this concentration has been linked to histological alterations in the gastric mucosa (Halima et al., 2023). As a lipophilic molecule, it accumulates in fat-rich tissues such as eggs, muscles, and adipose tissues, as well as in aquatic ecosystems and agricultural soils, sometimes exceeding regulatory limits (Yadav et al., 2023)

The main objective of this study is to evaluate the therapeutic potential of *Thymus numidicus* and *Lavandula stoechas* essential oils by evaluating their protective effect against deltamethrin-induced toxicity in female rabbits.

Method

Extraction and GC-MS Analysis of Essential Oils

Samples of the aerial parts of the *Thymus numidicus* (TN) and *Lavandula stoechas* (LS) harvested were dried in the open air and protected from light for two weeks. After drying, the essential oils were extracted by hydrodistillation using a Clevenger-type apparatus. The chemical composition of the essential oils (TNEO and LSEO) was carried out by gas chromatography–mass spectrometry (GC-MS) using a Shimadzu gas chromatograph coupled with a selective mass detector. The system was equipped with an auto-sampler injector and an HP-5 fused silica capillary column (30 m × 0.25 mm, 0.25 µm film thickness). Helium was used as the carrier gas at a flow rate of 0.5 mL/min. The ionization voltage of the mass spectrometer was set to 70 eV.

In Vivo Toxicity Study

The study involved forty healthy nulliparous female rabbits. The rabbits were 4 months old and had an average body weight of 2600 ± 200 g. The rabbits were ear-tagged and divided into eight groups of six females each. The animals were kept in individual cages and all the necessary procedures were carried out in accordance with the standard laboratory conditions. These conditions included a 12-hour light/dark cycle, a temperature of $25 \pm 3^\circ\text{C}$ and adequate ventilation. The rabbits were given a standard commercial pellet diet and had free access to drinking water ad libitum. The study was conducted over 28 days, divided into two distinct periods: the acclimatization and the treatment period (OCDE, 2008).

The rabbits underwent a 14-day acclimatization period to adapt to the experimental conditions. After this period, the animals were randomly divided into different groups and received repeated doses of deltamethrin and/or essential oils by oral gavage once daily for 14 consecutive days. The control group received corn oil under the same conditions (Table 1). This was done in accordance with European Directive 2010/63/EU on the protection of animals used for scientific purposes.

Several studies (Rohan Yadav et al., 2023; Mohammed et al., 2022; Yousef et al., 2006) have used a deltamethrin dose of 1.28 mg/kg, corresponding to 1/100 of the median lethal dose (128 mg/kg). Based on these data, we selected the same dose (1.28 mg/kg) for our experiments. The essential oil dose was set at 0.5 mg/kg, based on previous work (Bokreta et al., 2021).

Table 1. The allocation of experimental groups

Groups	Treatment
Group S	Group received corn oil
Group P	Deltamethrin (DM) treated group received 1.28 mg/kg/d BW
Group TNEO	<i>Thymus numidicus</i> essential oil (TNEO) treated group received 0.5mg/kg/d BW
Group P+TNEO	(Deltamethrin + TNEO) treated group received 1.28 mg/kg/d BW of Deltamethrin followed by 0.5 mg/kg/d BW after 1 h of DM administration
Group LSEO	<i>Lavandula stoechas</i> essential oil (LSEO) treated group received 0.5mg/kg/d BW
Group P+LSEO	Deltamethrin+ LSEO treated group received 1.28 mg/kg/d BW of Deltamethrin followed by 0.5 mg/kg/d BW of LSEO after 1 h of DM administration
Group X	Group received 0.5mg/kg/d BW of LSEO and 0.5mg/kg/d BW of TNEO
Group P+X	Group received 1.28 mg/kg/d BW of Deltamethrin followed by 0.5mg/kg/d BW of LSEO and 0.5mg/kg/d BW of TNEO after 1 hour of DM administration

d BW : per day and body weight

After dissection, the hides were removed immediately and organs (Kidneys and liver) were removed, weighed and measured to prevent any tissue degradation, then preserved in dry tubes filled with 10% formaldehyde (formalin) solution until uses. The coverslips were mounted onto the slides using a mounting machine after the slides had been stained and dried. The histological slides were observed and photographed using an optical microscope "micros Austria" which was equipped with a digital camera. Image acquisition was performed using ImageView (version x64, 4.10.17614.20200822) software, which allowed for precise and detailed capture of histological structures. Data were statistically analyzed to establish the dose–response relationship and to assess the significance of the observed alterations.

Results and Discussion

Chemical Composition of Essential Oils

Essential oils of *Thymus numidicus* (TNEO) and *Lavandula stoechas* (LSEO) are both rich in monoterpenes and oxygenated monoterpenes (Tables 2 and 3, respectively). For TNEO, 16 major compounds are identified with thymol is the most predominant compound (32.71%), followed by carvacrol (10.3%), γ -terpinene (9.0%), and p-cymene (8.0%). For LSEO, 13 major compounds are mentioned (Table 3). The results indicate a predominance of camphor (25.32%), followed by fenchone (19.16%) and eucalyptol (5.99%).

Table 2. Chemical composition of *Thymus numidicus* EO (TNEO)

Retention time (min)	Compounds	%
9.1	α -thujene	1.0
9.4	α -Pinene	4.3
10.8	1-Octen-3-ol	1.1
11.1	β -Myrcene	2.5
11.9	α -Terpinene	2.9
12.1	p-Cymene	8.0
12.2	Limonene	1.8
13.1	γ -Terpinene	9.0
13.3	Cis-Sabinene hydrate	1.0
14.1	Linalool	1.7
17.4	Thymol methyl ether	1.2
18.9	Thymol	32.7
19.1	Carvacrol	10.3
21.6	Caryophyllene	4.0
23.1	β -Bisabolene	4.4
23.5	δ -Cadinene	1.1

Table 3. Chemical composition of *Lavandula stoechas* EO (LSEO)

Retention time (min)	Compounds	%
9.4	α -Pinene	1.4
9.9	Camphene	2.9
12.2	D-Limonene	1.0
12.3	Eucalyptol	6.0
14.0	Fenchone	19.2
15.6	Camphor	25.3
15.9	Borneol	1.7
16.3	p-Cymen-7-ol	3.9
16.9	Eucaryone	1.8
18.7	Borneyl acetate	3.4
19.5	Myrtenyl acetate	2.0
24.9	Viridiflorol	1.8
25.1	Cubebol	1.2

In Vivo Toxicity Study

Animal's Behavior

During the acclimation period, the female rabbits remained calm, with no notable behavioral changes observed across all groups, indicating good adaptation to the experimental conditions. However, during the treatment period, rabbits in the DLM-treated groups showed significant behavioral disturbances starting from the first hour of administration. These included tremors, agitation, unusual hyperactivity, tachycardia, and stereotyped behaviors such as excessive grooming and repetitive circular movements upon being returned to their cages. These alterations were particularly noticeable during the first two days of treatment and appeared to subside approximately one hour after gavage. These manifestations may be attributed to esophageal irritation caused by pesticide. In contrast, no behavioral changes were observed in the control group (S) or in the group treated with essential oils (TNEO and LSEO).

Histomorphological on Kidneys

The control group showed normal morphological features, with no signs of hemorrhage or pyknosis (Figure 1A). In the renal cortex, the Malpighian corpuscles appeared well-organized, with rounded glomeruli and a clearly defined Bowman's space, capillary and mesangial cells are clearly visible. No structural alterations were observed in the glomeruli, proximal convoluted tubules, or distal convoluted tubules, indicating that the renal structure remained intact and unaffected under the experimental conditions.

The group of female rabbits treated with Deltamethrin (DLM) at a dose of 1.28 mg/kg/day showed significant destruction of renal structures, observable at both low and high magnifications (Figure 1B). In the group of female rabbits treated separately with TNEO (Figure 1C) and LSEO (Figure 1E), the glomeruli and renal tubules appear overall well-preserved. However, vascular dilation and possible red blood cell accumulation suggest a slight vascular disturbance, which may indicate mild toxicity. Notably, the toxic effects appear to be more pronounced in the LSEO-treated group, as evidenced by more visible vascular alterations and congestion (Figure 1E). Figure 1F showed that the DLM+LSEO-treated group had no major alterations in renal structure, no cellular disorganization or destruction, and numerous well-rounded glomeruli surrounded by renal tubules. However, the group treated with the mixture of the two essential oils (TNEO + LSEO) showed mild vascular congestion and preserved renal architecture, with intact glomeruli and no signs of inflammatory infiltration (Figure 1G). This suggests that the simultaneous combination of these two essential oils induces a protective effect against renal toxicity induced by DLM (Figure 1H).

Histomorphological on Liver

Histological observation of the liver sections shows that the control group (Figures 2A) exhibits well-preserved hepatic architecture, characterized by hepatocytes arranged in radial cords around the central vein. The hepatic lobules are well-defined, composed of hepatocytes with a regular shape, organized in plates and radially arranged around a central vein, known as the centrilobular vein. The hepatic sinusoids are well-defined, with no

signs of congestion, inflammation, or necrosis. The absence of structural abnormalities suggests a normal physiological state of the hepatic tissue.

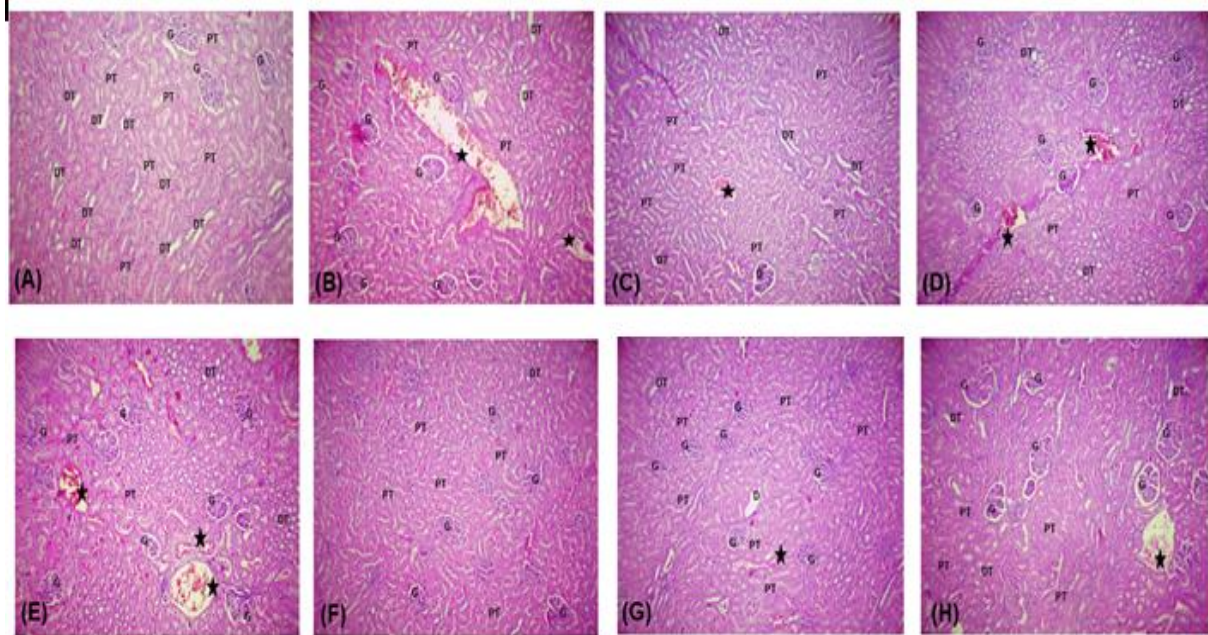


Figure 1. Histological sections of kidney tissue from female rabbits (H&E staining, $\times 100$ magnification). Comparison between the control group (A), the DLM-treated group (B), the TNEO treated group (C), the DLM+TNEO-treated group (D), the LSEO treated group (E), the DLM+LSEO – treated group (F), TNEO+LSEO treated group (G) and DLM + TNEO + LSEO treated group (H) (G: Glomeruli; DT: Distal Tube; PT: Proximal Tube; and ★ hemorrhages)

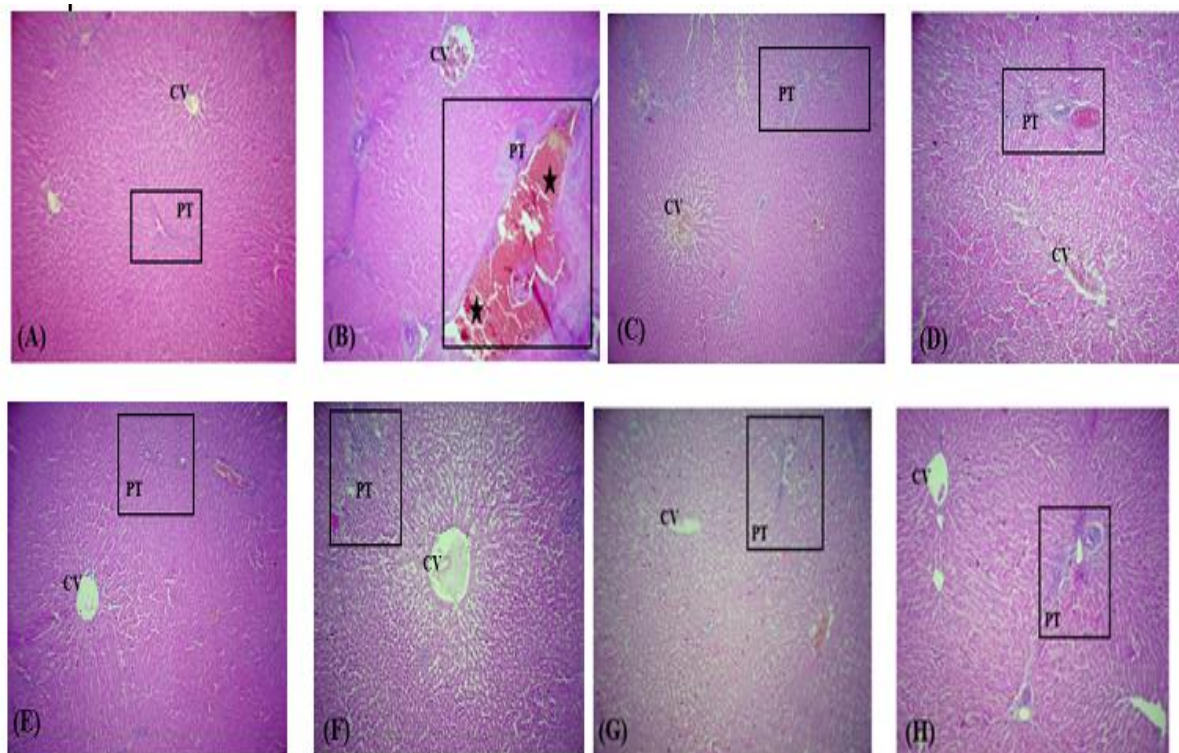


Figure 2. Histological sections of liver tissue from female rabbits (H&E staining, $\times 100$ magnification). Comparison between the control group (A), the DLM-treated group (B), the TNEO treated group (C), the DLM+TNEO-treated group (D), the LSEO treated group (E), the DLM+LSEO – treated group (F), TNEO+LSEO treated group (G) and (DLM + TNEO + LSEO) treated group (H) (CV: Central Vein; PT: Portal Triad; and ★ hemorrhages)

The group of female rabbits treated with Deltamethrin (DLM) at a dose of 1.28 mg/kg/day exhibits hepatic lesions characterized by significant histopathological alterations (Figure 2B). Necrosis, hemorrhages, and dilation of the sinusoids and portal spaces are observed. Additionally, inflammation with cellular infiltration is evident, indicating severe hepatic damage (Figure 2B). The liver of the TNEO-treated group exhibits visible sinusoidal dilation and vascular congestion (Figure 2C). Small scattered hemorrhagic areas are also observed, along with mild inflammatory infiltrates. However, the overall hepatic architecture remains preserved, suggesting moderate toxicity (Figure 2C). The group treated with DLM+TNEO (Figure 2D), exhibits significant dilation of the portal spaces and enlarged sinusoids, which may indicate blood congestion or hepatic distress. A slight perivascular edema is also observed, suggesting a moderate inflammatory reaction.

Although hepatocytes are generally preserved, signs of cellular stress are evident (Figure 2D). The liver of the LSEO-treated group exhibits modifications in the portal spaces, characterized by dilation and a clearer appearance around the vessels, suggesting the presence of edema (Figure 2E). A mild inflammatory infiltrate is visible in the portal space, marked by dark cells around the vessel, indicating a moderate inflammatory response. Hepatocytes are generally preserved, but a slight dilation of the sinusoids is observed, potentially indicating moderate congestion, which may suggest hepatic distress or moderate toxicity (Figure 2E). The liver of DLM+LSEO treated group exhibits hypertrophy of the portal space accompanied by perivascular inflammation (Figure 2F). An inflammatory infiltrate, in the form of small dark cells surrounding the vessel, is observed, indicating an inflammatory reaction (Figure 2F). Vascular congestion is also noted, with an accumulation of red blood cells in the vessels, suggesting an alteration in hepatic blood circulation. Furthermore, the clear zone around the vessel may reflect an inflammatory response and could be an early sign of hepatic fibrosis (Figure 2F). The liver of the group treated with both essential oils (TNE + LSEO) exhibits generally preserved hepatocytes, although the sinusoids appear slightly more visible (Figure 2G). No inflammatory infiltrate is observed, but moderate signs of hepatic distress are present (Figure 2G). The group of female rabbits treated with DLM and both essential oil (TNEO and LSEO), exhibits dilation of the portal spaces, with a clear halo around the vessels, suggesting the presence of marked perivascular edema (Figure 2H). An inflammatory infiltrate is also observed, along with slight modifications in the sinusoids. Additionally, possible hepatocyte alterations are noted, indicating signs of intermediate hepatic distress (Figure 2H).

Conclusion

The present study clearly demonstrates that administration of DLM at 1.28 mg/kg/day for 14 days, acting on the nervous system induced significant histopathological damage in both the liver and kidneys. Our findings are consistent with those reported by Saoudi et al., (2017), who observed marked renal histopathological alterations in rats treated with an intraperitoneally injection of deltamethrin at a dose of 7.2 mg/kg body weight, including tubular epithelial cell necrosis and vacuolation.

In the kidneys, DLM caused glomerular alterations suggestive of atrophy and inflammation, tubular dilatation, and cellular damage (pyknosis), consistent with previous reports of DLM-induced nephrotoxicity. Saoudi et al. (2017) observed tubular necrosis and vacuolation in rats, while Jiang et al. (2024) linked DLM to renal fibrosis via the TGF- β /Smad2/3 pathway and noted inflammatory infiltration. The observed glomerular proliferation and capillary compression in our study might reflect an acute inflammatory response or early glomerulonephritis (Ahmadvand et al., 2016; Yildizhan et al., 2023).

The liver, as the primary site of detoxification, is particularly vulnerable to damage from xenobiotics like DLM. Similarly, the liver exhibited severe lesions following DLM exposure, including hepatocyte necrosis, hemorrhage, sinusoidal dilation, and inflammation. These findings align with the known hepatotoxicity of DLM, attributed mainly to its metabolism in the liver leading to the generation of reactive oxygen species (ROS) and subsequent oxidative damage (Abdel-Daim et al., 2015; Küçükler et al., 2021).

The administration of essential oil alone induced mild histological changes, primarily vascular congestion in both organs and slight inflammation in the liver. This suggests that the dose used (0.5 mg/kg/day) might have slight pro-inflammatory or vasoactive effects, or it could reflect a physiological response. However, the overall architecture remained preserved, indicating low intrinsic toxicity at this dose under the current experimental conditions. The hemorrhages observed in the liver of the TN-treated group may be due to thymol metabolism (Liu et al., 2022). Although the use of EO rich in monoterpenes is generally considered safe, an overdose can be harmful to humans (Wojtunik-Kulesza, 2022).

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the authors.

* The animal experiments in this study were conducted in accordance with European Directive 2010/63/EU on the protection of animals used for scientific purposes. All experimental procedures were approved by the Ethics Committee of Mouloud Mammeri University in Tizi-Ouzou, (Approval Number: UMMTO/2022/Ani024).

Conflict of Interest

* The authors declare that they have no conflicts of interest

Funding

* This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Basic Sciences, Engineering and Technology (www.icbaset.net) held in Istanbul/Türkiye on September 17-18, 2026.

References

- Abdel-Daim, M. M., & El-Ghoneimy, A. (2015). Synergistic protective effects of ceftriaxone and ascorbic acid against subacute deltamethrin-induced nephrotoxicity in rats. *Renal Failure*, 37(2), 297–304.
- Ahmadvand, H., Ghabaee, D. N. Z., Malekshah, A. K., & Navazesh, A. (2016). Virgin olive oil ameliorates deltamethrin-induced nephrotoxicity in mice: A biochemical and immunohistochemical assessment. *Toxicology Reports*, 3, 584–590.
- Alokail, M. S., Elhalwagy, M. E. A., Abd-Alrahman, S. H., Alnaami, A. M., Hussain, S. D., Amer, O. E., Sabico, S., & Al-Daghri, N. M. (2024). Pesticide residues and associated health effects in marketed fruits in Saudi Arabia. *Arabian Journal of Chemistry*, 17(11), 105993.
- Basak, M., Choudhury, R. A., Goswami, P., Dey, B. K., & Laskar, M. A. (2021). A review on non-target toxicity of deltamethrin and piperonyl butoxide: Synergist. *Journal of Pharmaceutical Research International*, 33(51B), 85–89.
- Bellala, H., Mahmoud, F. M., Ziane, A. H., & Batam, A. (2022). Chronic toxicity of six pesticides mixture traces on biochemical, hematological, and histological parameters of liver and kidney in female Wistar rats. *Nutrition & Santé*, 11(02), 119-129.
- Benedetti, D., Lopes Alderete, B., de Souza, C. T., Ferraz Dias, J., Niekraszewicz, L., Cappetta, M., Martínez-López, W., & Da Silva, J. (2018). DNA damage and epigenetic alteration in soybean farmers exposed to complex mixture of pesticides. *Mutagenesis*, 33(1), 87–95.
- Bokreta, S., Hassina, K.-O., Amine, F. M., Makhoulouf, C., & Nacira, D.-Z. (2021). Protective effects of *Thymus vulgaris* essential oil against Voliam Targo® induced kidney and brain toxicity in male rabbits. *Egyptian Academic Journal of Biological Sciences, D. Histology & Histochemistry*, 13(1), 79–95.
- Borromeo, I., De Luca, A., Domenici, F., Giordani, C., Rossi, L., & Forni, C. (2024). Antioxidant properties of *Lippia alba* essential oil: A potential treatment for oxidative stress-related conditions in plants and cancer cells. *International Journal of Molecular Sciences*, 25(15), Article 15.
- Boukhatem, M. N., Chader, H., Houche, A., Oudjida, F., Benkebaili, F., & Hakim, Y. (2021). Topical emulsion containing *Lavandula stoechas* essential oil as a therapeutic agent for cutaneous wound healing. *J*, 4(3), 288–307.
- Calfee, R. C., & Valencia, R. R. (1991). *APA guide to preparing manuscripts for journal publication*. Washington, DC: American Psychological Association.
- Carvalho, F. P. (2017). Pesticides, environment, and food safety. *Food and Energy Security*, 6(2), 48–60.

- Chargui, I., Grissa, I., Bensassi, F., Hrira, M. Y., Haouem, S., Haouas, Z., & Bencheikh, H. (2012). Oxidative stress, biochemical and histopathological alterations in the liver and kidney of female rats exposed to low doses of deltamethrin (DM): A molecular assessment. *Biomedical and Environmental Sciences*, 25(6), 672–683.
- Domingues, J. L., Delgado, F. M. G., Gonçalves, J. C., & Pintado, C. S. (2021). Essential oils of *Lavandula stoechas* subsp. *luisieri* as antifungal agent against fungi from strawberry tree fruit. *Journal of Pharmacy and Pharmacology*, 9(3). Retrieved from <https://repositorio.ipcb.pt/handle/10400.11/7881>
- Gupta, V. K., Park, U., Kim, E., Kim, S., Siddiqi, N. J., Huh, Y. S., & Sharma, B. (2023). Antioxidative effect of *Aloe vera* against malathion induced neurotoxic response in Wistar rats. *Arabian Journal of Chemistry*, 16(10), 105169.
- Halima, A., Akbar, W., Ali, H., Junaid, & Imtiaz, H. (2023). Residual level of deltamethrin induced gastritis and preventive role of curcumin on stomach mucosa. *Journal of Ayub Medical College Abbottabad*, 35(4), 534–537.
- Ilyas, W. M., Chavan, G., & Gadkari, C. (2023). Deltamethrin poisoning mimicking organophosphate poisoning: A case report. *Cureus*.
- Kaki, F. A., Benkiniouar, R., Touil, A., Demirtas, I., Merzoug, A., & Khattabi, L. (2021). *Thymus numidicus*: Phenolic constituents, antibacterial, and antioxidant activities of butanolic extract. *Environmental and Experimental Biology*, 19(2), 67–72.
- Qu, K., Shi, M., Chen, L., Liu, Y., Yao, X., Li, X., Tan, B., & Xie, S. (2024). Residual levels of dietary deltamethrin interfere with growth and intestinal health in *Litopenaeus vannamei*. *Ecotoxicology and Environmental Safety*, 288, 117376.
- Küçükler, S., Kandemir, F. M., Özdemir, S., Çomaklı, S., & Caglayan, C. (2021). Protective effects of rutin against deltamethrin-induced hepatotoxicity and nephrotoxicity in rats via regulation of oxidative stress, inflammation, and apoptosis. *Environmental Science and Pollution Research*, 28(44), 62975–62990.
- Liu, Y., Yan, H., Yu, B., He, J., Mao, X., Yu, J., Zheng, P., Huang, Z., Luo, Y., & Luo, J. (2022). Protective effects of natural antioxidants on inflammatory bowel disease: Thymol and its pharmacological properties. *Antioxidants*, 11(10), 1947.
- Makhlouf, C., Khaldoun, H., Béchohra, L., Djennane, N., Settari, A., Tarzaali, D., Oularbi, Y., Krabi, S., Bokreta, S., & Zerrouki Daoudi, N. (2025). Ampligo® 150 ZC affect the expression of sex hormone receptors and cell proliferation marker in female rabbit ovary: Protective effects of thyme essential oil and vitamin C. *Reproductive Toxicology*, 132, 108833.
- Messara, Y., Fernane, F., & Meddour, R. (2018). Chemical composition, antibacterial, and antifungal activities of the essential oil of *Thymus numidicus* Poiret from Algeria. *Phytothérapie*, 16(3), 163–168.
- Mohammed, N., Hassan, H., Ali, A., Khaled, F., & Mohamed, S. (2022). Histopathological alterations in liver of male rabbits exposed to deltamethrin and the ameliorative effect of folic acid. *Alq J Med App Sci*, 5(2), 454–460.
- Rasheed, H. M., Farooq, U., Bashir, K., Wahid, F., Khan, T., Khusro, A., Gajdacs, M., Alghamdi, S., Alsaiani, A. A., & Almhadi, M. (2023). Isolation of oleanolic acid from *Lavandula stoechas* and its potent anticancer properties against MCF-7 cancer cells via induced apoptosis. *Journal of King Saud University-Science*, 35(2), 102454.
- Yadav, R., Shinde, N. G., Patil, K. T., Kote, A., & Kadam, P. (2023). Deltamethrin toxicity: Impacts on non-target organisms and the environment. *Environment and Ecology*, 41(3D), 2039–2043.
- Saoudi, M., Badraoui, R., Bouhajja, H., Ncir, M., Rahmouni, F., Grati, M., Jamoussi, K., & El Feki, A. (2017). Deltamethrin induced oxidative stress in kidney and brain of rats: Protective effect of *Artemisia campestris* essential oil. *Biomedicine & Pharmacotherapy*, 94, 955–963.
- Sharma, P., Singh, R., & Jan, M. (2014). Dose-dependent effect of deltamethrin in testis, liver, and kidney of Wistar rats. *Toxicology International*, 21(2), 131.
- Tewari, A., Banga, H., & Gill, J. P. (2018). Sublethal chronic effects of oral dietary exposure to deltamethrin in Swiss albino mice. *Toxicology and Industrial Health*, 34, 423–432.
- Wojtunik-Kulesza, K. A. (2022). Toxicity of selected monoterpenes and essential oils rich in these compounds. *Molecules*, 27(5), Article 5.
- World Health Organization. (2011). *Deltamethrin in drinking-water: Background document for development of WHO guidelines for drinking-water quality* (pp. 179–249). Geneva, Switzerland: World Health Organization.
- Yadav, I. C., & Devi, N. L. (2017). Pesticides classification and its impact on human and environment. *Environmental Science and Engineering*, 6(7), 140–158.
- Yildizhan, E., Ülger, B. V., Akkuş, M., Katanalp, Ö. F., Özkorkmaz, E. G., & Yıldızhan, İ. (2023). Rosmarinic acid ameliorates deltamethrin induced hepatotoxicity and nephrotoxicity. *Medical Records*, 5(2), 400–405.

Yousef, M. I., Awad, T. I., & Mohamed, E. H. (2006). Deltamethrin-induced oxidative damage and biochemical alterations in rat and its attenuation by vitamin E. *Toxicology*, 227(3), 240–247.

Author(s) Information

Farida Fernane

Mouloud Mammer's University, Natural Resources
Laboratory, BP17 – 15000 – Tizi Ouzou, Algeria
ORCID iD: <https://orcid.org/0000-0001-7828-884X>
*Contact e-mail: farida.fernane@ummto.dz

Nacira Daoudi - Zerrouki

Mouloud Mammer's University, Natural Resources
Laboratory, BP17 – 15000 – Tizi Ouzou, Algeria
ORCID iD: <https://orcid.org/0009-0000-0915-2594>

Ouardia Chaouchi

Mouloud Mammer's University, Natural Resources
Laboratory, BP17 – 15000 – Tizi Ouzou, Algeria
ORCID iD: <https://orcid.org/0009-0008-3453-4982>

Hakima Aitissad

Mouloud Mammer's University, Natural Resources
Laboratory, BP17 – 15000 – Tizi Ouzou, Algeria
ORCID iD: <https://orcid.org/0009-0007-3140-7638>

*Corresponding author(s) contact email

To cite this article:

Fernane, F., Daoudi-Zerrouki, N., Chaouchi, O., & Aitissad, H. (2026). Assessment of *Thymus numidicus* and *Lavandula stoechas* essential oils effects on deltamethrin-induced toxicity in female rabbits. *The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM)*, 42, 76–84.