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Hematological Toxicity of Graded Dietary Exposure to Lambda-Cyhalothrin in Wistar Rats

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ABSTRACT

Lambda-cyhalothrin is a widely used type II pyrethroid pesticide employed in agricultural pest control. Although effective against pests, concerns have been raised regarding its potential toxicity to mammals following chronic exposure. This study evaluated the hematological effects of graded concentrations of lambda-cyhalothrin in Wistar rats. Twenty-four healthy Wistar rats weighing 160–185 g was randomly assigned to four groups (n = 6). Three experimental groups received diets containing 0.2%, 0.4%, and 0.8% lambda-cyhalothrin respectively for six weeks, while the control group received pesticide-free feed. Hematological parameters including hemoglobin concentration, red blood cell indices, white blood cell count, platelet count, neutrophils, and lymphocytes were analysed. Results indicated a significant ($p < 0.05$) reduction in hemoglobin levels and alterations in red blood cell indices in treated groups compared with controls. No statistically significant changes were observed in total white blood cell counts, platelet counts, or neutrophil levels. However, lymphocyte counts differed significantly ($p < 0.05$) from those of the control group. These findings demonstrate that dietary exposure to lambda-cyhalothrin can induce hematological disturbances in Wistar rats, suggesting potential toxicological risks associated with prolonged exposure. The study highlights the need for stricter monitoring of pesticide exposure to protect animal and human health.

Keywords: *Lambda-cyhalothrin, hematotoxicity, pesticide toxicity, hematological parameters, Wistar rats.*

Introduction

Pesticides are among the most widely used chemical agents in modern agriculture, playing a major role in improving crop yield and controlling pests. However, their extensive use has raised concerns regarding their potential environmental and health impacts. Pesticide residues have been detected in various environmental compartments including soil, water, air, and biological tissues of humans and animals [1].

Synthetic pyrethroids represent one of the most commonly used groups of pesticides due to their high insecticidal activity and relatively low acute toxicity to mammals compared with older pesticide classes such as organochlorines and organophosphates [2]. Lambda-cyhalothrin is a type II pyrethroid insecticide widely used in agriculture and household pest control.

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Despite its effectiveness in pest management, several studies have reported toxicological effects associated with lambda-cyhalothrin exposure. Experimental studies have shown that this pesticide can induce oxidative stress, genotoxicity, and cytotoxicity in experimental animals [3]. Structural chromosomal abnormalities and increased frequency of micro nucleated erythrocytes in bone marrow cells have also been reported following exposure to lambda-cyhalothrin [4].

Hematological parameters are commonly used as indicators of physiological and pathological conditions in animals. Changes in blood indices may reflect toxic effects of chemical exposure on the hematopoietic system [5]. Studies have reported alterations in blood parameters in animals exposed to pyrethroid pesticides, suggesting possible interference with erythropoiesis and immune function [6].

Given the widespread use of lambda-cyhalothrin in agricultural practices, particularly among farmers in many developing countries, it is important to evaluate its potential toxic effects on biological systems. Therefore, the present study investigated the hematological effects of graded dietary concentrations of lambda-cyhalothrin in Wistar rats.

Materials and Methods

Ethical Approval

All experimental procedures were conducted in accordance with established guidelines for the care and use of laboratory animals and were approved by the relevant institutional ethics committee.

Chemicals

Commercial lambda-cyhalothrin formulation (trade name: Attacke®) was obtained from agrochemical store.

The concentration of active ingredient was verified according to manufacturer specifications.

Experimental Animals

Twenty-four clinically healthy Wistar rats (Rattus norvegicus) weighing between 160 and 185 g were used for the study. The animals were obtained from a certified animal facility and allowed to acclimatize for two weeks prior to the experiment. During this period, the rats were housed in labeled plastic bowls covered with wire gauze under standardized animal conditions, fed with pelleted feed (Vita feed Nigeria) twice daily, with each rat consuming estimated feed weight of 30g per day and drinking water *ad libitum*.

Experimental Design

The animals were randomly divided into four groups of six rats each:

Control group: Standard diet without pesticide exposure
Treatment group 1: Diet containing 0.2% lambda-cyhalothrin
Treatment group 2: Diet containing 0.4% lambda-cyhalothrin
Treatment group 3: Diet containing 0.8% lambda-cyhalothrin

Blood Collection and Hematological Analysis

After six weeks, animals were anesthetized, and blood was collected via cardiac puncture into EDTA tubes. Hematological parameters were analysed within 24 hours using an automated hematology analyser. Parameters included:

- Red Blood Cells (RBC)
- White Blood Cells (WBC)
- Hemoglobin (Hb)
- Pack Cell Volume (PCV)
- Mean Corpuscular Volume (MCV)
- Mean Corpuscular Hemoglobin (MCH)
- Platelet count
- Differential leukocyte counts (neutrophils and lymphocytes)

All analyses were conducted within 24 hours of blood sample collection.

Statistical Analysis

Data were expressed as mean ± standard deviation (SD). Statistical analysis was performed using analysis of variance (ANOVA) followed by Tukey's post-hoc test for multiple comparisons using SPSS software. Differences were considered statistically significant at $p < 0.05$.

Results

Table 1: Effects of lambda-cyhalothrin on erythrocyte indices

Groups	RBC ($\times 10^{12}$/L)	PCV (%)	Hb (g/dL)	MCV (fL)	MCH (pg)
Control (0.0%)	5.8 ± 0.42	36.9 ± 2.63	9.7 ± 0.99	58.6 ± 1.22	15.7 ± 0.59
Treatment 1 (0.2%)	4.9 ± 0.24	28.3 ± 1.51	8.2 ± 0.91	57.5 ± 1.15	15.6 ± 0.43
Treatment 2 (0.4%)	4.5 ± 0.31	28.3 ± 1.51`	7.4 ± 0.56	52.7 ± 2.50	13.5 ± 1.05
Treatment 3 (0.8%)	4.6 ± 0.75	27.3 ± 2.59	7.4 ± 1.04	48.4 ± 3.69	12.7 ± 0.88

Values are expressed as mean ± SD (n = 6)
Exposure to graded concentrations of lambda-cyhalothrin produced dose-dependent alterations in several hematological parameters.

Red blood cell counts showed a gradual decrease across treatment groups compared with the control group, although the differences were not statistically significant. Packed cell volume also showed a slight decrease across treated groups.

Hemoglobin concentration decreased significantly in treated animals compared with the control group ($p < 0.05$). Mean corpuscular volume also decreased significantly across treatment groups in a dose-dependent manner.

Platelet counts decreased slightly in treated groups but the changes were not statistically significant. White blood cell counts showed a mild increase across treated groups compared with the control group.

Table 2: Effects on leukocyte and platelet parameters

Groups	Platelets (x 10^9/L)	WBC (x 10^9/L)	Lymphocytes (x 10^9/L)	Neutrophils (x 10^9/L)
Control (0.0%)	205.3 ± 5.12	5.8 ± 0.25	78.7 ± 2.56	18.7 ± 1.74
Treatment 1 (0.2%)	201.3 ± 15.69	9.4 ± 1.54	71.4 ± 5.24	24.8 ± 5.12
Treatment 2 (0.4%)	193.3 ± 19.21	10.1 ± 0.88	66.4 ± 2.71	18.5 ± 1.23
Treatment 3 (0.8%)	163.3 ± 15.22	10.8 ± 0.87	62.6 ± 4.89	17.7 ± 2.84

Values are expressed as mean ± SD (n = 6)
Lymphocyte counts decreased significantly in treated animals ($p < 0.05$), while neutrophil counts did not show significant differences between treated and control groups.

Discussion

The present study demonstrated that dietary exposure to lambda-cyhalothrin resulted in alterations in several hematological parameters in Wistar rats. Hematological indices are commonly used as biomarkers for evaluating physiological stress and toxicological effects of chemical exposure [5].

The observed decrease in red blood cell count and packed cell volume may indicate suppression of erythropoiesis or increased destruction of erythrocytes following pesticide exposure. Similar findings have been reported in animals exposed to pyrethroid pesticides, suggesting that these compounds may affect bone marrow activity or induce oxidative damage to erythrocyte membranes [6].

The significant reduction in hemoglobin concentration observed in the present study suggests that lambda-cyhalothrin may interfere with hemoglobin synthesis or promote hemolysis. Reduced hemoglobin levels may impair oxygen transport within the body and potentially lead to anaemia [7].

Changes in red blood cell indices such as mean corpuscular volume and mean corpuscular hemoglobin further indicate possible disturbances in erythrocyte morphology and maturation. Such alterations have been reported in animals exposed to environmental toxicants including pesticides [8].

The significant decrease in lymphocyte counts observed in treated animals suggests possible immunosuppressive effects of lambda-cyhalothrin exposure.

Lymphocytes play an essential role in immune defence mechanisms, and their reduction may compromise immune responses [9].

Overall, the hematological changes observed in this study indicate that lambda-cyhalothrin exposure may disrupt normal hematopoietic processes and immune function in Wistar rats.

Limitations

No oxidative stress biomarker measurements (MDA, SOD, CAT). No bone marrow histopathology. Limited sample size (n = 6). No cytokine profiling.

Conclusion

The present study demonstrates that exposure to graded concentrations of lambda-cyhalothrin can induce significant hematological alterations in Wistar rats. The observed reductions in hemoglobin concentration, mean corpuscular volume, and lymphocyte counts suggest potential toxic effects on erythropoiesis and immune function.

These findings highlight the need for careful regulation and monitoring of lambda-cyhalothrin use in agricultural environments to minimize potential health risks associated with pesticide exposure.

Further studies investigating molecular, biochemical markers of oxidative stress and histopathological changes are recommended to better understand the mechanisms underlying lambda-cyhalothrin toxicity.

Conflict of Interest

The authors declare no conflict of interest.

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