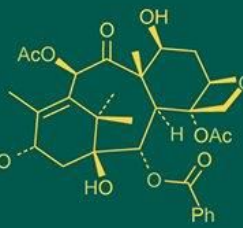
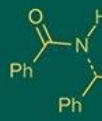


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(2): 841-845
www.biochemjournal.com
Received: 07-11-2025
Accepted: 10-12-2025

Poonam
M.V.Sc. Scholar, Department
of VPT, Veterinary College,
Hassan, Karnataka, India

Ravikumar C
Department of VPT,
Veterinary College, Hassan,
Karnataka, India

Shridhar NB
Department of VPT,
Veterinary College,
Shivamogga, Karnataka, India

Ravikumar BP
Department of VCC,
Veterinary College, Hassan,
Karnataka, India

Anjan Kumar KR
Department of VPP,
Veterinary College, Hassan,
Karnataka, India

Ramesh D
Department of VPB,
Veterinary College, Hassan,
India

Sushma HL
Department of VPT,
Veterinary College, Hassan,
Karnataka, India

Corresponding Author:
Poonam
M.V.Sc. Scholar, Department
of VPT, Veterinary College,
Hassan, Karnataka, India

Hematological and biochemical evaluation of Ameliorative effects of mangiferin on deltamethrin induced toxicity in rats

Poonam, Ravikumar C, Shridhar NB, Ravikumar BP, Anjan Kumar KR, Ramesh D and Sushma HL

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i2k.7735>

Abstract

Deltamethrin is a synthetic pyrethroid insecticide widely used in agriculture and public health, but its exposure is associated with haematological and biochemical disturbances. Mangiferin, a natural polyphenolic compound, possesses antioxidant and protective properties. The present study evaluated the protective effect of mangiferin against deltamethrin-induced haematological and biochemical alterations in rats. Experimental animals were divided into control, deltamethrin-treated, mangiferin-treated and combined treatment groups. Deltamethrin exposure resulted in significant reductions in haemoglobin concentration, total erythrocyte count and packed cell volume, along with alterations in leukocyte profile. Serum biochemical analysis revealed elevated levels of aspartate aminotransferase, alanine aminotransferase, urea and creatinine indicating hepatic and renal impairment. Total protein and albumin levels were reduced in the toxic group. Administration of mangiferin along with deltamethrin significantly restored haematological indices and normalized altered biochemical parameters. The findings demonstrate that mangiferin exerts protective effects against deltamethrin-induced toxicity, likely through its antioxidant and membrane-stabilizing properties. The study suggests that mangiferin may serve as a potential therapeutic agent in managing pesticide-induced haematological and biochemical disturbances.

Keywords: Deltamethrin, mangiferin, haematology, serum biochemistry, toxicity, rats

Introduction

Deltamethrin is a type II synthetic pyrethroid insecticide extensively used for crop protection and vector control. Although considered relatively safe at recommended doses, prolonged or excessive exposure has been reported to cause oxidative stress, hepatic damage, renal impairment and haematological alterations in experimental animals (Mongi *et al.*, 2011) ^[10]. Toxic effects are primarily mediated through free radical generation and membrane damage. Haematological parameters serve as important indicators of toxic insult and physiological stress. Alterations in haemoglobin concentration, erythrocyte count, leukocyte profile and packed cell volume reflect systemic toxicity (Ncir *et al.*, 2020) ^[11]. Serum biochemical markers such as liver enzymes, total protein, urea and creatinine are sensitive indicators of hepatic and renal function (Manna *et al.*, 2006) ^[8]. Mangiferin is a naturally occurring xanthone glycoside found in *Mangifera indica*. It possesses antioxidant, anti-inflammatory and hepatoprotective properties. Previous experimental studies have demonstrated its ability to scavenge free radicals and protect against chemical-induced organ toxicity. The present study was undertaken to evaluate the haematological and biochemical alterations induced by deltamethrin in rats and to assess the protective efficacy of mangiferin against such toxicity.

Materials and Methods

The experiment was conducted in accordance with the guidelines of the Committee for the Control and Supervision of Experiments on Animals (CCSEA) after obtaining prior approval from the Institutional Animal Ethics Committee. The study was carried out at the Small Animal House, Hassan Veterinary College, Karnataka Veterinary, Animal and Fisheries Sciences University (KVAFSU).

Female Wistar rats aged 6-8 weeks, non-pregnant and nulliparous, were used for the experiment. The animals were maintained under controlled environmental conditions with a temperature of 22 ± 3 °C, relative humidity of 50-60%, and a 12-hour light/12-hour dark cycle. Standard laboratory feed and water were provided ad libitum throughout the study period.

A total of 40 rats were randomly allocated into five groups, with eight animals in each group. Group I (normal control) received Peanut oil orally. Group II (positive control) was administered deltamethrin where deltamethrin of pure form was dissolved in Peanut oil where Peanut oil was used as a vehicle, at a dose of 5.2 mg/kg body weight (1/10th of LD50 dose). Group III received mangiferin alone at a dose of 30 mg/kg body weight. Group IV was treated with deltamethrin (5.2 mg/kg body weight) in combination with mangiferin (30 mg/kg body weight). Group V received deltamethrin (5.2 mg/kg body weight) along with a higher dose of mangiferin (60 mg/kg body weight).

Body weight Measurement

The body weight of all the experimental animals were recorded weekly once and the dosing was adjusted accordingly.

Hematology

The blood samples collected in EDTA vials on 14th and 28th day of the experiment were subjected for haemoglobin (Hb), total erythrocyte count (TEC), total leucocyte count (TLC), total platelet count, packed cell volume (PCV) Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) estimation using Mindray BC-2800VET auto Haematology auto analyser in the Department of Teaching Veterinary Clinical Complex, Veterinary College, Hassan.

Serum Biochemistry

For serum biochemical parameters analysis, blood was collected on 14th and 28th day into serum vacutainers, centrifuged at 3000 rpm for 15 min and serum separated and stored at -20 °C till further analysis. Biochemical estimation for AST, ALT, ALP, Urea, BUN and Creatinine levels were analysed using standard laboratory procedure by Robonik, India Semi-automatic Biochemistry Analyzer (Prietest Compact) using reagent kits from Lifechem, Ahmedabad.

Results

General observations

Oral administration of deltamethrin to rats for 28 days did not result in mortality. However, animals in Group II showed noticeable clinical signs, including roughened hair coats and reduced feed intake compared with Group I. During the last two weeks of treatment, Group II rats exhibited anorexia, lethargy, weakness, abnormal gait, aggressive behavior, and dizziness. In contrast, rats in Groups III, IV, and V displayed normal behavior and activity throughout the experimental period.

Body weights were recorded weekly and are presented in Table 1. The rate of body weight gain was significantly influenced by deltamethrin administration, both alone and in combination with mangiferin. From the second week onward, the mean body weight of rats in Group II was significantly lower compared with Groups I, III, IV, and V.

Conversely, Group III animals showed a progressive increase in body weight throughout the study period.

Absolute organ weights

A significant increase in absolute liver weight was observed in Group II compared with Group I. In Groups IV and V, liver weights were significantly reduced relative to Group II, while liver weights in Group III were comparable to those of Group I.

Similarly, the absolute kidney weight was significantly higher in Group II than in Group I. In Groups IV and V, kidney weights were significantly lower compared with Group II, whereas a marginal increase was noted in Group III relative to Group I.

Relative organ weights

The relative weights of the liver and kidneys were significantly increased in Group II compared with Group I. In contrast, Groups IV and V showed a significant reduction in relative liver and kidney weights when compared with Group II. No significant differences in relative liver or kidney weights were observed between Group III and Group I.

Hematological parameter

The mean values of hematological parameters with standard error of mean on 14th and 28th day are presented in Table 2. On days 14 and 28, Group II showed a significant decrease in total erythrocyte count (TEC) compared to Groups I, IV, and V. In contrast, TEC levels were significantly higher in Groups IV and V when compared with Group II. TEC levels in Group III were similar to those in Group I. During the same periods, total leukocyte count (TLC) was significantly increased in Group II compared to Group I. However, Groups IV and V showed a significant decrease in TLC levels compared to Group II. No significant difference in TLC levels was observed between Group III and Group I. Hemoglobin (Hb) levels on days 14 and 28 were significantly lower in Group II compared to Group I. In contrast, Hb levels were significantly increased in Groups IV and V relative to Group II. Group III showed Hb levels comparable to Group I.

Serum Biochemistry

The mean values of Serum Biochemistry parameter values with standard error of mean on 14th and 28th day are presented in Table 3. Serum ALT, AST and ALP levels were significantly elevated in Group II compared to Group I. In contrast, Groups IV and V showed a significant reduction in these enzyme levels relative to Group II. Enzyme levels in Group III remained comparable to those in Group I. Renal function markers, including urea, blood urea nitrogen (BUN), and creatinine, were significantly increased in Group II compared to Group I. However, Groups IV and V exhibited a significant decrease in these parameters when compared with Group II. No significant differences were observed between Group III and Group I.

Discussion

Body weight gain is an important indicator of growth. In the present study, rats treated with deltamethrin alone (Group II) showed a significant reduction in both absolute and percentage body weight gain after 28 days compared to the control group (Group I). Although Group III showed an

increase in body weight gain, the difference was not statistically significant compared to Group I. These findings are consistent with earlier reports showing reduced body weight gain following deltamethrin exposure (Gerbed *et al.*, 2014; Ncir *et al.*, 2018) [6, 11]. The reduction in body weight may be due to the metabolic and hormonal effects of deltamethrin (Manna *et al.*, 2005) [7]. Similar effects on body weight have also been reported in fipronil-induced toxicity in rats (Mohan, 2023) [9]. Relative organ weight is a key indicator of organ toxicity. In this study, a significant increase in relative liver weight was observed in Group II compared to Group I, which may be attributed to inflammatory changes and liver enlargement caused by deltamethrin exposure, as previously reported (Sharma *et al.*, 2014) [18].

Similarly, Group II showed a significant increase in relative kidney weight compared to Group I. This increase may result from inflammatory cell accumulation and altered renal function, consistent with earlier findings (Rehman *et al.*, 2014; Ncir *et al.*, 2016; Manna *et al.*, 2005) [16, 12, 7].

Hematological analysis is commonly used to assess disease conditions and toxic effects caused by chemicals and pesticides (Al-Attar *et al.*, 2010) [3]. Erythrocytes play a vital role in oxygen transport and hemoglobin levels are closely associated with total erythrocyte count (Pasini *et al.*, 2010) [15]. In the present study, Group II showed a significant decrease in TEC and Hb levels, along with an increase in TLC, compared to Group I. These findings are consistent with earlier reports on deltamethrin toxicity (Mongi *et al.*, 2011; Aljali *et al.*, 2023) [10, 4] and similar hematological alterations reported in fipronil-induced toxicity (Mohan, 2023) [9]. The reduction in hemoglobin may indicate regenerative anemia due to interference with erythropoiesis, while decreased TEC and increased TLC could be attributed to oxidative stress-induced damage to red blood cells (Mongi *et al.*, 2011; Aljali *et al.*, 2023) [10, 4]. Similar protective effects of mangiferin on these parameters have also been reported by Mohan (2023) [9] supporting the present findings.

A significant increase in AST, ALT, ALP, creatinine, urea and BUN levels was observed in Group II compared to Group I. These findings are consistent with previous reports showing deltamethrin-induced liver and kidney toxicity in rodents (Abdel *et al.*, 2016) [1]. Elevated ALT and AST levels indicate liver cell damage, which may be associated

with bile duct hyperplasia, hepatic congestion, Kupffer cell hyperplasia and altered membrane permeability. Increased ALP levels, which are present on hepatocyte membranes and bile duct epithelium, serve as a sensitive indicator of toxic liver damage (Tewari *et al.*, 2014) [21].

The rise in urea levels observed in this study supports the findings of (Tewari *et al.*, 2014) [21] and correlates with kidney tissue damage. Elevated BUN and creatinine levels further indicate impaired renal function, likely due to reduced glomerular filtration and tubular dysfunction (Mongi *et al.*, 2011; Aljali *et al.*, 2023) [10, 4]. Meanwhile, Mangiferin is a natural xanthone compound known for its antioxidant, anti-inflammatory, and protective properties. It reduces toxicity by scavenging free radicals and strengthening antioxidant defense mechanisms (Shashirekha *et al.*, 2015; Ajay *et al.*, 2023) [19, 2]. Based on these properties, this study evaluated the protective effect of mangiferin against sub-acute deltamethrin-induced toxicity in Wistar rats. Groups IV and V showed a significant increase in absolute and percentage body weight gain compared to Group II, indicating that mangiferin reduced deltamethrin-induced oxidative stress and neurotoxicity. Group III showed values comparable to Group I. Similar protective effects of mangiferin on body weight were reported by Song *et al.* (2020) [20]. Relative liver and kidney weights were significantly reduced in Groups IV and V compared to Group II, suggesting hepato- and nephroprotective effects of mangiferin. This may be due to inhibition of the NF- κ B inflammatory pathway and reduced reactive oxygen species formation. These findings are consistent with earlier reports on the protective role of mangiferin (Song *et al.*, 2020) [20].

Serum biochemical markers, including ALT, AST, ALP, urea, creatinine, and BUN, were significantly lowered in Groups IV and V compared to Group II, supporting the protective effects of mangiferin on liver and kidney function (Mongi *et al.*, 2011) [10].

Hematological parameters such as TEC, Hb, and TLC were also significantly improved in Groups IV and V relative to Group II. These results agree with previous studies showing the hemoprotective and immunoprotective effects of mangiferin, likely through enhanced erythropoiesis and reduced oxidative damage to blood cells (Das *et al.*, 2011; Sellamuthu *et al.*, 2014; Mohan, 2023) [5, 17, 9].

Table 1: Body weight (g: Mean $\pm$ SEM) of experimental groups rats (n = 8)

Groups	Week 0	Week 1	Week 2	Week 3	Week 4
I	185.06 $\pm$ 4.00a	190.05 $\pm$ 4.25a	201.81 $\pm$ 4.16a	210.05 $\pm$ 3.50a	230.06 $\pm$ 3.22a
II	180 $\pm$ 3.47a	188.22 $\pm$ 3.02ab	194.05 $\pm$ 3.66b	200.25 $\pm$ 2.88b	210.06 $\pm$ 2.56b
III	182.25 $\pm$ 3.00a	187.4 $\pm$ 2.96ab	201.56 $\pm$ 3.05a	220 $\pm$ 2.56a	221.11 $\pm$ 3.84ab
IV	178.5 $\pm$ 2.05a	190.75 $\pm$ 2.76a	198.19 $\pm$ 3.06ab	205.05 $\pm$ 3.05b	220.44 $\pm$ 3.16ab
V	185.25 $\pm$ 2.50a	195.25 $\pm$ 2.94a	196.50 $\pm$ 2.66b	215.31 $\pm$ 2.91a	219.13 $\pm$ 2.00ab

Note: Mean $\pm$ SEM values of body weight within the same column bearing different superscripts differ significantly at $p \leq 0.05$.

Absolute organ weight (g: Mean $\pm$ SEM) of liver and kidney of experimental groups rats (n = 8)

Groups	Liver	Kidney
Group I	5.01 $\pm$ 0.22a	0.76 $\pm$ 0.05a
Group II	6.73 $\pm$ 0.16b	1.28 $\pm$ 0.03b
Group III	5.52 $\pm$ 0.24a	0.88 $\pm$ 0.05a
Group IV	5.42 $\pm$ 0.11a	1.01 $\pm$ 0.03a
Group V	5.39 $\pm$ 0.08a	0.96 $\pm$ 0.04a

Note: Mean $\pm$ SEM values of Absolute organ weight within the same column bearing different superscripts differ significantly at $p \leq 0.05$.

Relative organ weight (g/100 g; Mean $\pm$ SEM) of liver, kidney of experimental groups rats (n = 8)

Groups	Liver	Kidney
Group I	2.17 $\pm$ 0.03a	0.33 $\pm$ 0.02a
Group II	3.27 $\pm$ 0.07c	0.79 $\pm$ 0.02c
Group III	2.49 $\pm$ 0.08b	0.49 $\pm$ 0.02b
Group IV	2.36 $\pm$ 0.04b	0.47 $\pm$ 0.03b
Group V	2.32 $\pm$ 0.02b	0.45 $\pm$ 0.02b

Note: Mean $\pm$ SEM values of Relative organ weight within the same column bearing different superscripts differ significantly at $p \leq 0.05$.

Table 2: TEC (x106/ μ l; Mean $\pm$ SEM) and TLC (x103/ μ l; Mean $\pm$ SEM) of experimental groups (n = 8) of rats.

Groups	Hematological parameters			
	TEC (x106/ μ l)		TLC (x103/ μ l)	
	14th Day	28th Day	14th Day	28th Day
Group I	7.18 $\pm$ 0.16b	7.93 $\pm$ 0.15a	10.13 $\pm$ 0.39c	11.53 $\pm$ 0.15c
Group II	6.31 $\pm$ 0.29c	5.29 $\pm$ 0.17c	14.84 $\pm$ 0.23a	16.14 $\pm$ 0.17a
Group III	7.48 $\pm$ 0.10a	7.77 $\pm$ 0.10a	11.31 $\pm$ 0.52bc	11.51 $\pm$ 0.10c
Group IV	6.82 $\pm$ 0.08bc	7.12 $\pm$ 0.09b	11.30 $\pm$ 0.69bc	11.71 $\pm$ 0.09c
Group V	6.92 $\pm$ 0.12b	6.98 $\pm$ 0.42b	10.87 $\pm$ 0.42c	12.75 $\pm$ 0.42b

Note: Mean $\pm$ SEM values of TEC and TLC within the same column bearing different Superscripts differ significantly at $p \leq 0.05$.

Hb (g/dl; Mean $\pm$ SEM) of experimental groups rats (n = 8)

Groups	Hematological parameters	
	Hb (g/dl)	
	14th Day	28th Day
Group I	12.09 $\pm$ 0.41a	12.37 $\pm$ 0.07a
Group II	10.75 $\pm$ 0.24c	8.95 $\pm$ 0.20c
Group III	11.63 $\pm$ 0.08b	11.49 $\pm$ 0.10b
Group IV	10.59 $\pm$ 0.17c	11.25 $\pm$ 0.17bc
Group V	10.83 $\pm$ 0.17c	11.79 $\pm$ 0.14ab

Note: Mean $\pm$ SEM values of Hb within the same column bearing different superscripts differ significantly at $p \leq 0.05$.

Table 3: ALT levels and AST Levels(IU/L; Mean $\pm$ SEM) in tissue of experimental groups of rats (n = 8)

Groups	Serum biochemical parameters			
	ALT (IU/L)		AST (IU/L)	
	14th Day	28th Day	14th Day	28th Day
Group I	41.78 $\pm$ 0.94b	41.81 $\pm$ 0.67b	88.20 $\pm$ 0.74a	90.46 $\pm$ 0.78b
Group II	62.64 $\pm$ 2.74a	80.60 $\pm$ 2.80a	90.76 $\pm$ 1.40a	115.86 $\pm$ 0.76a
Group III	33.78 $\pm$ 0.83c	44.29 $\pm$ 0.79b	60.51 $\pm$ 2.27c	69.68 $\pm$ 2.62cd
Group IV	50.36 $\pm$ 1.01b	32.89 $\pm$ 0.85c	84.02 $\pm$ 1.72a	75.72 $\pm$ 2.02c
Group V	48.97 $\pm$ 1.07b	35.21 $\pm$ 0.89c	71.53 $\pm$ 1.57b	63.19 $\pm$ 1.48d

Note: Mean $\pm$ SEM values of ALT and AST within the same column bearing different superscripts differ significantly at $p \leq 0.05$.

ALP level and Urea level(IU/L; Mean $\pm$ SEM) in tissues of experimental groups rats (n = 8)

Groups	Serum biochemical parameters			
	ALP (IU/L)		Urea (IU/L)	
	14th Day	28th Day	14th Day	28th Day
Group I	102.32 $\pm$ 2.35b	119.96 $\pm$ 4.54b	32.78 $\pm$ 2.4a	36.36 $\pm$ 1.17a
Group II	149.08 $\pm$ 9.29c	165.00 $\pm$ 8.09c	64.34 $\pm$ 3.7c	76.66 $\pm$ 3.13c
Group III	84.05 $\pm$ 4.19a	71.86 $\pm$ 3.88a	60.73 $\pm$ 1.75b	58.44 $\pm$ 1.27b
Group IV	91.15 $\pm$ 2.20a	81.70 $\pm$ 2.53a	62.75 $\pm$ 1.44b	61.20 $\pm$ 1.40b
Group V	84.96 $\pm$ 2.47a	81.74 $\pm$ 2.05a	63.70 $\pm$ 1.60b	61.80 $\pm$ 1.90b

Note: Mean $\pm$ SEM values of ALP and Urea within the same column bearing different Superscripts differ significantly at $p \leq 0.05$.

BUN and Creatinine level(mg/dl; Mean $\pm$ SEM) in tissues of experimental groups rats (n = 8)

Groups	Serum biochemical parameters			
	BUN (mg/dl)		Creatinine (mg/dl)	
	14th Day	28th Day	14th Day	28th Day
Group I	26.32 $\pm$ 0.82a	25.58 $\pm$ 0.64a	1.18 $\pm$ 0.03a	1.13 $\pm$ 0.02a
Group II	33.19 $\pm$ 1.05c	36.64 $\pm$ 1.36c	2.45 $\pm$ 0.33c	3.06 $\pm$ 0.43c
Group III	27.66 $\pm$ 0.83ab	27.43 $\pm$ 0.58ab	1.19 $\pm$ 0.04a	1.35 $\pm$ 0.04b
Group IV	29.22 $\pm$ 0.73b	28.70 $\pm$ 0.66b	1.34 $\pm$ 0.02b	1.52 $\pm$ 0.04b
Group V	29.61 $\pm$ 0.76b	29.01 $\pm$ 0.79b	1.22 $\pm$ 0.02ab	1.29 $\pm$ 0.04b

Note: Mean $\pm$ SEM values of BUN and Creatinine within the same column bearing different Superscripts differ significantly at $p \leq 0.05$.

Conclusions

Sub-acute oral administration of deltamethrin in rats produced marked toxic effects, including decreased body weight gain, changes in liver and kidney weights, hematological alterations (reduced TEC and hemoglobin with elevated TLC), and increased hepatic and renal biomarkers, indicating liver and kidney toxicity.

Exposure to deltamethrin significantly elevated serum ALT, AST, ALP, urea, creatinine, and BUN levels, along with increased relative liver and kidney weights, demonstrating functional impairment and structural damage to these organs. Concurrent treatment with mangiferin notably mitigated deltamethrin-induced toxicity by improving body weight gain, normalizing organ weight indices, restoring hematological parameters, and lowering elevated liver and kidney biochemical markers.

The protective action of mangiferin is likely attributed to its antioxidant and anti-inflammatory properties, which reduce oxidative stress and suppress inflammatory responses, thereby maintaining hepatic, renal, and hematological health during deltamethrin exposure.

Acknowledgement

I would like to convey my heartfelt appreciation to the Veterinary College, Hassan, for providing me with the opportunity to undertake my M.V.Sc. research work.

References

1. Abdel-Daim M, El-Bialy BE, Rahman HGA, Radi AM, Hefny HA, Hassan AM. Antagonistic effects of *Spirulina platensis* against sub-acute deltamethrin toxicity in mice: biochemical and histopathological studies. Biomed Pharmacother. 2016;77:79-85.
2. Ajay HM, Ravikumar C, Sarma MBM, Gowda H, Ramesh D. Insights into anticancerous, antioxidant and anti-inflammatory effects of mangiferin. Pharm Innov. 2023;12:1576-1582.
3. Al-Attar AM, Al-Taisan WAA. Preventive effects of black seed (*Nigella sativa*) extract on Sprague Dawley rats exposed to diazinon. Aust J Basic Appl Sci. 2010;4(5):957-968.

4. Aljali A, Othman H, Hazawy S. Toxic effect of deltamethrin on some hematological and biochemical parameters of male rats. *AJMAS*. 2023;536-546.
5. Das S, Rao BN, Rao BS. Mangiferin attenuates methylmercury-induced cytotoxicity against IMR-32 human neuroblastoma cells by inhibition of oxidative stress and free radical scavenging potential. *Chem Biol Interact*. 2011;193(2):129-140.
6. El-Gerbed MS. Protective effect of lycopene on deltamethrin-induced histological and ultrastructural changes in kidney tissue of rats. *Toxicol Ind Health*. 2014;30(2):160-173.
7. Manna S, Bhattacharyya D, Mandal TK, Das S. Repeated dose toxicity of deltamethrin in rats. *Indian J Pharmacol*. 2005;37(3):160-164.
8. Manna S, Bhattacharyya D, Mandal TK, Dey S. Neuropharmacological effects of deltamethrin in rats. *J Vet Sci*. 2006;7(2):133-136.
9. Mohan N. Effect of mangiferin on fipronil-induced toxicity in rats [thesis]. Bidar (Karnataka): Karnataka Veterinary, Animal and Fisheries Sciences University; 2023.
10. Mongi S, Mahfoud M, Amel B, Kamel J, Abdelfattah EF. Protective effects of vitamin C against haematological and biochemical toxicity induced by deltamethrin in male Wistar rats. *Ecotoxicol Environ Saf*. 2011;74(6):1765-1769.
11. Ncir M, Ben Ali M, Sellami H, Allagui MS, Lahyani A, Makni Ayadi F, *et al*. Protective effects of *Allium sativum* essential oil rich in disulfides against deltamethrin-induced oxidative stress and hepatotoxicity in rats. *J Food Meas Charact*. 2020;14(5):2667-2675.
12. Ncir M, Ben Salah G, Kamoun H, Makni Ayadi F, Khabir A, El Feki A, *et al*. Histopathological, oxidative damage, biochemical and genotoxicity alterations in hepatic rats exposed to deltamethrin: modulatory effects of garlic (*Allium sativum*). *Can J Physiol Pharmacol*. 2016;94(6):571-578.
13. Ncir M, Saoudi M, Sellami H, Rahmouni F, Lahyani A, Makni Ayadi F, *et al*. *in vitro* and *in vivo* studies of *Allium sativum* extract against deltamethrin-induced oxidative stress in rat brain and kidney. *Arch Physiol Biochem*. 2018;124(3):207-217.
14. Organisation for Economic Co-operation and Development (OECD). OECD guideline for the testing of chemicals 407: repeated dose 28-day oral toxicity study in rodents. Paris: OECD; 2008.
15. Pasini EM, Lutz HU, Mann M, Thomas AW. Red blood cell (RBC) membrane proteomics—Part I: proteomics and RBC physiology. *J Proteomics*. 2010;73(3):403-420.
16. Rehman H, Aziz AT, Saggu S, Abbas ZK, Mohan A, Ansari AA. Systematic review on pyrethroid toxicity with special reference to deltamethrin. *J Entomol Zool Stud*. 2014;2(6):60-70.
17. Sellamuthu PS, Arulselvan P, Fakurazi S, Kandasamy M. Beneficial effects of mangiferin isolated from *Salacia chinensis* on biochemical and hematological parameters in rats with streptozotocin-induced diabetes. *Pak J Pharm Sci*. 2014;27(1):161-167.
18. Sharma P, Singh R, Jan M. Dose-dependent effect of deltamethrin in testis, liver and kidney of Wistar rats. *Toxicol Int*. 2014;21(2):131-139.
19. Shashirekha MN, Mallikarjuna SE, Rajarathnam S. Status of bioactive compounds in foods, with focus on fruits and vegetables. *Crit Rev Food Sci Nutr*. 2015;55(10):1324-1339.
20. Song Y, Liu W, Tang K, Zang J, Li D, Gao H. Mangiferin alleviates renal interstitial fibrosis in streptozotocin-induced diabetic mice through regulating the PTEN/PI3K/Akt signaling pathway. *J Diabetes Res*. 2020;2020:356-373.
21. Tewari A, Gill JPS. Assessment of hemato-biochemical parameters on exposure to low level of deltamethrin in mouse model. *Vet World*. 2014;7(3):789-795.