

## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; 10(5): 44-50  
[www.biochemjournal.com](http://www.biochemjournal.com)  
Received: 27-02-2026  
Accepted: 30-03-2026

**Arastu Kumar**  
Department of Veterinary  
Pharmacology & Toxicology,  
Sardar Vallabhbhai Patel  
University of Agriculture &  
Technology, Meerut, Uttar  
Pradesh, India

**Rajesh Mandil**  
Department of Veterinary  
Pharmacology & Toxicology,  
Sardar Vallabhbhai Patel  
University of Agriculture &  
Technology, Meerut, Uttar  
Pradesh, India

**Amit Kumar**  
Department of Animal  
Biotechnology, Sardar  
Vallabhbhai Patel University  
of Agriculture & Technology,  
Meerut, Uttar Pradesh, India

**Shikha Chaudhary**  
Department of Veterinary  
Pharmacology & Toxicology,  
Sardar Vallabhbhai Patel  
University of Agriculture &  
Technology, Meerut, Uttar  
Pradesh, India

**Vikas Jaiswal**  
Department of Veterinary  
Pathology, Sardar Vallabhbhai  
Patel University of Agriculture  
& Technology, Meerut, Uttar  
Pradesh, India

**Corresponding Author:**  
**Arastu Kumar**  
Department of Veterinary  
Pharmacology & Toxicology,  
Sardar Vallabhbhai Patel  
University of Agriculture &  
Technology, Meerut, Uttar  
Pradesh, India

## Effect of curcumin on sub acute exposure of chlorantraniliprole induced toxicity in Wistar rats

Arastu Kumar, Rajesh Mandil, Amit Kumar, Shikha Chaudhary and Vikas Jaiswal

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i5a.8309>

### Abstract

Forty male Wistar rats were divided in five groups each having eight animals. Rats of groups A (distilled water), B (corn oil) were control while rats of groups C to E administered curcumin (@ 100 mg/kg), chlorantraniliprole (@ 250 mg/kg) and chlorantraniliprole (@ 250 mg/kg) + curcumin (@ 100 mg/kg), respectively, orally. Chlorantraniliprole administered rats showed increased activity and sweating response, decreased feed intake, no body weight and percent body weight gain. Absolute organ and relative organ weights did not differ significantly in different treatment groups. Total RBCs count, Hb values, MCV, MCHC and MCH, WBCs count, lymphocyte percentage, monocyte percentage, absolute lymphocyte and platelets count, PCT (%) did not differ significantly in rats of different treatment groups. RDW-SD was significantly higher in rats of chlorantraniliprole alone-treated rats. Histopathological examination of heart showed degenerative and toxic insult in histology of chlorantraniliprole group as compared to control groups. Co-administration of curcumin and chlorantraniliprole in rats improve the behavioral response towards the rats of control groups, Increased feed and water intake, body weight gain, normalize the organ and relative organ weight towards the control groups, normalize the haematological parameters and ameliorate the histological alteration in heart towards the control group indicating free radical scavenging, antioxidant ameliorative action of curcumin.

**Keywords:** Chlorantraniliprole, curcumin, haematology, feed and water intake, histology

### 1. Introduction

Among pesticides producer countries, India ranked 4<sup>th</sup> position after USA, Japan and China, respectively. Anthranilic diamine (chlorantraniliprole) was registered in 2008 <sup>[1]</sup>, with the technical formulation (DuPont Rynaxypyr Technical, EPA Reg. No. 352-728) has 95.3% chlorantraniliprole <sup>[1]</sup>, used against several insect-pests (Lepidoptera, Coleoptera, Diptera and Isoptera species etc). Chlorantraniliprole is use on agriculture crops such as pome fruit, stone fruit, grapes, leafy vegetables, brassica leafy vegetables, cucurbit vegetables, fruiting vegetables, potatoes, cotton, rice, oilseeds, soybean, teff, and quinoa, and ornamentals and turf grass growing in residential, commercial, and public landscaped area for control of moths, beetles, and caterpillars etc <sup>[1]</sup>. Chlorantraniliprole a Ryanodine receptor agonist, which regulates calcium-induced muscle-contraction. Mode of action is selective toxicity for insect ryanodine receptors <sup>[2, 3]</sup>. It has been observed that RyR plays a vital role in Ca<sup>2+</sup> signaling in the body, which is responsible for its effects on mammal's tissues <sup>[4]</sup>. Curcumin is commonly called as turmeric powder, extensively use in ayurvedic medicine for centuries due to possesses variety of therapeutic properties including anti-oxidant, analgesic, anti-inflammatory, antiseptic <sup>[5]</sup>, and anti-proliferative effects, useful in treatment of neuro-inflammatory degenerative conditions like Alzheimer's disease <sup>[6]</sup>, metabolic syndrome, arthritis, anxiety, hyperlipidemia, and cancers etc. <sup>[7-13]</sup>

Based on above studies and availability of a few research data on subacute exposure effect of chlorantraniliprole on haematological alteration and histological changes in heart of rat and lack of the information on ameliorative potential of curcumin against chlorantraniliprole subacute exposure in rats, present study was designed to investigate amelioration potential of curcumin against chlorantraniliprole induced subacute toxicity study in rats.

## 2. Materials and Methods

Present study was conducted on forty adult male Wistar rats, which were procured from Lab Animal Facility (LAR), ICAR-Indian Veterinary Research Institute (IVRI) Izatnagar-243122 and maintained under standard managemental conditions in the Small Animal House Facility, Department of Animal Biotechnology, College of Biotechnology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110. Animals were divided into five groups each having eight rats namely- Group A (deionized water), Group B (vehicle control), groups C, D and E treated with curcumin (@ 100 mg/kg), chlorantraniliprole (@ 250 mg/kg) and chlorantraniliprole (@ 250 mg/kg) + curcumin (@ 100 mg/kg), respectively. Duration of exposure period was 28 days, orally. The dose of chlorantraniliprole was  $1/20^{\text{th}}$  of  $LD_{50}$  (i.e. 5000 mg/kg, oral <sup>1,4</sup>). Animals had free access to pelleted feed, clean and deionized drinking water. Daily light and dark cycle of 12 h was ensured. Before start of the experiment, an acclimatization period of fifteen days was allowed. All the experimental animals were kept under constant observation before and during the entire period of study. The study was approved from Institutional Animal Ethics Committee (IAEC Approval no. IAEC/SVPUAT/2024/137), COVAS, SVPUA&T, Meerut.

### 2.1 General toxicity

#### 2.1.1 Gross observations

Rats of all the groups were closely observed during the entire experimental period for any apparent signs of toxicity including behavioral changes, discomfort, gait, loss of hair, diarrhea or mortality etc.

#### 2.1.2 Body weight

Body weight of different rat treatment groups was recorded at 0 day, 7<sup>th</sup>, 14<sup>th</sup>, 21<sup>th</sup> and 28<sup>th</sup> day of experimental period and body weight gain was calculated.

#### 2.1.3 Feed and water intake

Feed and water intake in rats of all treatment groups were recorded daily and computed on weekly basis during the entire duration of study.

### 2.2 Hematological studies

#### 2.2.1 Collection of blood

Blood from experimental rats was collected on 29<sup>th</sup> day in EDTA tubes from inner canthus of eye through retro-orbital plexus puncture with the help of glass capillary tubes after overnight fasting <sup>[14]</sup> for determination of hematological parameters by Hematology Auto analyzer (Mind Ray BC-30).

### 2.3 Collection of organs

At the end of exposure period after collection of blood, rats were humanely sacrificed by cervical dislocation. Heart was collected, blotted with tissue paper, and weighed to determine the absolute and relative organ weights (g/100 g bw).

#### 2.3.1 Histopathological studies

Heart was collected in 10 percent formalin and was processed as per standard procedure for determination of

histological changes in these tissue, if any. 5-6-micron thick sections of tissue were cut with the help of a microtome (SLEE 5062), and stained with standard procedure.

### 2.4 Statistical analysis

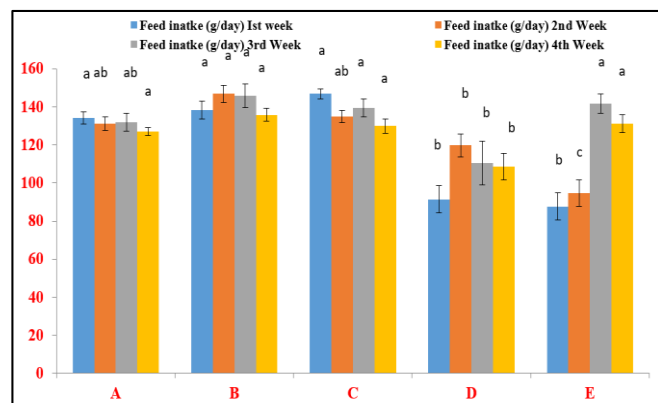
Statistical difference between respective means for various parameters (organ weights, relative organ weights, hematology) was evaluated by using one-way ANOVA followed by Tukey's multiple post hoc tests with the help of SPSS software 20 and daily feed and water intake was analyzed by the two-way ANOVA with the help of SPSS software 20. Comparisons were made among the treatment groups. Data was presented as Mean $\pm$ SE and significant difference was considered at  $p < 0.05$ .

## 3. Results and Discussion

### 3.1 Effect of curcumin on general toxicity parameters in rats following 28-day exposure of chlorantraniliprole

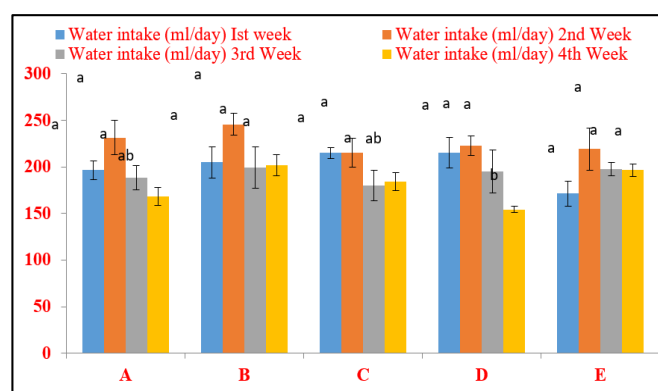
**3.1.1 Clinical signs:** Exposure of rats of control groups (A, B and C) showed normal behaviour and activities and no loss of hair and mortality in animals of any of the treatment group rats throughout the duration of studies period except in chlorantraniliprole group (D) showed increased activity and anxiety like behaviour and sweating may be suggestive of neurological involvement. Similar observation was reported by <sup>[15]</sup> in mice following chlorantraniliprole-administration due to chlorantraniliprole-induced stress and increases neuronal activity, anxiety-like behaviour as well as neurotransmitter disturbances in mammals. He reported the greater numbers of c-Fos-immunoreactive cells in the hippocampal dentate gyrus and decreased 3-methoxytyramine and histamine level in mice. Similarly, <sup>[16]</sup> observed increased neuronal activities (hyperexcitation) following exposure of endosulfan (due to antagonistic effects on GABA receptors), dieldrin and lindane in rodents. Concurrent administration of rats with curcumin and chlorantraniliprole (E) showed normal behaviour and locomotor activity possibly due to antioxidant and neuroprotective effect of curcumin which may be due to decreasing malondialdehyde (MDA) and NO levels in brain tissues and significant increasing GSH concentration in brain tissue of chlorpyrifos exposed rats indicated ameliorative potential of curcumin <sup>[17]</sup>.

**3.1.2 Feed and water intake:** Present study indicated that daily feed intake in rats of group D (chlorantraniliprole) was less during the entire period of study i.e. I<sup>st</sup>, II<sup>nd</sup>, III<sup>rd</sup> and IV<sup>th</sup> weeks as compared to rats of control groups A, B and C may be due to stress induced by chlorantraniliprole in rats. Result of present study are in line with observation of <sup>[18]</sup> in acephate administered rats for 45 days may be due to disturbance in hormone level or direct. Daily feed intake in rats of co-treated group (curcumin + chlorantraniliprole) was also was increased during the III<sup>rd</sup> and IV week of period of study indicated increased weight gain similar to control group. This may be due to antistress inducing effect of curcumin and increased consumption of daily feed and also feed conversion efficiency was increased resulting in more body weight gain in this group. Result of present study of daily water intake data revealed no significant alteration in water intake in rats of different treatment groups (Fig. 1 & 2).



\*Values (mean  $\pm$  SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).

**Fig 1:** Effect of curcumin (100 mg/kg) on weekly feed intake in rats (g) of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

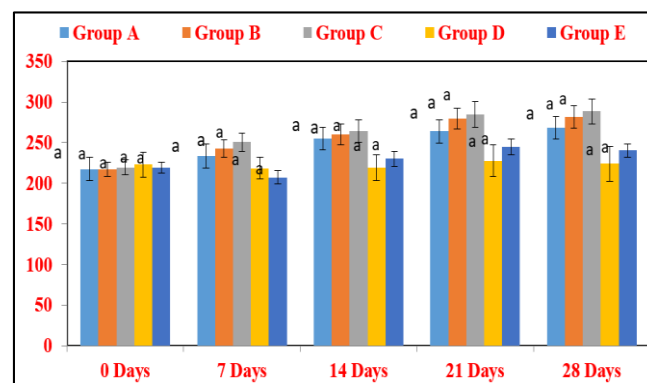


\*Values (mean  $\pm$  SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).

**Fig 2:** Effect of curcumin (100 mg/kg) on weekly water intake in rats (ml) of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

**Weekly body weight (g) and percent weight gain:** Weekly body weight gain in rats of different treatment groups showed no significant alteration (Fig 3). However, slight reduction in body weight gain was recorded during the IVth week of exposure of chlorantraniliprole in group of rats D which is due significant decline in feed intake in rats of this group during the entire study period. Result of present study are in agreement of [19] report in which no weight gain and mean weight reduction was observed in mice following 28 days exposure of chlorantraniliprole possibly due to reduction in feed efficiency [19]. Result of present study are in agreements with the findings of [20] as they observed significant decrease in body weight gain in rats of chlorantraniliprole (coragen) fed rats at the dose rate of 1/20<sup>th</sup>, 1/40<sup>th</sup> and 1/60<sup>th</sup> of LD<sub>50</sub> following 90 days exposure as compared to the rats of control group, possibly due to stress of chronic exposure of coragen. [21] observed significant reduction in body weight and body weight gain in mice at higher dose of chlorantraniliprole administration possibly due to reduction in feed efficiency. In the present study concurrent administration of curcumin and chlorantraniliprole in rats of group E showed body weight gain throughout the duration of study period of 28days

which may be due to antioxidant activity and decreasing oxidative stress effect of curcumin in rats. In the present study highest weight gain was observed in rats of curcumin alone group (C). The result of present study is in agreements [22], who reported body weight gain activity of curcumin against pyrethroid exposed Wistar rats which is due to antioxidant activity.



\*Values (mean  $\pm$  SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).

**Fig 3:** Effect of curcumin (100 mg/kg) on body weight gain (g) of rats of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (Curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

#### Effect of curcumin on haematological-parameters in rats following 28-day exposure of chlorantraniliprole

Result of present study revealed that total RBCs count value was slightly higher in rats of chlorantraniliprole group (D) which was similar in observation of [20], where significant increase in red blood cells (RBCs) value following 90 days' exposure of chlorantraniliprole at 1/20<sup>th</sup>, 1/40<sup>th</sup> and 1/60<sup>th</sup> of LD<sub>50</sub>. [20] also reported significant decline in the level of haemoglobin (Hb) and haematocrit (PCV) value following 90 days exposure of chlorantraniliprole which was contrast to present study in which slight increase (non significant) in haemoglobin and haematocrit value were observed. In the present study, non-significant alteration was observed in red cell distribution width (RDW-SD and RDW-CV), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) values in rats of different treatment groups (Table 1 and 2). However, [20] reported significant alteration in MCH and MCHC concentration following 90 days oral exposure at the 1/20<sup>th</sup>, 1/40<sup>th</sup> and 1/60<sup>th</sup> of LD<sub>50</sub> which was contrast of the present study. Similar observation was reported by [23] in coragen exposure in rats at 14<sup>th</sup> and 21<sup>th</sup> day at the dose rate of 1000 mg/kg with significant decrease in RBCs, haemoglobin percentage, haematocrit percentage which may be possibly due to haemorrhages [24], impaired synthesis of haemoglobin in RBCs and deficiency of iron, folic acid and vitamin B12. [25, 26] reported significant alteration in RBCs, Hb, haematocrit, MCV, MCH and MCHC values in 42 days exposure of coragen (@ 1000 mg/kg) in rats. In the present study, curcumin administration with chlorantraniliprole in rats of group E provide protective effect on haematological parameters may be due to mitigative oxidative stress produced by chlorantraniliprole. Body defence system regulated by white blood cells (WBCs) by acting against invading microbes and any alteration in their number would result in degradation of

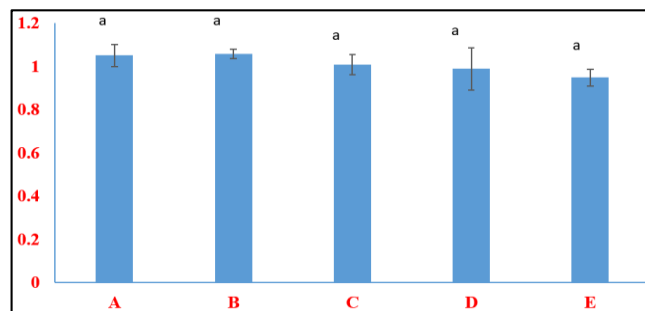
immune response. Decreased WBCs count in chlorantraniliprole alone group was not significant which was in agreement of finding of [20] who reported significant decline in WBCs count following 90 days exposure of coragen to rats at the 1/20<sup>th</sup>, 1/40<sup>th</sup> and 1/60<sup>th</sup> dose of LD<sub>50</sub>. Similarly, significant decrease in WBCs count was observed by [26] following coragen administration of at the dose rate of 1000 mg/kg bw for 42 days. The decrease in WBCs count in present study may possibly due to consumption of WBCs while encountering a variety of inflammatory injury caused by coragen (chlorantraniliprole) or failure or destruction of stem cells in the bone marrow [27]. Co-administration of curcumin with chlorantraniliprole tended to normalized the value of WBCs towards the control groups due to induction of leucocytosis and leucocyte mobilization during severity of stress induced by causative agent [24].

Present study revealed no significant alteration in lymphocyte, monocytes and granulocytes percentage was observed in different treatment groups. Non significant increase in the granulocyte percentage in chlorantraniliprole group (D) was decreased following administration of curcumin in rats of group (E) indicative of ameliorative potential of curcumin on haematological indices as observed by [28] following turmeric administration in carbofuran exposed rats possibly due to antioxidant activity and decrease in lipid peroxidation. Non significant decrease in the absolute count of lymphocyte and monocytes in chlorantraniliprole group indicate the toxic effect of chlorantraniliprole and suppression of immune system and making the animals more susceptible to infection. Co-administration of rats with curcumin and chlorantraniliprole increased the absolute count of lymphocyte and monocyte towards the control group which is indicative of ameliorative and immunomodulating and antioxidant activity of curcumin (Table 3).

In the present study, total platelet count value was moderately decreased in rats of chlorantraniliprole alone-treated rats group D. In contrast to our observation, [28] reported non significant increase in platelet value in carbofuran (@ 1mg/kg bw) exposed rats. Co-treatment of rats with chlorantraniliprole and curcumin (E) moderately increased the platelet count indicative of protective effect of curcumin on haemopoietic system. Similar observation was obtained by [28] following carbofuran and turmeric administered rats. Platelets has role in blood coagulation mechanism, cardiovascular health etc and alteration in structure, number and membrane stability resulting in bleeding or thrombic disorders. MPV and PDWC is important markers of cardiovascular health condition determinants [29, 30]. No significant alteration in MPV, PDWC values and marked decrease in plateletcrit percent value (PCT%) in chlorantraniliprole group while concurrent treatment of chlorantraniliprole + curcumin indicative of ameliorative potential of curcumin (Table 4).

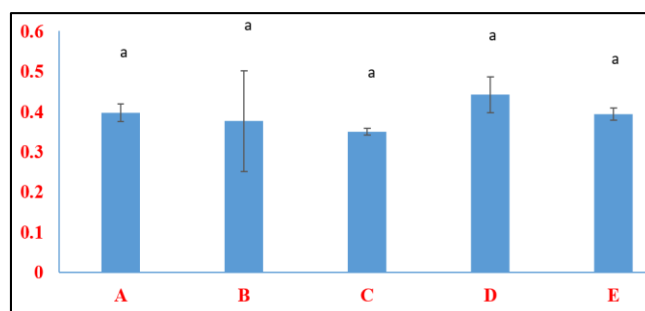
#### Absolute (g) and relative organ weights (g/100 g body weight)

Present study revealed that there was no significant alteration in absolute weight of heart of different treatment groups. In the present study, relative weight of heart was non-significant altered in different treatment groups (A to E) (Figure 4 and 5).



\*Values (mean  $\pm$  SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).

**Fig 4:** Effect of curcumin (100 mg/kg) on absolute organ weight of heart (g) in rats of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).



\*Values (mean  $\pm$  SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).

**Fig 5:** Effect of curcumin (100 mg/kg) on relative organ weight of heart (g/100 bw) in rats of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

#### 3.4 Effect of curcumin on heart histopathology in rats following 28 day exposure of chlorantraniliprole.

Histological examination of heart tissue of rats of control groups showed normal histology appearance with the presence of myocardial smooth muscles fibers. Chlorantraniliprole exposed rats produced changes in histological structure in the form of heavy congestion and mild focal mononuclear infiltration. Result of present study are in line with observation of [31] findings following monocrotophos exposure rats with presence of nonspecific inflammatory changes and oedema formation in muscle fibers of cardiac tissue which may be due to oxidative stress effect of monocrotophos in rats. Co-administration of rats with chlorantraniliprole and curcumin showing marked recovery and only mild congestion seen in cardiac smooth muscles fibers which may be due to antioxidant action of curcumin (Fig 6). In the present study, cardio-protective effect of curcumin on heart tissue are in agreement with [32] who observed that curcumin significantly decreased the cardiac enzyme maker and increased the antioxidant level in heart tissue and provided ameliorative effect against cardiac damaging effect of chlorpyrifos in rats.

Therefore, histopathological examination of heart tissue of chlorantraniliprole exposed rats suggested that marked alteration in histoarchitecture of this organ and may be indicative of toxic effect of chlorantraniliprole on this organ. Co-administration of curcumin and chlorantraniliprole significantly improved the histology of this vital organ and provide ameliorative action by normalizing the histology of heart almost towards the control groups.

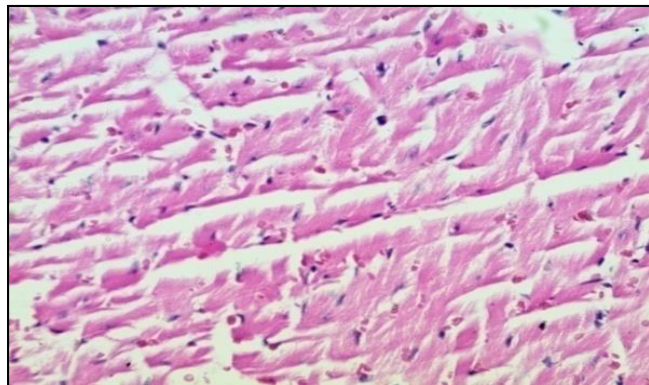


**Fig 6:** Microphotograph of cardiac tissue of group-A showing normal histology (Stain H&E; 100X)

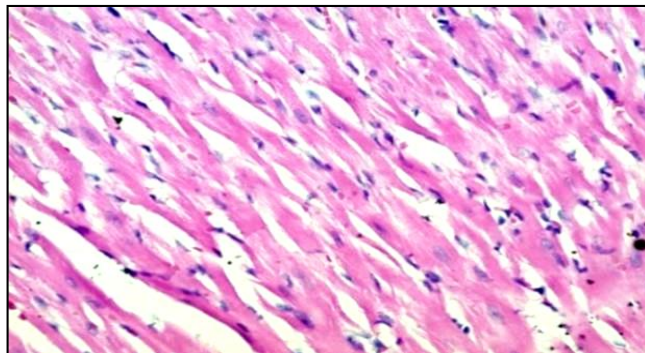


**Fig 8:** Microphotograph of cardiac tissue of group-C (curcumin treated @ 100 mg/kg) showing normal histology (Stain H&E; 100X)

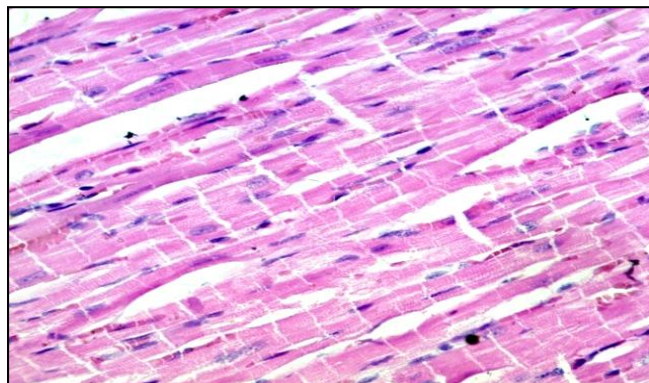


**Fig 7:** Microphotograph of cardiac tissue of group-B (corn oil) showing normal histology (Stain H&E; 100X)

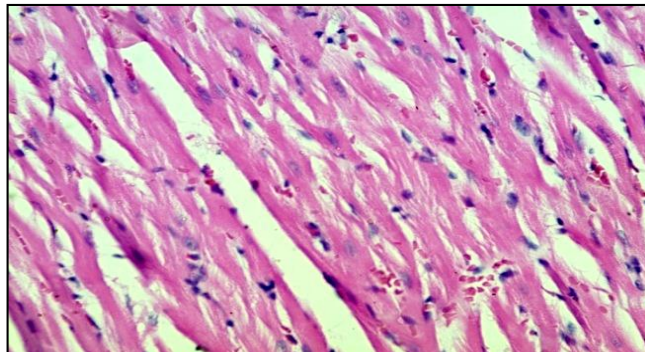


**Fig 9:** Microphotograph of cardiac tissue of group D (chlorantraniliprole @ 250 mg/kg) showing heavy congestion and mild focal mononuclear infiltration (H&E; 100X)

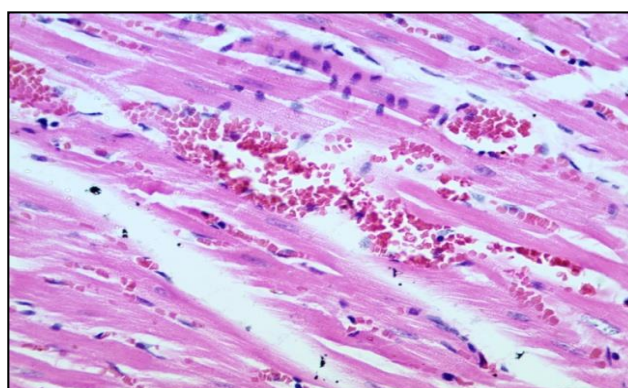


**Fig 10:** Microphotograph of cardiac tissue group E (Chlorantraniliprole @ 250 mg/kg + Curcumin @ 100 mg/kg) showing marked recovery showing only mild congestion (H&E; 100X)

**Table 1:** Effect of curcumin (100 mg/kg) on erythrocytic indices of rats of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

| Groups | Treatment                                              | RBCs (X 10 <sup>4</sup> U/L) | Hb (g/dl)               | HCT/PCV (%)             | RDW-SD (fl)              | RDW-CV (%)              |
|--------|--------------------------------------------------------|------------------------------|-------------------------|-------------------------|--------------------------|-------------------------|
| A      | Control                                                | 821.62±17.60 <sup>a</sup>    | 14.74±0.38 <sup>a</sup> | 44.14±1.50 <sup>a</sup> | 32.61±0.93 <sup>ab</sup> | 15.40±0.37 <sup>a</sup> |
| B      | Vehicle control (Corn oil)                             | 823.75±15.06 <sup>a</sup>    | 15.18±0.26 <sup>a</sup> | 44.28±0.61 <sup>a</sup> | 30.30±0.78 <sup>b</sup>  | 14.57±0.34 <sup>a</sup> |
| C      | Curcumin (100 mg/kg)                                   | 855.50±36.25 <sup>a</sup>    | 15.54±0.56 <sup>a</sup> | 45.03±1.78 <sup>a</sup> | 30.60±0.32 <sup>ab</sup> | 14.62±0.22 <sup>a</sup> |
| D      | Chlorantraniliprole (250 mg/kg)                        | 843.5±64.11 <sup>a</sup>     | 15.39±1.13 <sup>a</sup> | 45.26±3.54 <sup>a</sup> | 33.40±0.78 <sup>a</sup>  | 15.85±0.35 <sup>a</sup> |
| E      | Chlorantraniliprole (250 mg/kg) + Curcumin (100 mg/kg) | 803.12±21.35 <sup>a</sup>    | 14.71±0.32 <sup>a</sup> | 42.49±.50 <sup>a</sup>  | 31.78±0.58 <sup>ab</sup> | 14.85±0.20 <sup>a</sup> |

- Values (mean ± SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).
- HCT-hematocrit; Hb-Hemoglobin; PCV-Packed cell volume; RBCs-blood cells; RDW-Red cell distribution width

**Table 2:** Effect of curcumin (100 mg/kg) on erythrocytes indices (MCV, MCH and MCHC) of rats of different treatment groups following 28 days oral exposure to chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin 100 mg/kg) + chlorantraniliprole 250 mg/kg).

| Groups | Treatment                                              | MCV (fl)                | MCH (pg)                | MCHC (g/dl)             |
|--------|--------------------------------------------------------|-------------------------|-------------------------|-------------------------|
| A      | Control                                                | 53.20±0.74 <sup>a</sup> | 18.36±0.30 <sup>a</sup> | 33.73±0.44 <sup>a</sup> |
| B      | Vehicle control (Corn oil)                             | 53.50±0.57 <sup>a</sup> | 18.24±0.21 <sup>a</sup> | 34.44±0.22 <sup>a</sup> |
| C      | Curcumin (100 mg/kg)                                   | 53.50±0.46 <sup>a</sup> | 18.31±0.29 <sup>a</sup> | 34.43±0.31 <sup>a</sup> |
| D      | Chlorantraniliprole (250 mg/kg)                        | 53.68±0.47 <sup>a</sup> | 18.29±0.25 <sup>a</sup> | 34.06±0.35 <sup>a</sup> |
| E      | Chlorantraniliprole (250 mg/kg) + Curcumin (100 mg/kg) | 54.46±0.50 <sup>a</sup> | 18.35±0.18 <sup>a</sup> | 33.71±0.31 <sup>a</sup> |

- Values (mean ± SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).
- MCHC-Mean corpuscular hemoglobin concentration; MCH-Mean corpuscular hemoglobin; MCV-Mean corpuscular volume.

**Table 3:** Effect of curcumin (100 mg/kg) on leucocytic indices of rats of different treatment groups following 28 days oral exposure to Chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

| Groups | Treatment                                              | WBCs ( $1 \times 10^3/\mu\text{l}$ ) | LY%                     | MO%                    | GR%                     | LYM ( $\times 10^9/\text{L}$ ) | MON ( $\times 10^9/\text{L}$ ) | GRA ( $\times 10^9/\text{L}$ ) |
|--------|--------------------------------------------------------|--------------------------------------|-------------------------|------------------------|-------------------------|--------------------------------|--------------------------------|--------------------------------|
| A      | Control                                                | 14.94±1.26 <sup>a</sup>              | 59.34±4.64 <sup>a</sup> | 5.50±0.59 <sup>a</sup> | 34.07±3.85 <sup>a</sup> | 8.78±1.72 <sup>a</sup>         | 0.72±0.12 <sup>a</sup>         | 4.43±0.83 <sup>a</sup>         |
| B      | Vehicle control (Corn oil)                             | 17.25±1.70 <sup>a</sup>              | 69.45±2.13 <sup>a</sup> | 4.83±0.23 <sup>a</sup> | 24.45±1.78 <sup>a</sup> | 12.23±1.32 <sup>a</sup>        | 0.83±0.09 <sup>a</sup>         | 4.05±0.41 <sup>a</sup>         |
| C      | Curcumin (100 mg/kg)                                   | 13.99±1.53 <sup>a</sup>              | 70.07±0.72 <sup>a</sup> | 5.18±0.21 <sup>a</sup> | 24.37±0.80 <sup>a</sup> | 10.28±1.07 <sup>a</sup>        | 0.74±0.08 <sup>a</sup>         | 3.46±0.30 <sup>a</sup>         |
| D      | Chlorantraniliprole (250 mg/kg)                        | 12.35±0.85 <sup>a</sup>              | 54.47±7.01 <sup>a</sup> | 4.70±0.26 <sup>a</sup> | 40.82±7.18 <sup>a</sup> | 7.13±1.14 <sup>a</sup>         | 0.61±0.05 <sup>a</sup>         | 5.23±1.03 <sup>a</sup>         |
| E      | Chlorantraniliprole (250 mg/kg) + Curcumin (100 mg/kg) | 14.53±1.95 <sup>a</sup>              | 63.17±3.31 <sup>a</sup> | 4.86±0.21 <sup>a</sup> | 31.96±3.38 <sup>a</sup> | 9.36±1.40 <sup>a</sup>         | 0.71±0.08 <sup>a</sup>         | 4.52±0.74 <sup>a</sup>         |

- Values (mean ± SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).
- WBC-White blood cell; LY%-Lymphocytes percent; MO%-Monocytes percent; GR%-Granulocytes percent.

**Table 4:** Effect of curcumin (100 mg/kg) on thrombocytes indices of rats of different treatment groups following 28 days oral exposure to Chlorantraniliprole (250 mg/kg) alone and both in combination (curcumin (100 mg/kg) + chlorantraniliprole (250 mg/kg)).

| Groups | Treatment                                              | PLT* ( $\times 10^4/\text{U/L}$ ) | MPV (fL)               | PCT (%)                | PDWC (fL)               |
|--------|--------------------------------------------------------|-----------------------------------|------------------------|------------------------|-------------------------|
| A      | Control                                                | 66.07±9.48 <sup>a</sup>           | 7.18±0.12 <sup>a</sup> | 0.49±0.07 <sup>a</sup> | 14.97±0.16 <sup>a</sup> |
| B      | Vehicle control (Corn oil)                             | 77.35±5.78 <sup>a</sup>           | 7.19±0.10 <sup>a</sup> | 0.54±0.04 <sup>a</sup> | 15.17±0.08 <sup>a</sup> |
| C      | Curcumin (100 mg/kg)                                   | 79.26±0.06 <sup>a</sup>           | 7.13±0.06 <sup>a</sup> | 0.56±0.06 <sup>a</sup> | 15.32±0.06 <sup>a</sup> |
| D      | Chlorantraniliprole (250 mg/kg)                        | 56.69±12.32 <sup>a</sup>          | 7.49±0.20 <sup>a</sup> | 0.41±0.08 <sup>a</sup> | 15.16±0.09 <sup>a</sup> |
| E      | Chlorantraniliprole (250 mg/kg) + Curcumin (100 mg/kg) | 78.21±6.84 <sup>a</sup>           | 7.29±0.10 <sup>a</sup> | 0.57±0.04 <sup>a</sup> | 15.13±0.08 <sup>a</sup> |

- Values (mean ± SEM; n = 8) bearing different superscripts in the same column differed significantly ( $p < 0.05$ ).
- PLT-Platelets; MPV-Mean platelet volume; PCT-Plateletcrit; PDWC-Platelet distribution width.

## Conclusion

Result of present study concluded that chlorantraniliprole induced the alteration in behavioral, hematological and produced significant histoarchitectural changes in heart indicating adverse effect of chlorantraniliprole following 28 days oral administration and concurrent administration of curcumin and chlorantraniliprole in male Wistar rats ameliorates the neurobehavioral, hematological, and histological changes towards the control groups indicating protective effects of curcumin against chlorantraniliprole possibly due to free radicle scavenging and antioxidant potential.

## Acknowledgements

Authors are thankful to Hon'ble Vice chancellor, SVPUAT, Meerut for providing the necessary facilities and financial support for this study. Authors are also thankful to Dean, College of Veterinary Science for logistics support. Authors are thankful to OIC of Small animal facility and Referral Analytical Laboratory, College of Biotechnology for providing facilities for the current studies.

## References

1. USEPA. Chlorantraniliprole pesticide fact sheet. EFSA J. 2008;11(6):3143.
2. Lahm GP, Selby TP, Freudenberger JH, Stevenson TM, Myers BJ, Seburyamo G, *et al.* Insecticidal anthranilic diamides: a new class of potent ryanodine receptor activators. Bioorg Med Chem Lett. 2005;15:4898-4906.
3. Lahm GP, Stevenson TM, Selby TP, Freudenberger JH, Cordova D, Flexner L, *et al.* Rynaxypyr™: a new insecticidal anthranilic diamide that acts as a potent and selective ryanodine receptor activator. Bioorg Med Chem Lett. 2007;17:6274-6279.
4. USEPA. Chlorantraniliprole: human health risk assessment for proposed uses on oilseeds (subgroups 20A-C) and soybean (crop groups 6 and 7). Office of Pesticide Programs; 2012 May 17. Available from: <https://www.regulations.gov/document?D=EPA-HQ-OPP-2012-0029-0007>
5. Aggarwal BB, Sundaram C, Malani N, Ichikawa H. Curcumin: the Indian solid gold. Adv Exp Med Biol. 2007;595:1-75.
6. He LF, Chen HJ, Qian LH. Curcumin protects pre-oligodendrocytes from activated microglia *in vitro* and *in vivo*. Brain Res. 2010;1339:60-69.
7. Hewlings SJ, Kalman DS. Curcumin: a review of its effects on human health. Foods. 2017;6:92.
8. Wu GQ, Chai KQ, Zhu XM, Jiang H, Wang X, Xu EQ, *et al.* Anti-cancer effects of curcumin on lung cancer through the inhibition of EZH2 and NOTCH1. Oncotarget. 2016;7:26535-26550.
9. Zhang L, Ma Z, Wu Z, Jin M, An L, Xu F. Curcumin improves chronic pain-induced depression through

- regulating serum metabolomics in a rat model of trigeminal neuralgia. *J Pain Res.* 2020;13:3479-3492.
10. Shen H, Shen J, Pan H, Xu L, Sheng H, Liu B, *et al.* Curcumin analog B14 has high bioavailability and enhances the effect on breast cancer cells *in vitro* and *in vivo*. *Cancer Sci.* 2021;112(2):815-827.
  11. Guzman ACV, Razzak A, Cho JH, Kim JY, Choi SS. Curcumin-loaded human serum albumin nanoparticles prevent Parkinson's disease-like symptoms in *C. elegans*. *Nanomaterials (Basel).* 2022;12(5):758.
  12. Park BH, Lim JE, Jeon HG, Seo SI, Lee HM, Choi HY, *et al.* Curcumin potentiates antitumor activity of cisplatin in bladder cancer cell lines via ROS-mediated activation of ERK1/2. *Oncotarget.* 2016;7:63870-63886.
  13. Davoodvandi A, Farshadi M, Zare N, Akhlagh SA, Alipour NE, Mahjoubin-Tehran M, *et al.* Antimetastatic effects of curcumin in oral and gastrointestinal cancers. *Front Pharmacol.* 2021;12:668567.
  14. Sorg DA, Buckner B. A simple method of obtaining venous blood from small laboratory animals. *Exp Biol Med.* 1964;115:1131-1132.
  15. Kimura M, Shoda A, Murata M, Hara Y, Yonoichi S, Ishida Y, *et al.* Neurotoxicity and behavioral disorders induced in mice by acute exposure to the diamide insecticide chlorantraniliprole. *J Vet Med Sci.* 2023;85(4):497-506.
  16. Van Melis P, Peerdeman LVJ, Huiberts AM, Van Kleef EHW, Groot AD, Westerink RHS. Effects of acute insecticide exposure on neuronal activity *in vitro* in rat cortical cultures. *Neurotoxicology.* 2024;102:58-67.
  17. Farkhondeh T, Zardast M, Rajabi S, Abdollahi-Karizno M, Roshanravan B, Havangi J, *et al.* Neuroprotective effects of curcumin against chronic chlorpyrifos-induced oxidative damage in rat brain tissue. *Curr Aging Sci.* 2024;17(3):205-209.
  18. Jain E, Vashishat N. Toxicity of acephate to liver and kidney of female Wistar rats. *Indian J Entomol.* 2023;85(2):322-326.
  19. JMPR. Pesticide residues in food—2008: toxicological evaluations. Rome: FAO/WHO; 2008. p. 9-18.
  20. Shallan M, Hamdi E, Abdel RE. Coragen (chlorantraniliprole) insecticide effects on male albino rats. *Res J Pharm Biol Chem Sci.* 2016;7(6):1536-1545.
  21. Wolterink G, Dellarco V. Chlorantraniliprole. *JMPR.* 2008:105-134.
  22. Yadav S, Dewan RK, Rani A, Chopra J. Antioxidant effect of curcumin on body weight of male albino Wistar rats exposed to pyrethroid-based mosquito vaporizers fumes: an experimental study. *Innov Biol Sci.* 2024;5:156-168.
  23. Kumar A, Dutta K, Najam A, Nath A, Singh JK, Ali M, *et al.* Coragen causes hematological alterations in Charles Foster rats. *Eur J Toxicol Sci.* 2013;4:1-7.
  24. Celik I, Suzek H. Effects of subacute exposure of dichlorvos at sublethal dosages on erythrocytes and tissue antioxidant defense systems and lipid peroxidation in rats. *Ecotoxicol Environ Saf.* 2009;72(3):905-908.
  25. Murray RK, Granner DK, Mayes PA, Rodwell VW. Harper's illustrated biochemistry. New York: McGraw-Hill; 2007. p. 46-47.
  26. Dutta K, Ali M, Najam A, Kumar R, Kumar A. Ameliorative effect of seed extract of *Pterocarpus santalinus* on Coragen-induced hematological alterations and serum biochemical changes in Charles Foster rats. *J Toxicol Environ Health Sci.* 2014;6:194-202.
  27. Uzun FG, Kalender Y. Chlorpyrifos-induced hepatotoxic and hematologic changes in rats: the role of quercetin and catechin. *Food Chem Toxicol.* 2013;55:549-556.
  28. Hossein S, Tanvir EM, Prince MB, Billah M, Paul S, Saha M, *et al.* Protective mechanism of turmeric (*Curcuma longa*) on carbofuran-induced hematological and hepatic toxicities in a rat model. *Pharm Biol.* 2017;55(1):1937-1945.
  29. Slavka G, Perkmann T, Greisenegger H, Marsik C, Wagner OF, Endler G. Mean platelet volume may represent a predictive parameter for overall vascular mortality and ischemic heart disease. *Arterioscler Thromb Vasc Biol.* 2011;31(5):1215-1218.
  30. Yaghoubi A, Golmohamadi Z, Alizadehasl A, Azarfarin R. Role of platelet parameters and haematological indices in myocardial infarction and unstable angina. *J Pak Med Assoc.* 2013;63(9):1133-1137.
  31. Velmurugan G, Venkatesh BDD, Ramasamy S. Prolonged monocrotophos intake induces cardiac oxidative stress and myocardial damage in rats. *Toxicology.* 2013. doi:10.1016/j.tox.2012.11.022
  32. Abdollahi-Karizno M, Chahkandi M, Rajabi S, Roshanravan B, Jafari-Nozad AM, Aschner M, *et al.* Protective effect of curcumin against cardiotoxic effects induced by chronic exposure to chlorpyrifos. *Curr Mol Med.* 2024;24(5):676-682.