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Ameliorative Role of Nelumbo nucifera in CCl_4-Induced Biochemical Toxicity

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Abstract

Background: Carbon tetrachloride (CCl_4) is a common experimental toxicant which causes a high degree of serum biochemical changes associated with liver, kidney and lipid metabolic dysfunctions. The Nelumbo nucifera has been reported to have significant pharmacological properties such as antioxidant and hepatoprotective property. Thus, the present study aimed at evaluating the biochemical effects of lotus petals methanolic extract of *N. nucifera* against CCl_4 induced toxicity in albino Wistar rats.

Methodology: The lotus petals methanolic extract was obtained from the fresh N. nucifera petals. Albino Wistar rats were further subdivided into four groups: control group, CCl_4 only group, lotus petals methanolic extract at 250, 500 and 750 mg/kg b.w. and silymarin standard group. The protective effect of the lotus petals methanolic extract was investigated by serum biochemical markers such as AST, ALT, ALP, LDH, bilirubin, urea, creatinine, triglyceride and cholesterol.

Results: Serum hepatic enzyme markers, bilirubin, renal function markers and lipid profile markers were significantly raised after administration of CCl_4, suggesting biochemical disruption and systemic toxicity. Treatment with lotus petals methanolic extract improved all the serum biochemical parameters in a dose dependent manner. The lotus petals methanolic extract treated group at the highest dose (750 mg/kg) was the most protective against the CCl_4 induced alteration of the AST, ALT, ALP, LDH, bilirubin, urea, creatinine, triglyceride and cholesterol.

Conclusion: Lotus petals methanolic extract showed significant protective effect in terms of serum biochemical parameters against CCl_4-induced toxicity. From the result obtained it may be suggested that the lotus petals methanolic extract can bring hepatorenal and lipid metabolic balance to normal condition and the dose of 750 mg/kg exhibited the maximum response with respect to the other doses of lotus petals methanolic extract tested.

Keywords: *Nelumbo nucifera*; carbon tetrachloride; serum biochemistry; hepatotoxicity; renal markers; lipid profile.

1. INTRODUCTION

The liver is an important metabolic organ responsible for detoxification, digestion, immune regulation, nutrient storage, and biotransformation of endogenous and exogenous compounds. Because it metabolizes drugs, chemicals, toxicants, and by-products, it is vulnerable to injury. The liver is vascular and contains enzyme systems that convert foreign substances into metabolites. However, some compounds may become reactive or toxic products that disturb hepatic functions (Alnuqaydan et al. 2022). Therefore, biochemical parameters are indicators for liver injury and systemic toxicity.

Carbon tetrachloride (CCl_4) is a well-known experimental toxicant used to induce liver damage in animal models. Its hepatotoxicity occurs mainly through metabolic activation in the liver, producing free radicals. These reactive species disrupt biochemical functions, damage hepatocyte membranes, and attack cellular components(Li et al. 2021). Membrane injury causes leakage of intracellular enzymes into the bloodstream, resulting in elevated serum markers of hepatic damage. Thus, CCl_4-induced toxicity is widely used for evaluating protective effects of natural compounds and medicinal plant extracts (Kopilakkal et al. 2021). Recent studies confirm the importance of this model for assessing oxidative stress, inflammation, and hepatoprotective responses. Recent studies have also shown that natural products can reduce CCl_4-induced liver injury by improving oxidative stress, inflammation, fibrosis and hepatotoxicity (*Ganoderma lucidum*: (Johra et al. 2023), blueberry and cranberry extracts: (Sergazy et al. 2023).

Serum biochemical markers are reliable tools for assessing CCl_4-induced toxicity. Important hepatic enzymes include aspartate aminotransferase (AST) and alanine aminotransferase (ALT), which reflect liver cell damage and membrane disruption. ALT is mainly located in the cytoplasm, whereas AST is found in cytoplasmic and mitochondrial compartments. Increased serum levels of these enzymes indicate cellular leakage, hepatocyte damage, and loss of membrane integrity. Alkaline phosphatase (ALP) is associated with liver function and bile flow. Elevated ALP activity is related to hepatobiliary damage or membrane transport dysfunction (Choi et al. 2024). Lactate dehydrogenase (LDH), present in many tissues, increases after cellular injury. Bilirubin is an important liver function marker, and increased bilirubin concentration suggests impaired conjugation, excretion, or bile flow.

Apart from hepatic enzymes, CCl_4-induced toxicity may alter renal biochemical markers. Serum urea and creatinine are commonly used to evaluate kidney function. Increased levels indicate renal stress and impaired excretory function caused by toxic injury (Chen et al. 2019). Since toxicants may affect hepatic and renal functions, measurement of these parameters provides a broader understanding of systemic biochemical damage. CCl_4-induced renal toxicity is commonly associated with oxidative stress, inflammation and altered renal biochemical parameters, supporting the assessment of urea and creatinine as renal function markers (Alrashdi et al. 2025).

Lipid profile markers help assess biochemical disturbances caused by toxicants. Serum triglyceride and cholesterol levels provide information about lipid metabolism. CCl_4 may disturb lipid balance by affecting cholesterol biosynthesis, triglyceride metabolism, and lipid transport. Therefore, hepatic enzymes, bilirubin, renal markers, and lipid profile parameters together provide a serum biochemical assessment of CCl_4-induced toxicity (Munakarmi et al. 2023). Disturbances in cholesterol and triglyceride metabolism are features of biochemical injury and may indicate altered regulation. Medicinal plants have attracted attention because they contain bioactive compounds with antioxidant and pharmacological properties that may protect biological systems against chemically induced damage. Plant constituents such as flavonoids, phenolics, alkaloids, glycosides, steroids, and triterpenoids have been reported to protect against toxic injury (Shaban et al. 2023). In CCl_4-induced hepatic injury models, plant-based extracts have shown hepatoprotective effects, supporting their value as protective agents (Vun-Sang et al. 2022). Several plant-derived compounds and natural extracts have shown protective activity against CCl_4-induced liver injury through antioxidant and cytoprotective mechanisms. (*Clutia abyssinica* leaf extract: (Meharie et al. 2020); *Morchella importuna* polysaccharides: (Xu et al. 2021); 3,3′-diindolylmethane: (Munakarmi et al. 2022)). These findings support continued evaluation of natural compounds against chemically induced liver damage.

Nelumbo nucifera, commonly known as lotus, is an important medicinal plant used in traditional systems of medicine. Different plant parts, including petals, flowers, seeds, leaves, roots, and stems, have therapeutic value. It has antioxidant, anti-inflammatory, immune-protective, antidiabetic, anti-aging, anticancer, and hepatoprotective properties (Showkat et al. 2021). Therefore, N. nucifera may be a promising natural source for protection against CCl_4-induced serum biochemical alterations. The petals are important because lotus petal methanolic extract contains phenolic and flavonoid compounds, which are associated with antioxidant and membrane-stabilizing activity (Wang et al. 2021).

In the present study, albino Wistar rats were used to evaluate the protective effect of lotus petals methanolic extract of N. nucifera against CCl_4-induced toxicity at different oral doses. Silymarin was used as the standard reference drug. Serum biochemical parameters, including AST, ALT, ALP, LDH, bilirubin, urea, creatinine, triglyceride, and cholesterol, were assessed because these markers represent hepatic function, renal function, and lipid metabolism (Lin et al. 2022). Thus, this article evaluates serum biochemical changes caused by CCl_4 intoxication and examines the ability of N. nucifera to restore biochemical balance.

2. MATERIALS AND METHODS

2.1 Plant Material and Extract Preparation

The fresh flower/petals of *Nelumbo nucifera* were collected from a local flower nursery at Ranchi, Jharkhand. Collected plant material was first washed thoroughly with distilled water to remove surface dust and soil and other impurities. It was then quickly immersed in 70% ethanol for disinfection. The petals were cleaned after which dried under shade for few days or dried in the oven at 50 °C till complete drying was obtained. The material was dried and ground to a fine powder, passed through a sieve to get uniform particle size.

N. nucifera petals powder (10 g) was dissolved in 100 ml of methanol for preparation of lotus petals methanolic extract. The mixture was then placed on the rocker shaker and shaken for 72 hours at room temperature. The solution was filtered after extraction with Whatman filter paper No.1. Slow drying of the filtrate in an oven was then performed to get crude lotus petals methanolic extract. The last lotus petals methanolic extract was kept at 4 °C for future experimental applications.

2.2 Chemicals and Reagents

The experimental animals were made toxic by the administration of carbon tetrachloride (CCl_4). Olive oil was used as the solvent for CCl_4 administration. In this study, standard drug was silymarin and it was compared to N. nucifera treatment. Analytical grade chemicals and reagents were used in the study. The other chemicals used in the original study were purchased from E-Merck, Ranbaxy Pvt. Ltd., CDH and BDH Company, India while CCl_4 was purchased from Sigma-Aldrich.

2.3 Experimental Animals

For experimental study, albino Wistar rats weighing ~ 180 ± 10 g were used. Animals were kept in polypropylene cages under controlled conditions in the laboratory. Environmental conditions were a 14-hour light/dark cycle, relative humidity (60–70%), and a temperature of 25 ± 2 °C. Rats were fed a normal dry pellet diet and were allowed free-

choice water during the entire experimental period. The study followed the ethical instruction set by the Institutional Animal Ethical Committee (IAEC) at banasthali vidyapith india. The procedures was approved under reference number BV/IAEC/2023 and conformed to the regulation prescribed for the control and care of Experiment on animals (CPCSEA) in Chennai, India by the regulatory body.

2.4 Dose Preparation and Experimental Design

Olive oil was used as a vehicle for the intraperitoneal injection of carbon tetrachloride at a dose of 1.5 ml/kg of body weight. The lotus petals methanolic extract was used in oral administration at three different doses (250mg/kg, 500mg/kg, and 750mg/kg body weight). Oral doses of silymarin were used as the standard drug at the dose of 50 mg/kg of body weight. The animals were randomly assigned to 8 groups, having 6 rats in each group. Group I was the control group which received olive oil at 1.5 ml/kg of body weight intraperitoneally. The lotus petals methanolic extract was fed to Group II at a dose of 750 mg/kg body weight. CCl_4 (1.5 ml/kg b.wt.) was administered i.p. to group III. Groups IV, V, and VI were treated with CCl_4 and then orally fed with lotus petals methanolic extract at 250, 500, and 750 mg/kg, respectively. CCl_4 and Silymarin at 50 mg/kg body weight were given to Group VII. Lotus petals methanolic extract or silymarin was given 24 hours after administration of CCl_4 in the treatment groups.

2.5 Blood Collection and Serum Preparation

The animals were weighed following treatment and then partially anaesthetized with IP injection of ketamine and xylazine. Each rat had blood drawn from the retro-orbital venous sinus and placed in a clean test tube. Blood collected was left to clot at room temperature for 30 minutes. The clot was slowly removed from the test tube wall by a sterilized fine needle after the clot formed.

The blood samples were then centrifuged for 20 minutes at 2000 rpm and the serum was separated. The separated serum was carefully collected and stored at -20 ° C for biochemical analysis. This serum was utilized for estimation of different blood biochemical parameters associated with hepatic, renal and lipid profile change.

2.6 Serum Biochemical Marker Estimation

Biochemical markers of toxicity induced by CCl_4 were analyzed in the serum. Hepatic function markers consisted of aspartate aminotransferase (AST), alanine aminotransferase (ALT), serum alkaline phosphatase (ALP/SALP), lactate dehydrogenase (LDH), and bilirubin. Serum urea and creatinine were used as renal function parameters. Triglyceride and cholesterol were measured for the lipid profile markers.

The activities of ALT and AST were measured using the method described in the original study. Alkaline phosphates, cholesterol, triglycerides and urea were estimated in the serum as per the kit based methods as per the manufacturer's directions. The total protein concentration was measured by Lowry's method in serum and enzyme activities were expressed in suitable units. In order to evaluate the protective effect of lotus petals methanolic extract against serum biochemical changes induced by CCl_4, these biochemical estimations were carried out.

2.7 Statistical Analysis

The biochemical data were statistically analyzed to determine significance of differences between experimental groups. The results were presented as mean ± SD. One way analysis of variance (ANOVA) was used for comparing the treatment groups with the CCl_4 treated group and the control. $P \leq 0.001$ was taken as the level of significance and percentage protection was used to determine the dose dependent protective effect of against serum biochemical markers.

3. RESULTS

3.1 Effect of *Nelumbo nucifera* on Serum Transaminases

CCl_4 treatment resulted in significant elevations of serum transaminases, which is a marker of hepatocellular injury. AST increased to 152 ± 18.78 IU/L and ALT increased to 222 ± 27.44 IU/L in the CCl_4-treated group. Both enzymes were decreased in a dose-dependent manner by Nelumbo nucifera treatment. The highest dose, 750 mg/kg, reduced AST to 88 ± 10.87 IU/L and ALT to 105 ± 12.97 IU/L, showing 68.69% and 67.76% protection, respectively. The serum hepatic biochemical markers detailed values are shown in table-1.

Table 1. Effect of *Nelumbo nucifera* on CCl_4-induced alteration in serum hepatic biochemical markers

Treatment	AST IU/L	ALT IU/L	ALP IU/L	LDH mg Pi/h/100 ml	Bilirubin mg/dl
NN per se	60.3 ± 7.45	49.1 ± 6.06	205.6 ± 25.41	43.2 ± 5.34	0.28 ± 0.034
CCl_4 per se, 1.5 ml/kg	152 ± 18.78#	222 ± 27.44#	528 ± 65.26#	96.5 ± 11.9#	1.29 ± 0.15#
CCl_4 + NN, 250 mg/kg	133 ± 16.44* 18.01%	194 ± 23.98* 15.42%	409 ± 50.55* 36.96%	88 ± 10.87* 17.00%	1.18 ± 0.145* 8.33%

CCl_4 + NN, 500 mg/kg	109 ± 13.47* 45.04%	143 ± 17.67* 45.44%	335 ± 41.41* 59.53%	77.3 ± 9.55* 36.56%	0.89 ± 0.11* 38.54%
CCl_4 + NN, 750 mg/kg	88 ± 10.87* 68.69%	105 ± 12.97* 67.76%	270 ± 33.37* 79.28%	64 ± 7.91* 64.64%	0.73 ± 0.09* 55.20%
CCl_4 + Silymarin, 50 mg/kg	63 ± 7.87* 96.84%	57 ± 7.04* 95.94%	207.3 ± 25.62* 98.38%	49 ± 6.05* 88.95%	0.5 ± 0.06* 79.16%
F value at 1% level	53.56@	110.31@	55.99@	40.03@	93.67@

Note: Values are expressed as mean ± SD. NN = *Nelumbo nucifera*. # indicates significant difference compared with control group. * indicates significant difference compared with CCl_4-treated group.

3.2 Effect of *Nelumbo nucifera* on ALP, LDH, and Bilirubin

These increases in ALP, LDH, and bilirubin levels were also observed after exposure to CCl_4, thus confirming hepatic biochemical disruption. In the CCl_4-treated group, ALP was elevated to 528 ± 65.26 IU/L, LDH to 96.5 ± 11.9 mg Pi/h/100 ml, and bilirubin to 1.29 ± 0.15 mg/dl. These levels were subsequently lowered by over a period of time. At 750 mg/kg, ALP decreased to 270 ± 33.37 IU/L, LDH to 64 ± 7.91 mg Pi/h/100 ml, and bilirubin to 0.73 ± 0.09 mg/dl, with protection values of 79.28%, 64.64%, and 55.20%, respectively. The improvement was relatively greater for Silymarin. As seen in figure 1, the levels of AST, ALT, ALP, LDH and bilirubin were found to be significantly elevated by CCl_4 treatment and significantly decreased in dose dependent manner by N. nucifera treatment.

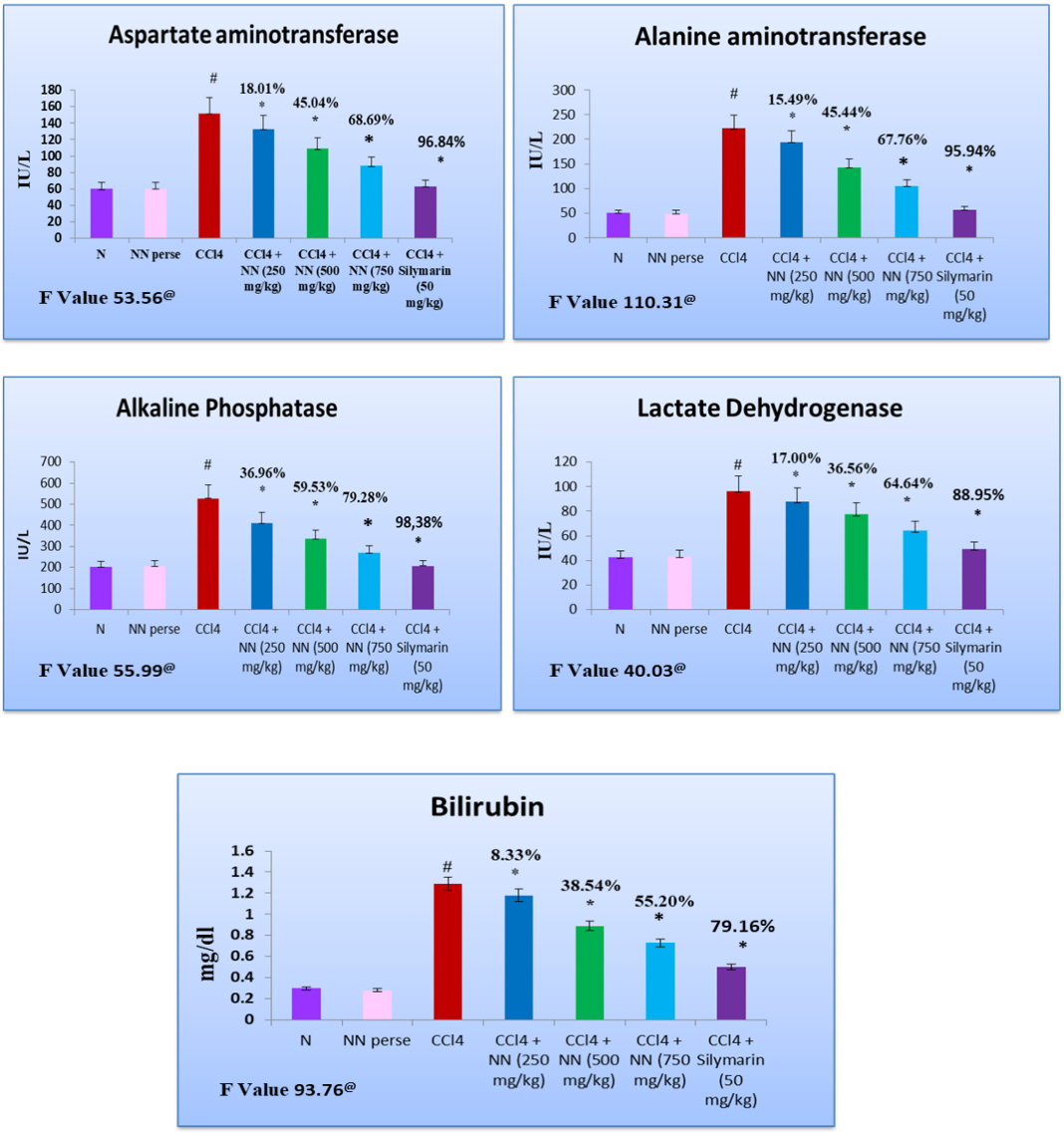


Figure 1. Effect of *N. nucifera* on serum hepatic markers

3.3 Effect of *Nelumbo nucifera* on Serum Renal Markers

There was increased serum urea and creatinine concentration with CCl_4 treatment, signifying renal biochemical alteration. The CCl_4 group had an elevated urea of 50.4 ± 6.23 mg/dl and elevated creatinine of 4.3 ± 0.53 mg/dl. N. nucifera treatment showed a dose dependent reduction in both markers. At 750 mg/kg, urea was reduced to 28.4 ± 3.51 mg/dl and creatinine to 1.64 ± 0.20 mg/dl, showing 66.85% and 64.81% protection, respectively. The serum renal and lipid profile markers detailed are presented in Table 2.

Table 2. Effect of *Nelumbo nucifera* on CCl_4-induced alteration in serum renal and lipid profile markers

Treatment	Urea mg/dl	Creatinine mg/dl	Triglyceride mg/dl	Cholesterol mg/dl
Control	17.1 ± 2.11	0.27 ± 0.033	9.8 ± 1.21	60.1 ± 7.42
NN per se	19.9 ± 2.45	0.25 ± 0.030	9.8 ± 1.21	62.1 ± 7.67
CCl_4 per se, 1.5 ml/kg	50.4 ± 6.23#	4.3 ± 0.53#	14.8 ± 1.82#	138.3 ± 17.09#
CCl_4 + NN, 250 mg/kg	47.2 ± 5.83* 13.25%	3.19 ± 0.39* 25.69%	13.4 ± 1.65* 28%	116.3 ± 14.37* 28.13%
CCl_4 + NN, 500 mg/kg	37.1 ± 4.58* 42.36%	2.91 ± 0.35* 32.82%	12.87 ± 1.59* 38.6%	102.4 ± 12.65* 45.90%
CCl_4 + NN, 750 mg/kg	28.4 ± 3.51* 66.85%	1.64 ± 0.20* 64.81%	10.7 ± 1.32* 82%	89.1 ± 11.01* 62.91%
CCl_4 + Silymarin, 50 mg/kg	18.8 ± 2.32* 94.85%	1.42 ± 0.17* 70.8%	10.2 ± 1.26* 92%	64.2 ± 7.93* 94.73%
F value at 1% level	65.77@	153.40@	11.43@	40.32@

Note: Values are expressed as mean ± SD. NN = *Nelumbo nucifera*. # indicates significant difference compared with control group. * indicates significant difference compared with CCl_4-treated group.

3.4 Effect of *Nelumbo nucifera* on Serum Lipid Profile

Triglyceride and cholesterol levels in the blood were disturbed by the administration of CCl_4. The CCl_4 treated group showed a rise in triglycerides to 14.8 ± 1.82mg/dl and cholesterol to 138.3 ± 17.09mg/dl. Lotus petals methanolic extract was found to dose-dependently decrease both parameters. At 750 mg/kg, triglyceride decreased to 10.7 ± 1.32 mg/dl and cholesterol to 89.1 ± 11.01 mg/dl, showing 82% and 62.91% protection, respectively. The lotus petals methanolic extract-treated groups once more showed less restoration than silymarin. As shown in figure 2, CCl_4 caused elevated levels of serum urea, creatinine, triglyceride and cholesterol levels, while N. nucifera brought down the levels of all the renal and lipid markers in a dose dependent manner.

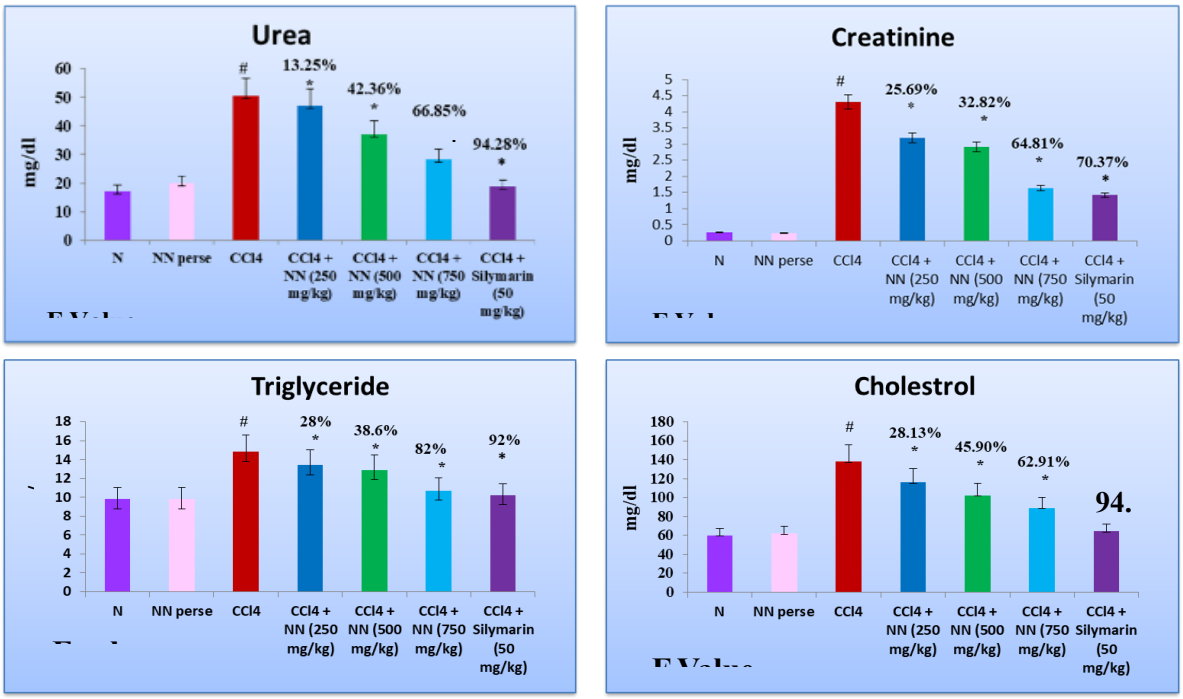
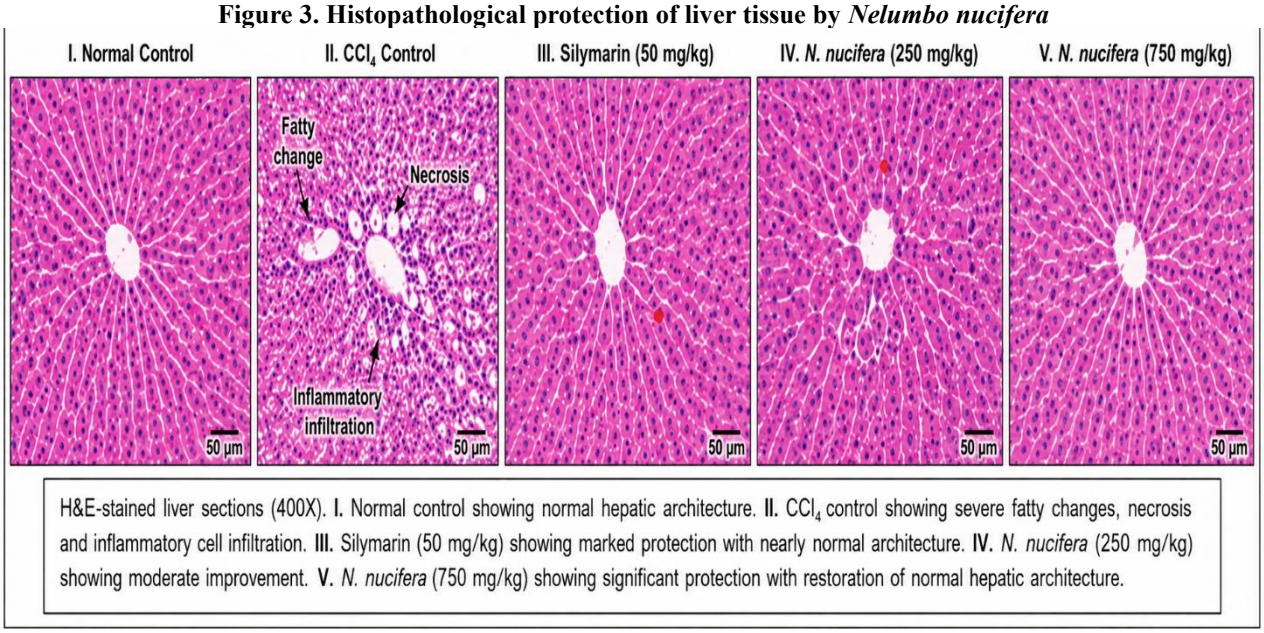


Figure 2. Effect of *N. nucifera* on serum renal and lipid markers.

4. DISCUSSION

There were marked changes in the serum biochemical markers of hepatic, renal and lipid metabolic disturbance, associated with the toxicity of CCl_4. Both AST and ALT are increased significantly after CCl_4 administration reflecting hepatocellular damage and loss of integrity of the cell membrane. These enzymes are present in the liver cells, but when the liver cells are damaged, these enzymes will be in the blood. In this study, AST and ALT levels decreased in a dose-dependent manner when injected with lotus petals methanolic extract of Nelumbo nucifera with the maximum effect seen at 750 mg/kg. This decrease implies that the lotus petals methanolic extract can be used to stabilise hepatocyte membrane which also decreases cell leakage and keeps liver cells away from being injured by CCl_4. Earlier, it was reported that these could aid in hepatoprotection by preventing the damage to liver caused by CCl_4 (Vun-Sang et al. 2022). As shown in Figure 3, H&E-stained liver sections revealed severe hepatic injury in the CCl_4 control group, whereas *N. nucifera*-treated groups showed dose-dependent improvement in liver architecture, with the 750 mg/kg dose showing marked restoration toward normal hepatic morphology.

Figure 3. Histopathological protection of liver tissue by *Nelumbo nucifera*



H&E-stained liver sections (400X). **I.** Normal control showing normal hepatic architecture. **II.** CCl_4 control showing severe fatty changes, necrosis and inflammatory cell infiltration. **III.** Silymarin (50 mg/kg) showing marked protection with nearly normal architecture. **IV.** *N. nucifera* (250 mg/kg) showing moderate improvement. **V.** *N. nucifera* (750 mg/kg) showing significant protection with restoration of normal hepatic architecture.

CCl_4 treatment also caused an increase in the levels of ALP, LDH and bilirubin, indicating hepatic biochemical dysfunction. High levels of ALP are generally associated with disturbances in bile flow, membrane transport and hepatobiliary function. The elevated LDH level in blood may be attributed to leakage of this enzyme from injured cells, while increased bilirubin may indicate impaired hepatic conjugation, excretion or bile duct obstruction. In the present study, treatment with *N. nucifera* improved the functional status of the liver by reducing ALP, LDH and bilirubin levels in a dose-dependent manner. The highest dose of lotus petals methanolic extract, 750 mg/kg, produced the maximum response and was found to be the most effective among the tested doses (Prakash et al. 2025). Similar improvements in liver function have been observed in CCl_4-induced hepatotoxicity models treated with plant-origin hepatoprotective agents. These findings support the present observation that natural products may protect the liver by restoring biochemical parameters and reducing toxicant-induced cellular injury ((Johra et al. 2023, Sergazy et al. 2023).

Exposure to CCl_4 also caused an increase in serum urea and creatinine concentrations, indicating renal biochemical stress. These markers are useful for assessing renal function, and elevated urea and creatinine levels indicate decreased renal excretory function and renal disturbance. In the current research, both urea and creatinine were decreased in a dose-dependent manner by lotus petals methanolic extract. The highest protection was observed at 750 mg/kg, suggesting that lotus petals methanolic extract may help mitigate hepatorenal biochemical disturbances caused by CCl_4 (Alrashdi et al. 2025). This protective effect may be related to improvement in systemic biochemical homeostasis and reduction of toxicant-induced functional damage. Medicinal plant extracts can reduce biochemical injury caused by toxicants, further supporting their protective role against CCl_4-induced toxicity (Meharie et al. 2020).

It has also been found that CCl_4 increased serum triglycerides and cholesterol, causing an imbalance in lipid metabolism. This lipid alteration may be associated with impaired lipid transport, changes in lipid synthesis and reduced lipid clearance during toxic injury. High serum triglyceride and cholesterol levels are important signs of disturbed metabolic regulation. In the present study, both parameters were decreased after treatment with lotus petals methanolic extract, and the highest protection was observed at 750 mg/kg. The improvement in lipid biochemical balance in CCl_4-

treated rats indicates that lotus petals methanolic extract may be beneficial in restoring lipid metabolism (Udavant et al. 2023, Xu et al. 2021). The improvement in triglyceride level is particularly important because triglycerides are closely related to systemic metabolic regulation and lipid transport. Related studies have also shown that natural compounds such as *Morchella importuna* polysaccharides and 3,3′-diindolylmethane can reduce CCl_4-induced hepatic oxidative injury and chronic liver damage through antioxidant and cytoprotective mechanisms (Xu et al. 2021, Munakarmi et al. 2022).

Overall, serum hepatic enzymes, bilirubin, renal markers and lipid profile parameters were improved in CCl_4-treated rats after administration of lotus petals methanolic extract. The extract showed a dose-dependent protective response, with 750 mg/kg identified as the optimum dose among the tested concentrations (Ahmed et al. 2019). However, the restoration activity was greater in the silymarin-treated group, confirming the stronger protective effect of the standard reference drug. The hepatoprotective potential of plant-based compounds has also been supported by studies using *Suaeda vermiculata*, 5-O-demethylnobiletin, gigantol and *Scutellaria linearis* against CCl_4-induced hepatic damage (Mohammed et al. 2020, Chang et al. 2021). Based on these findings, it may be suggested that lotus petals methanolic extract helps restore serum biochemical balance, prevents leakage of serum enzymes and promotes functional recovery in CCl_4-induced hepatorenal and metabolic toxicity.

5. CONCLUSION

Lotus petals methanolic extract was clearly protective against the serum biochemical changes induced by CCl_4 in Wistar rats. Doses of carbon tetrachloride significantly elevated serum liver enzyme activities including AST, ALT, ALP, LDH and bilirubin, which are indicative of liver cell injury and hepatic dysfunction. The elevated levels of these markers were reduced by lotus petals methanolic extract in a dose dependent manner indicating improvement in hepatic biochemical status and probably stabilization of liver cell membranes. The lotus petals methanolic extract also enhanced renal biochemical indices, such as decreased levels of serum urea and creatinine, which were raised following CCl_4 exposure. This suggests that N. nucifera can possess an effect on decreasing the biochemical stress in the kidney caused by toxins. Furthermore, the lotus petals methanolic extract demonstrated beneficial effect on triglyceride and cholesterol levels and thus improved serum lipid profile which was disturbed due to toxicity of CCl_4. In general, 750 mg/kg dose of silymarin showed the maximum protective effect in all serum biochemical parameters, while silymarin was more potent than the other tested doses. In general, the results indicate that lotus petals methanolic extract possesses significant serum biochemical protection effect against the hepatorenal and metabolic toxicity caused by CCl_4. More research is suggested to isolate the compounds that are responsible for these effects and to elucidate the exact mechanisms of protection.

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