Protective Role of *Coriandrum sativum* Seed Extract against Lead-Induced Oxidative Stress in Rat Liver and Kidney

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Abstract

Lead (Pb) is a well-known multi-organ toxicant and it damages liver and kidney. The objective of the present investigation was to determine the therapeutic role of *Coriandrum sativum* seed extract against lead-induced oxidative stress in rat liver and kidney. Male rats were divided into four groups: control (1000 ppm sodium acetate) and exposed (1000 ppm lead acetate) for 4 weeks; *Coriandrum sativum*-treated 1 (CST1) 250 mg/kg body weight/day and *Coriandrum sativum*-treated 2 (CST2) 500 mg/kg body weight/day (CST2) received separately the hydro-alcoholic seed extract of *Coriandrum sativum* for seven consecutive days after 4 weeks of lead exposure. After exposure and treatment periods, rats were sacrificed and the liver and kidney were isolated in all the groups. Blood was immediately stored at 4°C in heparinized vials. In liver and kidney, the reactive oxygen species (ROS), lipid peroxidation products (LPP) and total protein carbonyl content (TPCC) were estimated following standard protocols. Delta-ALAD activity (Δ-ALAD), Hemoglobin (Hb) concentration, red blood cell (RBC) count, white blood cell (WBC) count, and mean cell volume (MCV) were determined in blood. The data suggested a significant (*p*<0.05) increase in ROS, LPP and TPCC of liver and kidney in the exposed group compared with their respective controls. ROS levels were high in kidney than in liver of lead exposed group. Though the recovery was similar in both the organs, CST2 group showed higher recovery than that of CST1 group. The maximum recovery for LPP was seen in CST2 treated kidney restoring back to normal levels. Maximum increase in TPCC levels was found in exposed kidney than in liver. Whereas recovery for TPCC was partial in liver of CST1 group but complete in liver of CST2. Delta-ALAD activity, Hb, RBC, WBC and MCV showed a significant (*p*<0.05) decrease in exposed group. However, upon treatment with *Coriandrum sativum*, CST1 group showed partial restoration in some hematological parameters. Whereas, CST2 group showed restoration of deranged hematological parameters back to control. In conclusion, these results suggest that the seed extract of *Coriandrum sativum* might reduce the lead-induced oxidative stress organ specifically by its antioxidant and metal chelating activity and the mechanism needs to be studied further.

Keywords: Lead, *Coriandrum sativum*, Liver, Kidney, Oxidative stress.

Introduction

*Coriandrum sativum* (Common name: Coriander and Chinese parsley), belongs to Umbelliferae family, is an herb and is cultivated throughout India. *Coriandrum sativum* seeds are known for carminative and cooling properties (1), hypotensive property and it is also generally used for treating abdominal problems, especially stomach ulcers (2). Isocoumarines are the major active principle component present in *Coriandrum sativum* seeds, and the most vital...
molecule is Coriandrin. The seeds of *Coriandrum sativum* also contain Quercetin 3-glucuronide, isoquercitin and rutin (3). Coriander has been reported to reduce lipid peroxidation and also to restore the levels of antioxidant enzymes (4). *Coriandrum sativum* showed excretion of heavy metal in the urine of patients and also augmented the efficacy of antibiotics (5, 6).

Lead is a soft bluish-grey heavy metal and it is ubiquitous, one of the common source of heavy metal poisoning in domestic animals and cattle throughout the world (7). Lead (Pb) is a well-known multi-organ toxicant and it damages liver and kidney. Common health hazards from increased lead exposure are wide range of physiological and biochemical dysfunctions (8). Symptoms of lead toxicity are loss of appetite, weight loss, constipation, irritability, fatigue, occasional vomiting (9). Generation of ROS (Reactive Oxygen Species) and disturbance of pro-oxidant and antioxidant balance has been accepted as the most possible mechanism of lead toxicity (10, 11). Lead toxicity increases the excretion of accumulated ALA into the urine (12, 13) and decreases the production of PBG (Porphobilinogen). At present interest is gaining towards protective effects of antioxidants against chemically induced toxicities (14). Using a murine model of lead intoxication (15) *Coriandrum sativum* reduced lead accumulation in bone and protected mice from lead-induced kidney damage. Studies using *Coriandrum sativum* showed suppressive activity on lead deposition, probably resulting from the chelation of lead by some substances present in it (15). Metabolic homeostasis in the body is maintained by liver and it is susceptible to toxicity of heavy metals such as lead (16). In the present investigation an attempt has been made to study the protective effect of the hydroalcoholic extract of *Coriandrum sativum* seed against lead induced oxidative stress in liver and kidney. As the reactive oxygen species (ROS) formed during oxidative stress by lead can damage lipids and proteins forming lipid peroxidation products and protein carbonyls, these parameters were estimated in the present investigation on liver and kidney.

**Materials and Methods**

**Chemicals:** Lead acetate (99.8%), Thiobarbituric acid (TBA), 2, 7 Dichlorofluorescein diacetate (DCFH-DA), Meso-2, 3-Dimercaptosuccinic acid (DMSA) and Guanidine hydrochloride were purchased from Sigma Chemical Co. (St. Louis, MO, USA). All other chemicals were purchased from SISCO Research Laboratories Private Limited (Mumbai, India).

**Coriandrum sativum seed extract:** The hydroalcoholic extract of *Coriandrum sativum* seed was obtained as a gift sample in the form of dried powder from M/S. Laila Impex Private Limited (Vijayawada, Andhra Pradesh, India).

**Animals and treatments:** The male rats of Wistar strain (100-120 g) were purchased from Mahaveer Enterprises (Hyderabad, India) and they were maintained in the animal facility for four days before they were used for experimentation. They were given free access to feed (Pranav Agro Industries, India) and water ad libitum. The study was approved by the Institutional Animal Ethical Committee (IAEC). A total of 30 rats were treated with lead acetate (1000 ppm) through drinking water for a period of 4 weeks and parallel controls (10 rats) were maintained on sodium acetate (1000 ppm). Both the solutions were prepared daily with distilled water. Group-I (10 rats): Control received sodium acetate in water; Group-II (10 rats) exposed to lead acetate; Group-III (10 rats): *Coriandrum sativum* treated1 (CST1) received the hydroalcoholic seed extract of *Coriandrum sativum* at a dose of 250 mg/Kg body weight/day for seven consecutive days after four weeks of lead exposure. Group-IV: *Coriandrum sativum* treated2 (CST2) consisting of 10 rats received the hydroalcoholic seed extract of *Coriandrum sativum* at a dose of 500 mg/Kg body weight/day for seven consecutive days after four weeks of lead exposure. Group-IV: *Coriandrum sativum* treated3 (CST3) consisting of 10 rats received the hydroalcoholic seed extract of *Coriandrum sativum* at a dose of 1000 mg/Kg body weight/day for seven consecutive days after four weeks of lead exposure. The treatments and supply of food to rats were stopped six hours before sacrifice. The rats belonging to control and exposed were sacrificed after four weeks of lead exposure, whereas the Group-III and IV were sacrificed after one week treatment with plant extract. Sacrifice was done...
by cervical dislocation and the liver and kidney were isolated immediately on ice. The liver and kidney were washed in cold normal saline (0.85% NaCl) solution.

**Reactive Oxygen Species (ROS):** ROS levels in the tissues were determined using the method of Bondy and Guo (17). 10% homogenate was prepared in 0.32 M sucrose solution. The contents were centrifuged at 1800xg for 10 min. Pellet was discarded and the supernatant was centrifuged at 31,500xg for 10 min to obtain the pellet (P$_2$). The P$_2$ pellet was suspended in HEPES buffer (120 mM NaCl, 2.5 mM KCl, 0.1 mM MgCl$_2$, 6.0 mM glucose, 1.0 mM CaCl$_2$, 5.0 mM NaHCO$_3$, 10 mM HEPES, pH 7.4) to a concentration of 0.1g equivalent/ml. Diluted fractions were incubated with 5µM 2,7 Dichlorofluorescein diacetate (DCFH-DA) (added from the stock solution of 0.5 mM in 10% ethanol) at 37°C for 15 min. The obtained fluorescence was read at excitation wavelength of 488 nm and emission wavelength of 525 nm in a spectroflurometer (Systronics, 152). ROS levels were expressed as nanomoles of DCFH-DA oxidized/15 min/mg protein.

**Lipid Peroxidation Products (LPP):** Tissue LPP levels were estimated following the spectrophotometric method of Ohkawa et al. (18). 10% homogenate of liver or kidney was prepared in 1.5% KCl. To 1 ml of the homogenate, 2.5 ml of TCA (Trichloro acetic acid) was added to precipitate the proteins. The contents were centrifuged at 3500 rpm for 10 min at 4°C. The supernatant was discarded and the pellet was dissolved in 2.5 ml of 0.05 M H$_2$SO$_4$ and to this, 3 ml of 2 M thiobarbituric acid (TBA) was added. Whole contents were incubated in boiling water bath at 100°C for 30 min. The contents were cooled and color was extracted into 4 ml of n-butanol. The color was read at 530 nm using a spectrometer (Rayleigh UV - 9200) against the blank. The results were presented as micromoles of MDA (Malondialdehyde) formed/g weight of tissue.

**Total Protein Carbonyl Content (TPCC):** TPCC levels were quantified using a slightly modified method of Levine et al. (19). 10% homogenate was prepared in cold buffer (50 mM Phosphate buffer containing 1 mM EDTA, pH 6.7). The homogenate was centrifuged at 10,000xg for 15 min at 4°C and the supernatant was precipitated with equal amounts of 20% trichloroacetic acid and incubated on ice for 5 min. The tubes were centrifuged at 10,000xg for 10 min at 4°C and the supernatant was discarded. The pellet was re-suspended in 500µl of 10mM 2, 4-dinitrophenyl hydrazine (DNPH) in 2 M HCl and allowed to stand at room temperature for 1hr, with vortexing every 10 min at 4°C and the pellet was washed three times with ethanol: ethyl acetate mixture. After the final wash, the pellets were re-suspended in 500µl of 6 M guanidine hydrochloride (pH 2.3). The contents were incubated at 37°C for 15 min and were centrifuged at 10,000x g for 10 min at 4°C. Carbonyl content was measured in spectrophotometer (Rayleigh UV - 9200) at 360 nm against a reagent blank. The results were expressed as nanomoles of carbonyl/ml tissue.

**Blood parameters:** The blood samples from rats were collected by cardiac puncture and stored in heparinized vials. The blood samples were stored at 4°C until analysis. The samples were analyzed using SYSMEX-KX 21 hematological analyzer. Hemoglobin (g/dl), Red blood cell count (10$^6$/mm$^3$), White blood cell count (10$^3$/mm$^3$) (WBC) and Mean corpuscular volume (fL) (MCV) were estimated.

**Delta Amino Levulinic Acid Dehydratase (ALAD) activity:** Delta ALAD activity was estimated following Berlin and Schaller (20). The blood samples from rats were collected in heparinized vials using cardiac puncture. The samples were stored at 4°C until analysis. Blood was initially hemolyzed with water for 10min at 37°C. To the blood sample, potassium phosphate buffer and ALA (12 mM) were added and incubated for 90 min at 37°C. After incubation the enzyme activity was stopped with the addition of 10% TCA (10 mM HgCl$_2$). Later the samples were centrifuged at 6000 rpm for 10 min and to the supernatant, 1 ml of Erlich reagent was added
and incubated for 20 min. To the incubated sample, 0.5 ml of distilled water was added and read at 555 nm in a spectrophotometer (Rayleigh, UV-9200). The results were expressed as nmol PPB (Porphobilinogen) formed/hr/ml.

**Metal estimation:** Metal concentration was measured following the method of Zachariadis et al. (21). The analysis of metal content was carried out with wet tissue. A known quantity of the tissue was kept in muffle furnace at a temperature of 600 °C for about 4-5 hrs to make into ash. The ash obtained was digested with HNO₃ and dissolved in a known amount of 0.01N HNO₃. The final clear and colorless solution was used for metal estimation with Inductively Coupled Plasma- Mass Spectrometer (ICP-MS) (Agilent-7700S). Metal concentration was given as microgram metal/gm wet weight of tissue.

**Statistical analysis:** All the assays and metal estimation was done in triplicate. The mean values (n=6) with standard deviations were calculated. The significant differences between control, exposed and treated groups were determined using one-way ANOVA at $p < 0.05$ followed by Bonferroni's Multiple comparison test. One-way ANOVA was performed using Graph Pad Prism version 5.0 for Windows, Graph Pad Software, San Diego California USA, www.graphpad.com.

**Results**

Fig. 1 represents the data on reactive oxygen species (ROS) in liver and kidney of control, exposed, CST1 and CST2 groups. There was a significant ($p<0.05$) increase in the ROS in liver and kidney of the exposed group compared with their respective controls. Maximum increase in ROS was seen in kidney (38.16%) of exposed group followed by exposed liver (21.67%) with respect to their controls. The CST1 group of liver and kidney showed decrease in ROS levels. However, CST2 group showed better recovery than CST1 and the ROS levels were almost nearer to the control values of liver and kidney of CST2. The values of CST1 and
CST2 were not significant \((p>0.05)\) when compared to their control.

The results on lipid peroxidation products (LPP) are presented in Fig. 2 for liver and kidney of control, exposed, CST1 and CST2 groups. A significant \((p<0.05)\) increase was observed in LPP levels of liver and kidney of the exposed group compared to their respective controls. LPP levels in control group were high in kidney \((6.42 \, \mu\text{moles})\) than liver \((4.64 \, \mu\text{moles})\). The treated groups showed recovery with a maximum of 97% in CST2 of kidney followed by CST1 kidney \((89\%)\) and CST2 liver \((69.50\%)\). When compared to liver, kidney showed a better recovery in LPP. The CST1 groups of liver and kidney showed decrease in LPP levels when compared to exposed but the recovery was less when compared to CST2 group of liver and kidney.

Fig. 3 depicts data on total protein carbonyl content (TPCC) in the liver and kidney of control, exposed, CST1 and CST2 treated groups. The TPCC levels increased significantly \((p<0.05)\) in liver and kidney of exposed group. TPCC levels in control group were more for liver \((0.89\text{nmol/ml})\) than kidney \((0.71\text{nmol/ml})\). However, maximum increase in TPCC levels was observed in exposed kidney \((126.19\%)\) followed by exposed liver \((48.0\%)\) when compared to their respective controls. Liver \((\text{CST1 76\%, CST2 103\%})\) showed maximum recovery in TPCC levels when compared to kidney \((\text{CST1 38\%, CST2 74\%})\).

The data on tissue lead concentration in the liver and kidney of control, exposed, CST1 and CST2 groups are presented in Figure 4. A significant \((p<0.05)\) increase in lead concentration was seen both in liver and kidney of exposed group. Liver of exposed group showed maximum percent increase \((807\%, 4.4\mu\text{g/g})\) of lead concentration when compared to their respective control \((0.48\mu\text{g/g})\). However, treatment with Coriandrum sativum showed decrease in lead concentration in CST1 \((1.75\mu\text{g/g})\) and CST2 \((1.47\mu\text{g/g})\) and maximum decrease was seen in CST2 group. Kidney of exposed group showed a significant increase up to \(22.01\mu\text{g/g}\) of lead when compared to the

![Image](image-url)

**Fig. 2.** Lipid Peroxidation Products (LPP) in liver and kidney of control, exposed and treated rats. Lipid peroxidation was expressed as \(\mu\text{moles of MDA/gm. tissue}\). Values represent means \(\pm\text{S.D (n=6)}\). Vertical lines represent standard deviation. \(*\text{Significantly different from their respective controls at } P<0.05.\)**

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Fig. 3. Total Protein Carbonyl Content (TPCC) in liver and kidney of control, exposed and treated rats. TPCC levels were expressed as nmol of carbonyl/mg. protein. Values represent mean± S.D (n=6). Vertical lines represent standard deviation. *Significantly different from their respective controls at P<0.05.

Fig. 4. Lead in liver and kidney of control, exposed and treated rats. Lead concentration was expressed as µg lead/gm. wet weight. Values represent mean± S.D (n=6). Vertical lines represent standard deviation. *Significantly different from their respective controls at P<0.05.

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The concentration of copper in the liver and kidney of control, exposed, CST1 and CST2 groups were presented in Figure 5. There was a significant ($p<0.05$) decrease in copper concentration in the exposed liver (3.21µg/g) and kidney (4.06µg/g) when compared to their respective controls (5.35 and 10.37µg/g). Maximum decrease in copper concentration was seen in exposed kidney (60.84%) when compared to exposed liver (39.51%). However, treatment with *Coriandrum sativum* showed restoration of copper levels in the liver and kidney. The restoration is dose dependent of the extract and maximum restoration was seen in CST2 liver (74%).

Figure 6 shows data on zinc concentration in liver and kidney of control, exposed, CST1 and CST2 groups. Zinc concentration showed a significant ($p<0.05$) decrease on lead exposure in liver (23.98µg/g) and kidney (14.72µg/g) when compared to their respective controls (40.18 and 21.13µg/g). CST1 (28.22µg/g) and CST2 (30.19µg/g) groups showed restoration of zinc concentration in liver, CST2 (75%) showed maximum restoration of zinc than CST1 (70%). In the kidney of CST1 (19.53µg/g) and CST2 (21.67µg/g), maximum restoration was seen and zinc concentration restored near to control values.

Concentration of iron in liver and kidney was presented in Figure 7. Iron concentration showed a significant ($p<0.05$) decrease in liver of exposed (77.36µg/g) with respect to its control (100.98 µg/g). Whereas exposed kidney (71.5µg/g) showed insignificant decrease in iron concentration compared to its control (79.33µg/g). Treatment with *Coriandrum sativum* showed restoration of iron levels back to control in CST1 and CST2 of liver (93.52 and 115.18µg/g) and kidney (83.99 and 90.85µg/g). Kidney of CST2 showed maximum increase in iron concentration (114.52%) than the control and the increase was
Fig. 6. Zinc in liver and kidney of control, exposed and treated rats. Zinc concentration was expressed as µg zinc/gm. wet weight. Values represent mean± S.D (n=6). Vertical lines represent standard deviation. *Significantly different from their respective controls at P<0.05.

Fig. 7. Iron in liver and kidney of control, exposed and treated rats. Iron concentration was expressed as µg iron/gm. wet weight. Values represent mean± S.D (n=6). Vertical lines represent standard deviation. *Significantly different from their respective controls at P<0.05.
Blood delta-ALAD activity showed a significant ($p<0.05$) decrease (31.77%) in exposed group when compared to the control. CST1 (33.72%) and CST2 (57.32%) groups showed significant ($p<0.05$) increase in delta-ALAD activity and maximum increase in enzyme activity was seen in CST2 group.

Hemoglobin (Hb) concentration in the blood of control, exposed, CST1 and CST2 groups was presented in Figure 8. However, Hb concentration showed a significant ($p<0.05$) decrease in the exposed group (28.33%). Whereas CST1 (97%) and CST2 (107.35%) groups showed restoration of Hb levels, CST1 (8.84) restored Hb level near to control and CST2 (9.78) showed increase in Hb level than the control value.

RBC count showed a significant ($p<0.05$) decrease (19.31%) (Figure 8) in lead exposed ($3.55 \times 10^6$/mm$^3$) group when compared to the control ($4.40 \times 10^6$/mm$^3$). CST1 ($4.87 \times 10^6$/mm$^3$) group showed insignificant increase (10.68%) in RBC count while CST2 ($5.1 \times 10^6$/mm$^3$) group showed significant increase (16.13%) in RBC count than the control group.

WBC count showed a decrease (Figure 8) in lead exposed ($2.45 \times 10^3$/mm$^3$) group when compared to control ($7.17 \times 10^3$/mm$^3$) and the decrease was significant ($p<0.05$). Whereas CST1 ($5.46 \times 10^3$/mm$^3$) and CST2 ($8.66 \times 10^3$/mm$^3$) group showed restoration of WBC count near to control values and maximum restoration was seen in CST2.

MCV showed a significant ($p<0.05$) decrease in lead exposed ($49.18$ fL) group (Figure 8) when compared to the control ($51.99$ fL). Whereas CST1 ($50.59$ fL) and CST2 ($49.78$ fL) showed insignificant increase in MCV.

**Discussion**

The present investigation was intended to test the efficacy of *Coriandrum sativum* seed extract against lead induced oxidative stress in
a rat model. *Coriandrum sativum* is well known as a traditional and natural medicine. The increase in lead concentration in liver and kidney following experimental exposure was associated with increased oxidative stress, which might be responsible for lead induced toxic effects indicated by the increase in ROS, LPP and TPCC.

Lead is ubiquitous and detected in all phases of the environment and it enters biological system through air, water and food. Its persistence and toxicity in human and animal tissues had often been associated with considerable health risks (22). In the present study the levels of lead in tissues of liver and kidney were significantly \( p<0.05 \) higher in lead exposed group than controls. Lead exposed group showed increase in the levels of ROS, LPP, TPCC, metal content and decrease in the delta-ALAD enzyme activity.

Metal toxicity causes mitochondrial damage, this result in excessive free radical generation (23). Lead toxicity leads to free radical damage by increasing the production of reactive oxygen species (ROS) including hydroperoxides, singlet oxygen, hydrogen peroxide and direct reduction of antioxidant reserves (24). The primary target of oxidative damage produced by xenobiotics is cellular membrane (25). Oxygen radicals attack the cellular components such as polyunsaturated fatty acids of phospholipids which are sensitive to oxidation (26). Lead produces oxidative damage by increasing the oxidation of membrane lipids (27). Flavonoids such as Quercetin 3-glucuronide, isoquercitrin and rutin were separated and identified in coriander seeds (3). Studies on the antioxidant properties of flavonoids from various plant extracts showed stimulatory action on antioxidative enzymes (28) and they also showed stimulatory action on transcription and gene expression of certain antioxidant enzymes (29). The decrease in ROS levels in CST1 and CST2 can be attributed to the protective role of *Coriandrum sativum*. Administration of *Coriandrum sativum* restored the levels of ROS back to normal in both liver and kidney.

MDA (Malondialdehyde) is a major reactive aldehyde formed during the peroxidation of polyunsaturated fatty acids present in biological membrane (30). Generally the MDA levels are used as indicators of tissue oxidative stress involving a series of chain reactions (18). It is well known that lead binds to enzymes and reduces enzyme activities. It can even disturb protein synthesis in hepatocytes (31). Lead induces the free radical formation indirectly and influences the processes of lipid peroxidation through damage of protective antioxidant barrier (16). Lead possesses a strong affinity to thiol groups of amino acids, especially cysteine. Lead may affect the antioxidant barrier via inhibiting the functional thiol groups of enzymes such as SOD and GST (32, 33). Therapy with sodium molybdate showed significant protection from lead to liver and kidney and also reduced the formation of LPO (lipid peroxide) (34). Human lymphocytes pretreated with polyphenols isolated from *Coriandrum sativum* showed protection from oxidative damage induced by hydrogen peroxide. Polyphenols extracted from coriander seeds showed significant decrease in concentration of TBARS in human lymphocytes compared with the \( \text{H}_2\text{O}_2 \) control (35). Similarly in the present investigation the flavonoids present in *Coriandrum sativum* may have protected the liver and kidney from the oxidative damage induced by lead. Volatile compounds of coriander seed oil showed inhibition of lipid peroxidation (36, 37). Studies using coriander seed extract showed positive correlation between phenolic content and antioxidant activity. The seed extract showed concentration dependent inhibitory activity towards 15-lipoxygenase and DPPH radical scavenging activity (38). Treatment with *Coriandrum sativum* resulted in normalization of TBARS (Thiobarbituric acid reactive species) and glutathione of \( \text{CCl}_4 \) exposed rats. Pretreatment with *Coriandrum sativum* increased activity of antioxidant enzymes compared to \( \text{CCl}_4 \) animals indicating the efficacy of *Coriandrum sativum* to
act as an antioxidant (39). Administration of *Coriandrum sativum* (200mg/kg) significantly reduced the increased serum enzymes (SGOT and SGPT) induced by CCl₄, indicating improvement of the functional status of the liver, which was also supported by the histopathological findings (40). Quercetin a flavonoid effectively reduced lipid peroxidation and restored the activities of antioxidant enzymes and inhibited apoptotic damage (41). The seeds of *Coriandrum sativum* contain Quercetin(3) and this may be a possible mechanism of protection from lead-induced lipid peroxidation.

Similarly in the present investigation along with ROS and LPP there was decrease in TPCC levels after administration of *Coriandrum sativum*. This shows the protective role of *Coriandrum sativum* in reducing TPCC levels.

Lead toxicity inhibits delta aminolevulinate dehydratase activity. Delta-ALAD an indicator enzyme for lead toxicity and its activity is inhibited when lead binds to its active center (42). This enzyme catalyzes the asymmetric condensation of two molecules of delta-aminolevulinic acid to porphobilinogen in the initial steps of heme biosynthesis. Lead toxicity increases the excretion of accumulated ALA into the urine (12, 13) and decreases the production of PBG (Porphobilinogen). Administration of *Coriandrum sativum* decreased the concentration of urinary ALA (15). This suggests that Chinese parsley has efficacy against lead poisoning. Inhibition of Δ-ALAD activity may lead to accumulation of ALA (43), which may auto-oxidize to form reactive oxygen species. Inhibition of delta-ALAD activity leads to accumulation of delta-aminolevulinic acid (Δ-ALA) which undergoes auto-oxidation inducing free radicals and in this way induces lipid peroxidation (42). Similarly in the present study there was a decrease in Δ-ALAD activity and increase in the levels of ROS and LPP. The group treated with *Coriandrum sativum* showed reduction in the levels of ROS, LPP and TPCC. In contrast to this, there was increase in Δ-ALAD activity in CST1 and CST2. The decrease in haematological parameters (RBC, WBC, Hb and MCV) was in agreement with previous reports (44) that metal toxicity causes changes in the blood indices of rats. The significant reduction in RBCs indicated that lead adversely affected the hemoglobin synthesis by binding to delta-ALAD, and increased rate of destruction of erythrocytes. Treatment with *Coriandrum sativum* decreased the toxic effects of lead on the hematological values and had a protective role in anemia induced by lead. A similar decrease in Delta-ALAD activity was noticed by Adonaylo and Oteiza (10) and Pande et al (45) in rats exposed to lead. They also reported decrease in hematocrit on exposure to lead acetate. In the present investigation treatment with *Coriandrum sativum* restored the delta-ALAD enzyme activity in a dose dependent manner.

It is clear from the results of the present investigation that administration of the hydroalcoholic extract of *Coriandrum sativum* protected rat liver and kidney against lead induced oxidative stress. The results of the present study corroborate well with the early reports that showed the protective effects of *Coriandrum sativum* on localized lead deposition in male ICR mice (15). A similar prophylactic efficacy of *Coriandrum sativum* (Coriander) was reported by Sharma et al (46) on testis of lead-exposed mice.

Lead concentration significantly increased in the exposed rat liver and kidney, upon treatment with *Coriandrum sativum* there was decrease in lead levels in the CST1 and CST2 treated rats. Micronutrients such as zinc, copper and iron levels decreased in the lead exposed group but treatment with *Coriandrum sativum* showed restoration near to control in CST1 and CST2 treated rats. The concentration of zinc and copper in liver and kidney in the present study was similar to that of previous reports (45). Flavonoids and phenolic compounds potentiate the removal of lead from the body by their metal chelating ability (47). Administration of (Chinese parsley) *Coriandrum sativum* also prevented the accumulation of Cd in fish *Oncorhynchus mykiss* (48). Treatment with chelating agents such as
EDTA showed reduction in the levels of lead in the liver of rats exposed to lead (49, 31). The chelating agents form an insoluble complex with lead to remove it from lead burdened tissues (33). But natural chelating agent such as phytic acid has strong ability to chelate multivalent metal ions (50). There may be a possibility for the seeds of *Coriandrum sativum* that contain chelating agents similar to phytic acid. The results of the present study corroborate with earlier reports that suggest the preventive effects of *Coriandrum sativum* on lead induced oxidative stress in male rats. Using a murine model of lead intoxication (15) *Coriandrum sativum* reduced lead accumulation in bone and protected mice from lead-induced kidney damage. However, it appears that the protection shown by *Coriandrum* was organ-specific as well as parameter-specific in both liver and kidney.

**Conclusion**

Overall the results of the present investigation support the hypothesis that the hydro-alcoholic seed extract of *Coriandrum sativum* protects rat liver and kidney from lead induced-oxidative stress by its antioxidant and metal chelating properties. Tissue oxidative stress parameters and lead concentration in liver and kidney showed increase on exposure to lead and they restored back to control on treatment with *Coriandrum sativum*. Blood parameters, delta-ALAD enzyme activity, copper, zinc and iron levels showed inhibition on lead exposure and treatment with *Coriandrum sativum* showed protection against lead toxicity. Maximum protection from lead toxicity was seen in CST2 group. Further studies are needed to analyze the exact mechanism by which *Coriandrum sativum* protects rat liver and kidney from lead toxicity. Overall, these results suggest that the seed extract of *Coriandrum sativum* might reduce the lead-induced oxidative stress organ specifically by its antioxidant and metal chelating activity.

**References**


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