RESEARCH PAPER | Science | Volume : 5 | Issue : 2 | Feb 2015 | ISSN - 2249-555X

# Study The Effect of Coriandrum Sativum on liver Fibrosis Induced by Carbon Tetrachloride in Rats

KEYWORDS: Coriandrum sativum (CS); Liver fibrosis; Anti-oxidant activity; anti-smooth muscle actin (α-SMA).

| * Nabila Zein | EssamAbd Elghani | Eman Talat |
|---|---|---|
| Biochemistry Division, Chemistry Department, Faculty of Science, Zagazig University. * Corresponding author | Chemistry Department, Faculty of Science, Zagazig University | Biochemistry Division, Chemistry Department, Faculty of Science, Zagazig University |

**ABSTRACT** *The aim of this study was to investigate the possible anti-hepatic fibrosis effect and antioxidant role of Coriandrum sativum(CS) extract against Carbon tetrachloride (CCL4)induced liver fibrosis bearing adult male rats. The extracted CS was proved by phytochemical analysis e.g thin layer chromatography (TLC). The TLC analysis revealed the presence of some important polyphenolic compounds which could be responsible for the anti-oxidant activity. The effects of CS on liver enzymes alanine aminotransferase (ALT) and aspartate aminotransferase (AST),were studied, the level of lipid peroxidation, were estimated. Treatment with CS significantly decreased the elevation in (AST) and (ALT). It also inhibited the formation of lipid peroxidative products Malondialdehyde (MDA) and nitric oxide (NO) level during CCl4 treatment.The expression of anti-smooth muscle actin (α-SMA) in liver was decreased in combination, preventive,therapeutic and silymarine groups in comparison with positive control group. The present work indicates that the CS extract may possess significant anti-hepatic fibrosis and antioxidant activity against CCL4 induced hepatotoxicity in vivo.*

## INTRODUCTION

Hepatic diseases represent the major cause of human mortality in the world,they are characterized by a progressive evolution from steatosis to chronic hepatitis, fibrosis, cirrhosis and hepatocellular carcinoma **(Notas et al.,2009)**. A major cause of these disorders is due to exposure to different environmental pollutants and xenobiotics such as alcohol, paracetamol,carbontetrachloride and thioacetamide**(Jaeschkeet al., 2012)**.Carbontetrachloride (CCl4) an industrial solvent, cleaner and degreaser. The initial step in biotransformation of CCl4 is reductive dehalogenation and by formation trichloromethyl and trichloromethylperoxyl radicals**(Sabaetal.,2010).** Also, down regulates the gene expression of many antioxidant enzymes triggering an oxidative stress **(Aietal.,2013).** This oxidative stress plays a crucial role in the activation of hepatic stellated cells (HSCs) during liver fibrosis, developing a myofibroblast – like phenotype associated with increased cell proliferation, de novo expression of α-smooth muscle actin (α-SMA) and production of extracellular matrix (ECM) including fibril forming collagens**(PriyaandSudhakaran, 2008)**.

Polyphenolic compounds are widely distributed in plants and known to be excellent antioxidants in vitro and have the capacity to scavenge free radicals and protect antioxidant defence**(Mitraet al., 2000).**Since dietary polyphenols have been reported to be inversely associated with lipid peroxidation and cytotoxicity, an attempt was made to study the effects of the extracts of Coriandrum sativum on the activities of antioxidant enzymes in CCl4 treated liver. The present study was designed to investigate in vivo antioxidant activities of ethanolic extract of CS. Results were compared to a standard antioxidant drug Silymarin (SMN), which has awell established hepatoprotective properties. SMN effectively scavenges free radicals, antagonizes lipid peroxidation, and stabilizes cell membranes **(Letteronet al., 1990).**

## MATERIALS AND METHODS

Materials:Basal diet, carbon tetrachloride, and chemical kits for biochemical analysis were obtained from Biodiagnostic-Company, Giza, Egypt.The fresh leaves and stem of coriander Overall, were purchased from the local market at Zagazig, Egypt. The plant sample were kindly identified and proved by Herbarium unit of Potany Department Faculty of Science ZagazigUniversity.

***Extract Preparation:*** The plant samples were airdried for 10 days and powdered. The dried and powdered plant (2kg) were extracted successively with mixture of ethanol:water (3:1)in a soxhlet extractor for 48 hours at 60°C. After extraction, the solvent was evaporated to dryness at 50-55°C using a rotary evaporator**(Kilet al.,2009)**. Finally,The extract was stored at 4°Ctill the analysis of different parameters.

***Animals :*** Adult male Sprague-Dawely rats weighing 180-260 gm were purchased from Animal House of the National Research Center (NRC), Dokki, Giza, Egypt. They were kept individually in stainless steel wire bottomed cages at room temperature (25±2 °C). Rats had free access to food and water. They were used after acclimatization period of one week.

***Phytochemical analysis :*** The chromatographic profiles were developed for ethanolic extract using in triplicates for the identification of the polyphenols by paper chromatpgraphy. The Polyphenol separation included the isolation and identification of (a) Flavonoids (b) Phenolic Acids (c) Glycoflavones.The identities of all the compounds were confirmed with authentic samples **(Nambiaret al.,2010) .**

***Experimental Design :*** Animals were randomly assigned to six groups each of twelve rats as follow:**Group 1:** Negative control group, Rats injected i.p. with saline once daily for 7 days. **Group 2:** Positive control group, Rats injected i.p. with CCl4 in a dose of 0.5ml/kg b.wt. i.p. once daily for 7 days **(Ashokshenoyet al., 2001). Group 3:** Preven-

Volume : 5 | Issue : 2 | Feb 2015 | ISSN - 2249-555X

tive group, Rats were injected i.p with coriander extracted dose of 200mg/kg b.wt orally by gavages at the beginning of the experiment, at the second day Rats were injected i.p. within the dose ofCCl4 once daily for 7 days, and then Rats were received the same dose of the extracted once daily for 15 days.**Group 4:** Therapeutic group, Rats were injected i.p. within the dose of CCl4 once daily for 7 days, and then Rats were received the same dose of the extracted once daily for 15 days.**Group 5:**Silymarine group, Rats were injected i.p. within the dose of CCl4 once daily for 7 days, and then rats were received silymarin in a dose of 25 mg /kg b.wt orally by gavages once daily for 15 days **(Sreelathaet al., 2009)**.**Group 6:** Combination group, Rats were injected i.p. within the dose of CCl4 once daily for 7 days, and then rats were received orally by gavage a combined dose of 200mg/kg the coriander extracted and 25mg/kg silymarine once daily for 15 days.

***Blood collection***:At the end of 15th day, blood samples were collected from the retro-orbital vein plexus and direct cardiac puncture, under ether anesthesia samples for biochemical analysis into plain sample tubes. Serum was separated by centrifugation at 600 x *g* for 15 min. The sera were stored in the -20 ºC freezer before they were analyzed.

***Biochemical Analysis***:1)Determination of plasma aspartate and alanine amiontransferases activities was assayed according to**(Young, 2001).**2) Determination of liver malondialdehyd level was assayed according to **(Satoh, 1978)**andnitric oxide level according to **(Montgomery andDymock, 1961).**

***Immunohistochemical study***:The harvested liver tissues were fixed in Bouin's, embedded in paraffin and sectioned at 5 µm thickness. Immunocytochemical reactions were performed according to **(Erenoğluet al.,2011)**.

***Statistical Analysis:***Statistical analysis of data was performed by using SPSS 14.0 version using T-test (2- tailed) was applied to compare between groups and one way analysis of variance (ANOVA) according to the method described by**(Levesque,2007)** followed by post-hoc test using Graphpad Prism-5 software.Numerical data were expressed as mean±SD, P values < 0.05 were considered to be statistically significant.

## RESULTS

***Extraction of plant and Phytochemical consitituents:***
Corainder sativum (2 kg) after undergoing extraction yielded deeply green paste(60g) of the extract.This extract revealed the presence of various phytoconstituents of polyphenols like flavonoids and phenolic Acids.The flavonoids that were identified are kaempferol,quercetin,3'-OMe quercetin,4'-OMequercetin and acacetin. The phenolic acids that were identified vanilic acid, ferulic acid (cis and trans form) and p-coumaric acid as shown in table (1).

**Biochemicalresult:**
There was significant decrease in the level ofALT, AST,MDA and NO in combination, preventive, therapeutic and silymarine groups compared to positive control group as shown in Table (2)

***Immunohistochemical study (α-SMA) results***:
Liver tissue sections were stained by antibody to α-SMA. The negative control group showing no evidence of membranous or cytoplsmic immunostaining for α-SMA in any of the portal tracts shown **(Fig.1).** The positive control group showing markedly positive of membrane or cytoplasmic immunostaining for α-SMA in the portal tract as shown**(Fig.2**). The combination group showing weekly positively of membranous and cytoplasmic immunostaining for α -SMA in any of the portal tracts as shown**(Fig.3).** The preventive group showing mild positive of membranous or cytoplasmic immunostaining for α -SMA in any of the portal tracts as shown **(Fig.4).**The therapeutic group showing moderate positively of membranous and cytoplasmic immunostaining for α -SMA in any of the portal tractsas shown**(Fig.5)** The silymarine group showing moderate positively of membranous and cytoplasmic immunostaining for α -SMA in any of the portal tracts as shown**(Fig.6).**

**Table 1: The content of coriander**

| Polyphenolic compound | Coriander | Phenolic acid compounds | Coriander |
|---|---|---|---|
| Apigenin | - | Vanillic acid | + |
| 3',4'-di-OMe luteolin | - | Syringic acid | - |
| Kaempferol | + | p-OH benzoic acid | - |
| 4'-OMe kaempferol | - | Melilotic acid | - |
| 7'4'-di-OMe kaempferol | - | Gentisic acid | - |
| Quercetin | + | o-Coumaric acid | - |
| 3'-OMe quercetin | + | p-Coumaric acid | + |
| 4'-OMe quercetin | + | Cis-Ferulic acid | + |
| 3',4'-di-OMe quercetin | - | Trans-Ferulic acid | + |
| Acacetin | + | Phloretic acid | - |
| Gossypetin | - | Chlorogenic acid | - |
| Quercetagetin | - | Resorcylic acid | - |
| Proanthocyanidins | - | Trans-Ferulic acid | + |
| Anthocyanins | - | Phloretic acid | - |
| Coumarins | - | Chlorogenic acid | - |

**+ : Present; - : Absent**

**Table 2: Relation between ALT, AST MDA and NO level and all groups**

| | ALT (U/ml) | AST (U/ml) | MDA (nmol/g) | NO (umol/g) |
|---|---|---|---|---|
| Negative control | 37.3±4.5 | 99.5±9.7 | 31.4±14.5 | 41.9±9.4 |
| Positive control | 105±9.3*a | 264.9±37*a | 182.7±35.4*a | 79.2±4.5*a |
| Combination | 50.8±3*b | 128.3±6.4*b | 49.4±4.8*b | 49.8±4.2*b |
| % change | 51.6% | 51.1% | 72.9% | 59.03% |
| Preventive | 54.8±7.8*b | 149.4±7.2*b | 61.9±4.9*b | 60.9±1.8*b |
| % change | 43.04% | 43.6% | 66.1% | 30.04% |
| Therapeutic | 75.4±0.4*b | 180.4±14.3*b | 91.6±8.4*b | 68.3±4.0*b |
| % change | 30.09% | 31.8% | 49.8% | 15.95% |
| Silymarin | 85.2±4.3*b | 208.1±7.1*b | 126.8±13.5*b | 72.3±1.7*b |
| % change | 18.8% | 21.4% | 30.5% | 9% |

Volume : 5 | Issue : 2 | Feb 2015 | ISSN - 2249-555X

Values are expressed as mean±S.E.,
a: Values significantly differ from negative control group..
b: Values significantly differ from positive control group.,
*: P<0.001
% change: Values different from positive control group

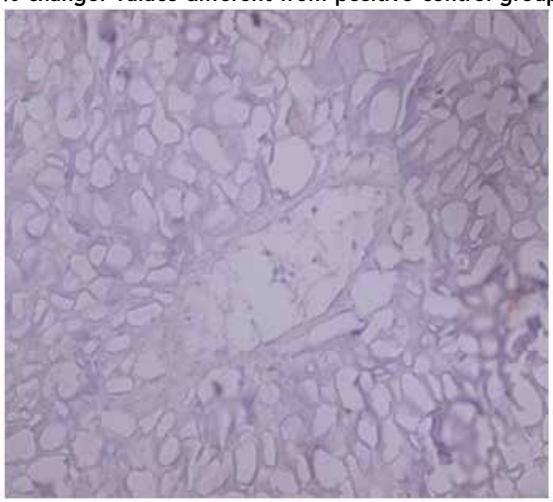

Fig. (1): Negative control: Photomicrograph of rat liver from negative control group.(H&E,X 400)

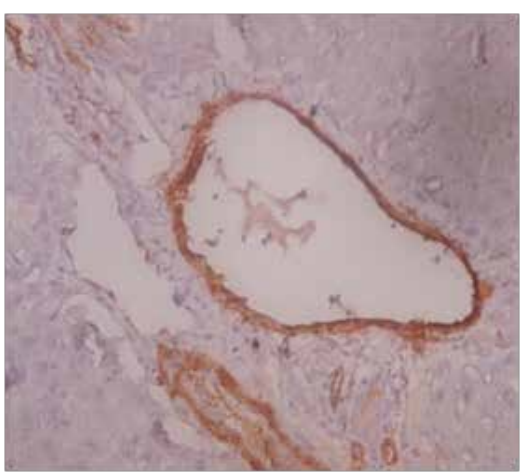

Fig (2):Positive control: Photomicrograph of rat liver frompositive control group.(H&E,X 400)

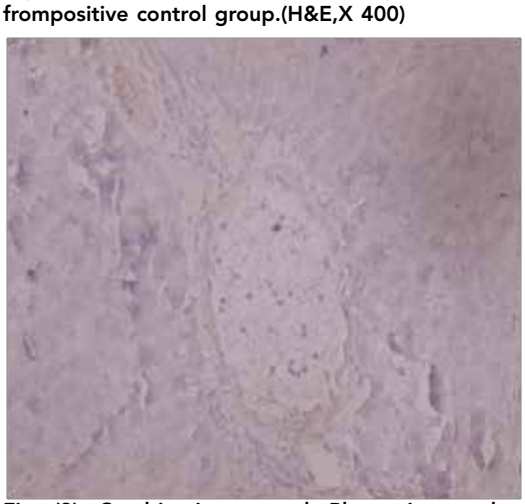

Fig. (3): Combination control: Photomicrograph of rat liver from combination control group.(H&E,X 400)

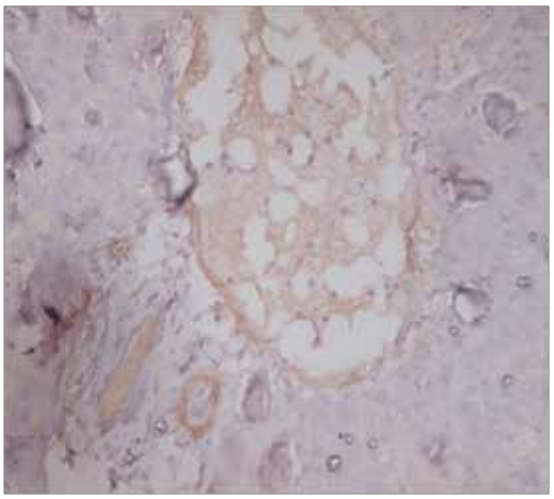

Fig. (4): Preventive control: Photomicrograph of rat liver from preventive control group.(H&E,X 400)

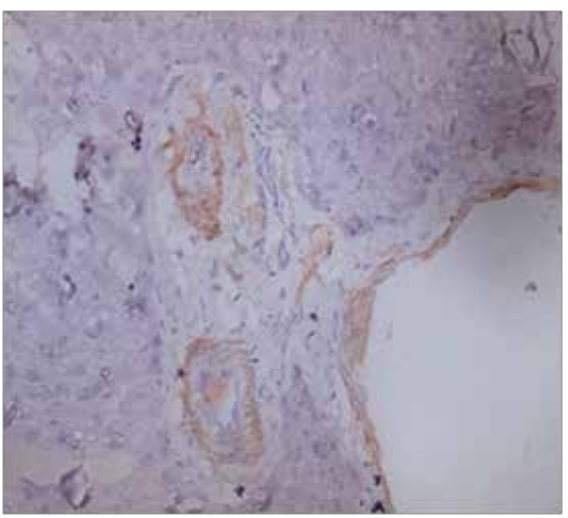

Fig. (5): Therapeutic control: Photomicrograph of rat liver from therapeutic control group.(H&E,X 400)

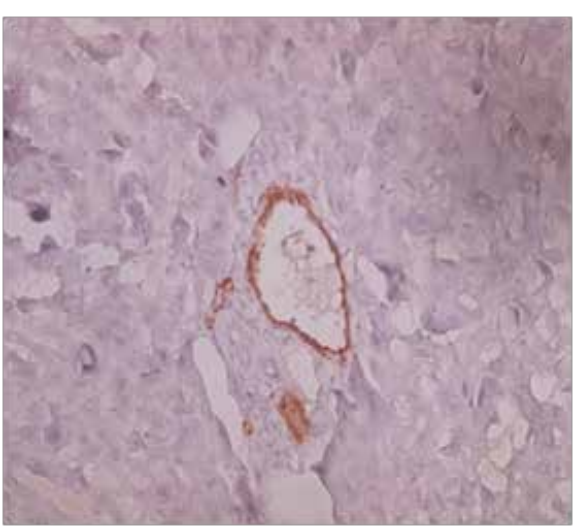

Fig. (6): Silymarinecontrol: Photomicrograph of rat liver from Silymarinecontrol group.(H&E,X 400)

Volume : 5 | Issue : 2 | Feb 2015 | ISSN - 2249-555X

**DISCUSSION**

Coriandeum sativum(Coriander) is considered as a rich source of biologically active compounds mainly polyphenolic compounds. The present study indicate the Polyphenol separation by co-chromatogaphy (paper and thin-layer chromatography) included the isolation and identification-flavonoids and Phenolic Acids.Generally, some flavonoids exert a stimulatory action on transcription and gene expression of certain antioxidant enzymes that play an important role against oxidative insults **(Rohrdanzet al., 2002).**

Hepatotoxicity produced by CCl4 seems to be mediated by reactive metabolite trichloro methyl free radical (.CCl3) formed by the hemolytic cleavage of CCl4 or even by more reactive species trichloro methyl peroxy free radical (Cl3COO.) formed by the reaction of **.**CCl3 with O2 caused membrane damage of hepatocytes and resulted in centrilobular necrosis**.**These free radicals attack microsomal lipids leading to its peroxidation and also covalently bind to microsomal lipids and proteins. This results in the generation of reactive oxygen species (ROS), which includes the super-oxide anion O2, H2O2 and the hydroxyl radical**(Ghadaet al., 2013)**.

The current study revealed that CCl4 treatment causes severe hepatic damage through a substantial elevation in the blood levels of hepatic biochemical markers like ALT and AST when liver cell membrane is damaged, a variety of enzymes normally located in the cytosol are released in to blood stream like, (AST) and (ALT) are found in higher concentrations in the cytoplasm and AST in particular also exists in mitochondria. AST is found in the liver,skeletal muscles,cardiac muscle, pancreas, kidney and others, meanwhile, ALT level is highest in the liver and therefore, it appears to be more sensitive test for hepatocellular damage than AST **(Nyblomet al., 2004).** Our data in table (2) showed that CS has significant decrease on the elevation of plasma levels of ALT and ASTdue to its antioxidant effect. This is in agreement with **(Kassemet al., 2014)** who reported that Pretreatment with CS before introduction of CCl4 had significantly reduced the elevated plasma enzyme significantly reduced the elevated plasma enzyme indicating a hepato-protection activity of CS via its antioxidant activity quenches ROS produced by CCl4, reserves antioxidant enzymes and restores their levels and protects cellular organelles from CCl4 damage such as cell membrane, lysosomes, mitochondria and microsomes.**Ahmed et al.(2003)** reported that, silymarin has an antihepatotoxic activity against ccarbontetrachloride induced hepatotoxicity in rats.

Malondialdehyde (MDA) is an end product of lipid peroxidation, is widely used as a marker of lipid peroxidation. Lipid peroxidation(LP) is one of the main manifestations of oxidative damage.It is well documented that CCl4 enhanced lipid peroxidation **(Sarhanet al.,2012)** that is an indication of free radical mediated toxicity. Free radicals are known to attack the highly unsaturated fatty acids of the cell membrane and induce lipid peroxidation that is considered a key process in many pathological events induced by oxidative stress**(Schinellaet al., 2002)**.

In the present study,MDA was found to be significantly higher in the animals treated with CCl4 alone suggesting that this agent has a significant effect on LP**.**From the results showed in Table (2) it may be possible that CS decreases LP level due to its antioxidant effect.Our resultsare in agreement with **Haggag, (2011)**who reported that the increase in malondialdehyde (MDA) levels in liver suggests enhanced lipid peroxidation leading to tissue damage and failure of antioxidant defense mechanisms to prevent formation of excessive free radicals in CCl4 induced hepatotoxicity in rats. Treatment with ethanol extract of *CS* significantly reversed these changes, and it may be possible that the mechanism of hepatoprotection by ethanol extraction of CS is due to its antioxidant effect.

The excessive production of nitric oxide (NO) in the cell may be due to viral or bacterial infections and can promote pathogenesis by promoting oxidative stress, tissue injury and even cancer**(Ratheeet al., 2009).**In the current study, the ingestionof CCl4 significantly increased NO suggesting that CCl4 preferentially affects macrophage functions. Our data showed in Table (2) that CS has significant inhibition on NO formation that might be due to its anti-inflammatory effect.Nitric oxide reacts with free radicals, thereby producing peroxynitrite can directly oxidize LDL, resulting in irreversible damage to the cell membrane. When flavonoids are used as antioxidants, free radicals are scavenged and, therefore can no longer react with nitric oxide, resulting in less damage. Coriander is also reported to be a chelating agent and effective as pharmaceutical agents in removing heavy metals **(Omura,1998) .**

Hepatic stellated cells(HSCs) are responsible for the over-abundant and maladaptive generation of matrix proteins in human liver diseases,**.** The activation of hepatic stellate cells involves increased cellular proliferation, increased synthesis of extracellular matrix proteins, and the expression of the activation marker α-smooth muscle actin (α-SMA) **(Miyazakiet al.,1993).**α- SMA, an intermediate filament protein that is expressed by activated HSC and is widely accepted as a marker of HSC activation, was used to identify and quantify activated HSC by immunostaining the fibrotic liver tissue. Like**(Aksuet al., 2010)** studies, found that the positive stainings for α- SMA were greatly increased, especially in vascular smooth muscle cells and sinusoids and also in the cells of portal ducts, fibrotic septa, present and around the cells of portal ducts, fibrotic septa, present and around the proliferated bile ducts.Our results showed that α-SMA significantly decrease by the administration of CS.**Wuet al.(2010)**reviewed that one of the well- know mechanisms of CS as cytoprotective and anti-inflammatory response by preventing the development of the liver fibrosis and suppressing proliferation and inducing apaptosis of HSC and decreasing the expression of α-SMA.

**Conclusion:**It could be concluded from the present results that, CCl4 intoxication considerably damaged the liver. It also depleted the antioxidant enzymes. As a result, CS as well as the reference drug silymarin enriched in phenolic compounds can protect humans against hepatotoxicity induced by various xenobiotics and help maintain healthy liver by restoration of the liver function enzymes and enhancement of the reduction in malondialdehyde. CS may protect free radical mediated damage of parenchyma by inducing apoptosis of activated HSCs decreasing the expression of α-SMA.

**Acknowledgment:**We acknowledge Prof. Dr.Samih Ibrahim El Dahmy, Department of Pharmacognosy and Medicinal Plants, Faculty of Pharmacy, Zagazig Universityfor performance and Interpretation of the Phytochemical analysis.

Volume : 5 | Issue : 2 | Feb 2015 | ISSN - 2249-555X

**REFERENCE**

Ahmed, B., Khan, S.A.,andAlam, T. (2003):Synthesis and antihepatotoxic activity of some heterocyclic compounds containing the 1, 4-dioxane ring system.Pharmazie., 58: 173-176. | Ai, G., Liu, Q., Hua, W., Huang, Z., and Wang, D. (2013):Hepatoprotectiveevaluation of total flavonoids extract from flowers of Abdelmoschusmanihot (L.).Medicai., 146: 794-80. | Aksu, B., Umit, H., Kanter, M., Guzel, A.Aktas, C.andCivelek, S. (2010):Effectsof methylene blue in reducing cholestatic oxidative stress and hepatic damage after bile-duct ligation in rats.ActaHistochem., 112: 259-69. | Ashokshnoy,K., Somayaji, S.N. and Bairy, K.L. (2001):Hepato protective effects of ginkgo biloba against carbon tetrachloride induced hepatic injury in rats.Indianjournal of pharmacology.,33: 260-266. | Erenoğlu, C.,Kanter, M.,Aksu, B.,Sağiroğlu,T.,Ayvaz, S.,Aktaş, C. andErboğa, M. (2011):Protective effect of curcumin on liver damage induced by biliary obstruction in rats.Balkan Med.,28: 352-357 | Ghada, M.A.R., Ezzeldeen, S.E.Aziza, M.H,.Sekena, H.A.,Nabila, S.H., Fathia, A.M. and Mosaad, A.A. (2013):Grape (Vitisvinifera) seed extract inhibits the cytotoxicity and oxidative stress in liver of rats treated with carbon tetrachloride. Global Journal of Pharmacology, 7 (3): 258-269. | Haggag, M.H., (2011):Protective effect of Coriandrumsativum plant of hepatotoxicity and nephrotoxicity induced by carbon tetrachloride in male albino rats. In 'The 6 Arab and 3 International Annual Scientific Conference on: Development of Higher Specific Education Programs in Egypt and the Arab World in the Light of Knowledge Era Requirements'. pp: 2332-2348. | Jaeschke, H., Me-Gill, M.R. andRamachandran, A. (2012):Oxidant stress mitochondria and cell death mechanism in drug induced liver injury: Lessons learned from acetaminophen hepatotoxicity. Drug Metab., Rev., 44: 88-106. | Kassem, S. S.,Abdel-Kader, M. M.,Al-Sayed, E.M.El-Din, S.,El-Hawary,M.H.A. Z., andHaggag, M. M. (2014):Modulatoryeffects of aerial parts of Coriandrumsativum L. on carbon-tetrachlorid induced hepatorenal toxicity. Global Veterinaria, 12 (4): 523-531. | Kil, H.Y., Seong, E.S., Ghimire, B.K.,Chung, I.M.,Kwon, S.S.,Goh, E.J., Hoe, K.,Kim, M.J.,Lim, J.D.,Lee, D.andYu, C.Y. (2009):Antioxidant and antimicrobial activities of crude sorghum extract.Food Chemistry, 115: 1234-1239. | Letteron, p., Labbe, g. andDegott, C. (1990):Mechanismfor the protective effects of silymarin against carbon tetrachloride-induced lipid peroxidation and hepatotoxicity in mice: evidence that silymarin acts both as an inhibitor of metabolic activation and as a chain-breaking antioxidant. BiochemPharmacol., 39: 2027–2034. | Levesque, R. (2007):Programming and Data Management:A Guide for SPSS and SAS Users, Fourth Edition SPSS Inc. ChicagoIII. | Mitra, S.K., Seshadri, S.J. and Venkataranganna, M.V. (2000):Effectof HD-03-a herbal formulation in galactosamine-induced hepatopathy in rats. Ind. J. Physiol. Pharm., 44: 82–86. | Miyazaki, H., Van Eyken, P.,Roskams, T.,DeVos, R. and Desmet, V. J.(1993):Transient expression of tenascin in experimentally induced cholestaticfibrosis in rat liver: an immunohistochemical study. J Hepatol 19:353-66. | Montgomery, H.A.C. andDymock, J.F. (1961):The determination of nitrite in water.Analyst., 86: 414-416. | Nambiar,V.S., Danial, M. and Guin, P.(2010): Characterization of polyphenols from coriander leaves (coriandrumsativum), red amaranthus (A.Paniculatus) and green amaranthus (A.Frumentaceus) using paper chromatography: and their health implications. Herbal Medicine and Toxicology 4 (1) 173-177 . | Notas, G., Kisseleva, T. and Brenner, D. (2009):NK and NKR cells in liver injury and fibrosis. Clinical Immunology., 130: 16-26. | Nyblom, H.,Berggren, U.Balldin,J. andOlsson, R. (2004): High AST/ALT ratio may indicate advanced alcoholic liver disease rather than heavy drinking. Alcohol Alcoholism, 39(4): 336-339. | Omura, O. (1998):Chelation of mercury and other heavy metals. Acupunct.Electrother.Res., (21) 2: 133-6. | Priya, S. andSudhakaran, P. R. (2008): Curcumin- induced recovery from hepatic injuryinvolves induction of apoptosis of activated hepatic stellate cells .Indian of Biochemistry &Biophysic.,45:317-325. | Rathee, P., Chaudhary,H.Rathee,S.Rathee, D.Kumar, V. and Kohli, K. (2009):Mechanismof action of flavonoids as anti-inflammatory agents: a review. Inflamm. Allergy Drug Targets, 8(3): 229-235. | Rohrdanz, E., Ohler, S.Tran-Thi, W.H. andKahl, R. (2002):Thephytoestrogendaidzen effects the antioxidant enzyme system of rat hepatoma Hells cells. J. Nutr., 13: 370-375. | Saba, A.B., Oyagbemi, A.A. andAzeez, O.I. (2010):Amelioration of carbon tetrachloride-induced hepatotoxicity and haemotoxicity by aqueous leaf extract of Cnidoscolusaconitifolius in rats Nig. J. Physiol. Sci., 25: 139 -147. | Sarhan, N.A., El-Denshary, E.S. Hassan, N.S.,Abou-Salem, F.M. andAbdel-Wahhab, M.A.(2012):Isoflavones-Enriched soy protein prevents CCL4- induced hepatotoxicity in rats. ISRN Pharmacol. 347930. Epub 2012 Mar.1 | Satoh,K (1978):Serum lipid peroxide in cerebrovascular disorders determined by a new colorimetric method. Clinic ChimicaActa., 90: 37-43. | Schinella, G.R. Tournier, H.A.Prieto, J.M.,Mordujovich, D.B.P. andRios, J.L. (2002):Antioxidant activity of anti-inflammatory plant extracts. Life Sci., 18: 1023-1033. | Sreelatha, S.andInbavalli, R. (2012):Antioxidant, anti-hyperglycemic and anti-hyperlipidemic effects of Coriandrumsativum leaf and stem in alloxan - induced diabetic rats. J. Food Sci., 77: 119-123. | Sreelatha, S., Padma, P.R. andUmdevi, M. (2009):Protective effects of Corindrumsativum extracts on carbon tetrachloride induced hepatotoxicity in rats.Food and Chemical Toxicology., 47: 702-708. | Wu, T.T., Tsai, C.W., Yao, H.T., Liim, C.K., Chen, H.W., Wu, Y.L., Chen, P.Y. andLiu, K.L. (2010):Suppressive effects of extracts from aerial part of CoriandrumsativumL.on LPS-induced inflammatory responses in murine RAW264.7 macrophages. J. Sci. Food Agri., 90: 1846-1854. | Young D.S. (2001):Effect of disease on clinical lab. Tests, 4th ed. AACC press. |