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## Research Article

# Hepatoprotective Effects of Aqueous Extracts of Three Ethnomedicinal Plants of Northeast India

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## ABSTRACT

Pogostemon parviflorus Benth (Lamiaceae), Houttuynia cordata Thunb (Saururaceae) and Solanum spirale Roxb (Solanaceae) are traditionally used as vegetables to cure stomach disorders, dysentery and liver problems by the indigenous people of North East India. The current study was designed to examine the hepatoprotective effect of the aqueous extracts of the leaves of the above plant species against experimentally induced liver injury and to identify and quantify the polyphenolic compounds present in the aqueous plant extracts. The aqueous extracts of the leaves were studied against carbon tetrachloride-induced hepatotoxicity in rats. Activity was measured by monitoring the levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and total bilirubin. RP-HPLC was employed to identify the polyphenolic compounds of the aqueous extracts. Significant hepatoprotective effects were obtained against liver damage induced by the aqueous extracts (AEs) of all the three plants, as evident from changed biochemical parameters like serum transaminases (AST and ALT), alkaline phosphatase (ALP) and total bilirubin. Parallel to these changes, AEs treated rat liver anti-oxidant parameters (LPO, GSH, CAT, SOD) were significantly antagonized for the pro-oxidant effect of CCl<sub>4</sub>. Histopathological studies also supported the protective effect of AEs. HPLC analysis revealed the presence of phenolic acids such as gallic acid, protocatechuic acid, caffeic acid, gentisic acid, m-coumaric acid and sinapic acid and the flavonoids such as catechin, quercetin and kaempferol. The results supported the traditional use of Pogostemon parviflorus, Houttuynia cordata and Solanum spirale in preventing chemically induced acute liver injury.

## INTRODUCTION

Liver, one of the largest organs in human body, plays a vital role in detoxification of various

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components entering the body, and is also involved in different metabolic activities. However, dysfunctioning of these metabolic activities can cause hepatic injury and this may lead to several disorders such as transient elevation of liver enzymes, hepatic fibrosis, liver cirrhosis and hepatocellular carcinoma. [23, 24] So, hepatoprotective drugs must have to be developed to protect the people from liver damage.

In recent years, searching for an efficient liver protective drug in modern medicine, a number of studies have been carried out on the plants used traditionally by herbalists for the treatment of various liver diseases and also for the normal functioning of the liver. But still the availability of medicines, used successfully is limited and there is a need to search for some more potent hepatoprotective drugs from medicinal plants.

Research shows that plants contain different types of polyphenolic compounds and they are found to be responsible for diverse pharmacological properties such as hepatoprotective activity [2, 8, 17, 19]. So, the search for the presence of phenolic compounds in the plants is very important.

North East India is a mega bio-diversity centre and origin of many important cultivated plant species. The people belonging to this region have been using different traditional medicinal plants for the treatment of various diseases such as liver damage, dysentery, stomach disorder etc., and thus they have achieved much knowledge regarding the use of different ethnomedicinal plants. In India, the uses of 2416 plants of ethnomedical purposes has already been documented, and out of these 1953 plant species are used by different ethnic groups of the NE region of the country alone [18]

The plant *Pogostemon parviflorus* (locally known as Hukloti) belongs to the family Lamiaceae. The leaves of this plant are used as stimulant and the

leaf juice is taken as in colic, as a febrifuge and in liver problems. *Houttuynia cordata* (locally known as Masandari) belongs to the family Saururaceae. Its leaves are taken as salad and considered as tonic. Leaf paste is applied in measles, gonorrhoea and skin troubles. Leaf juice is taken for stomachache, cholera, dysentery and liver diseases. *Solanum spirale* (locally known as Bari-hundari) belong to the family Solanaceae. In Assam these leaves are said to kill intestinal worms and roots are found to be narcotics and diuretic. In Arunachal Pradesh, the Adi tribes use it as vegetable to cure urinary and stomach disorders, high blood pressure. In some places, this plant is used for the treatment of various liver diseases.

Thus the objectives of the present study was designed to test the hepatoprotective potentials of the aqueous extracts of above specified plants against carbon tetrachloride induced liver damage in rats. RP-HPLC analysis has also been carried out to identify the different phenolic compounds in the aqueous plant extracts.

## MATERIALS AND METHODS

### Chemicals and reagents

(+)-Catechin, gallic acid, kaempferol, quercetin, sinapic acid, protocatechuic acid, 3-hydroxy coumaric acid, gentisic acid, caffeic acid were purchased from Sigma Chemical Co. (MO, USA). Methanol, acetonitrile, water and acetic acid (HPLC grade) were obtained from Merck Co. (Germany). All other chemicals used were of analytical grade.

### Plant materials and Preparation of Extracts

The fresh tender leaves of *Pogostemon parviflorus*, *Houttuynia cordata* and *Solanum spirale* were collected from their natural habitats from nearby areas of Dibrugarh University,



Assam. The plants were identified by the Department of Life Sciences, Dibrugarh University, Dibrugarh, India. Voucher specimens (*Pogostemon parviflorus*: DCH-25, *Houttuynia cordata*: DCH-26, *Solanum spirale*: DCH-27) were deposited at the Herbarium of the Department of Chemistry, Dibrugarh University, Dibrugarh, India. The collected plant materials were dried in shade and made coarse powder for the preparation of extracts. The powdered plant materials were subjected to aqueous extracts by keeping 500g of material in 1 liter of water for 36 hours separately. The extracts were lyophilized into powder (5-8 g) and used for the study.

### Animals and acute toxicity studies

Adult healthy male Wistar albino rats weighing between 170 and 200 gm were used in the experiment, which were performed in Pinnacle Biomedical Research Institute (PBRI), Bhopal. These rats aged between 2 and 2.5 months were procured from and were housed in PBRI in well-ventilated stainless-steel cages at room temperature ( $24 \pm 2^\circ\text{C}$ ) in hygienic condition under natural light and dark schedule with not more than four animals per cage. They were allowed free access to standard laboratory diet (Golden Feed, New Delhi) and water regularly. Food and water were given *ad libitum*. The animals were acclimatized to laboratory condition for one week prior to experiment. All animal experiments and procedure described were approved by Institutional Animal Ethics Committee (IAEC) of PBRI, Bhopal (Reg. No. -1283/c/09/CPCSEA). Rats maintained under standard laboratory conditions were used for an acute oral toxicity test according to Organization for Economic Co-operation and Development (OECD) guideline 423. Animals were kept on overnight fasting prior to the administration of test samples. After the administration of three aqueous plant extracts, the

food was withheld for further 3-4 hours, subsequently, the animals were observed individually at least once during first 30 minutes after dosing, periodically during first 24 hours (with special attention during the first 4 hours), and daily thereafter for a period of 3 days. Observation was done daily for changes in mortality and behavioral.

### Induction of experimental hepatotoxicity

In order to study the effect of aqueous extracts of three plant species in rat, 200mg/kg b.w. of each was used. Silymarin (50 mg/kg b.w. p. o.) was used as a standard drug in this study. The experimental rats were divided into six groups with six rats each as following protocol:

- GROUP I : Normal control (the animals were given olive oil and water only for 16 days)
- GROUP II:  $\text{CCl}_4$  control group (the animals were given a single dose of  $\text{CCl}_4$  (1ml/kg, b.w. p.o.) with olive oil administered.
- GROUP III: Standard group (the animals were given silymarin for 16 days daily)
- GROUP IV: Treatment group (the animals were given 200mg/kg b.w. aqueous extract *P. parviflorus* for 16 days daily)
- GROUP V: Treatment group (the animals were given 200mg/kg b.w. aqueous extract *H. cordata* for 16 days daily)
- GROUP VI: Treatment group (the animals were given 200mg/kg b.w. aqueous extract *S. spirale* for 16 days daily)

Standard and extracts were administered one hour before  $\text{CCl}_4$  administration.

### Liver biochemical estimation

After 24 hours of administration on day 16, the blood was collected from overnight fasted rats of each group by cardiac puncture. Blood samples

were centrifuged for 15 minutes at 3000 rpm to separate the serum. The separated serum was used for the estimation of serum biochemical parameters. Serum Glutamate Oxaloacetate Transaminase (SGOT) or aspartate aminotransferase (AST), Glutamate Pyruvate Transaminase (SGPT) or alanine aminotransferase (ALT), alkaline phosphatase (ALP) and total bilirubin content were estimated by using commercially available kits (Lowery et al., 1951). The results of AST, ALT and ALP were expressed as units per liter (U/L), and total bilirubin was expressed as micrograms per deciliter ( $\mu\text{g/dL}$ ).

### Histopathological studies

The liver from each animal was removed after dissection and preserved immediately in 10% formalin. Then representative blocks of liver tissues from each lobe were taken and possessed for paraffin embedding using the standard microtechnique [1, 4, 13]. Sections of 5 mm thickness of livers stained with haematoxylin and eosin were observed microscopically for histopathological studies.

### Statistical analysis

All results were expressed as the mean  $\pm$  standard deviation (SD). The results were analyzed for statistical significance by one way of variance (ANOVA) followed by Bonferroni of significance (SPSS, version 16).  $P < 0.05$  was considered as statistically significant.

## RESULTS AND DISCUSSIONS

### Acute toxicity

The oral  $\text{LD}_{50}$  value of the aqueous extracts in rats was 200 mg/kg b.w. All extracts were found to be not toxic up to the dose of 2000 mg/kg b.w. Neither mortality nor any significant behavioral changes were observed up to the dose of 2000

mg/kg b. w. Thus, in present case 2000 mg/kg was considered as No Observable Adverse Effect Level (NOAEL) for all extracts.

### Carbon Tetrachloride-induced hepatotoxicity

As a hepatotoxic agent,  $\text{CCl}_4$  has been extensively used in animal models to investigate chemical induced hepatic injury. The  $\text{CCl}_4$ -induced experimental damage resembles viral hepatitis histologically due to the formation of free radicals and the occurrence of lipid peroxidation in cellular and organelle membranes [22]. Toxicity begins with a highly reactive trichloromethyl free radical ( $\cdot\text{CCl}_3$ ), which is further converted to trichloromethyl peroxy radical ( $\text{CCl}_3\text{OO}\cdot$ ), a classical form of reactive oxygen species (ROS), as the initiator of lipid peroxidation [7, 9, 15]. That is, excessive production of free radicals accelerates the peroxidative degradation of cellular membrane, leading to the breakdown of cell integrity and the leakages of ALT and AST. Consequently, the levels of serum ALT and AST are elevated. SOD and other antioxidant enzymes automatically form a mutually supportive team of defense against ROS [5]. SOD activity being easily inhibited by lipid peroxides or ROS has been suggested [7].

### Serum biochemical estimation

The results of  $\text{CCl}_4$ -induced hepatotoxicity were represented in Table-2.  $\text{CCl}_4$  intoxication in normal rats significantly enhanced the serum levels of AST, ALT, ALP and serum bilirubin, indicating acute hepatocellular damage and biliary obstruction. The rats that received 200mg/kg b.w. of aqueous extracts of three plants showed a significant ( $P < 0.05$ ) decrease in the AST, ALT, ALP and serum bilirubin compared to induced control group. Mostly the plant *P. parvifloras* showed the more significant to reduce



the serum AST, ALT, ALP and bilirubin levels (Table-2a).

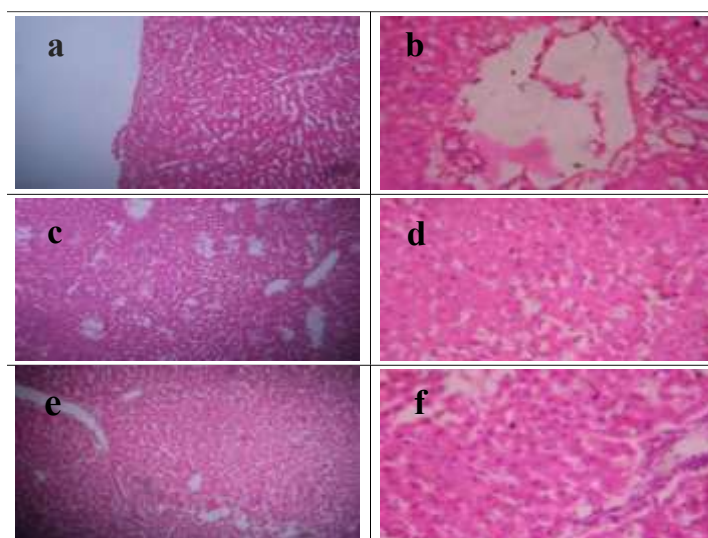
### Liver biochemical estimation

The lipid peroxidation indicated free radical activity and estimation of lipid peroxidase (LPO) enzyme level gives valuable information to lipidperoxidation. The increased lipid peroxidation results in changes in the cellular metabolism of the hepatic and extra-hepatic tissues, which ultimately leads to whole cell deformity and cell death <sup>[21]</sup>. In the present study, an elevation in LPO levels of the liver of rats treated with CCl<sub>4</sub> was observed, the enhanced LPO leading to tissue damage and failure of antioxidant defense mechanisms to prevent the formation of excessive free radicals. Pretreatment with the aqueous extracts of three medicinal plants (200 mg/kg b.w.) significantly ( $P < 0.05$ ) reduced the levels of LPO (Table-2b). Glutathione (GSH) is one of the most abundant, naturally occurring non-enzyme biological antioxidants present in liver. It is involved in the removal of free radicals, maintenance of membrane protein, detoxification of foreign chemicals, and biotransformation of drugs <sup>[6]</sup>. In the present study, the decreased level of GSH has been found in CCl<sub>4</sub>-intoxicated groups, while treatment with the aqueous extracts of all three plants (200mg/kg) significantly ( $P < 0.05$ ) increased the level of glutathione (Table-2b). Superoxide dismutase (SOD) and catalase (CAT) are endogenous enzymatic antioxidants present in all oxygen metabolizing cells involved in the clearing of superoxide and hydrogen peroxide. The suppression of SOD and CAT activities as a result of liver damage was reported <sup>[3, 16]</sup>. Similar finding was observed in present study in carbon tetrachloride treated rats. The administration of aqueous extracts of plants

significantly ( $P < 0.05$ ) recovered the superoxide dismutase (SOD) and catalase (CAT) activities towards normal (Table-2b). In all cases, it was observed that *P. parviflorus* showed the highest activity than the others.

### Histopathological study

Results of histopathological studies provided supportive evidence for biochemical analysis, as presented in Figure-1. Histology of liver section of normal control animal (group 1) exhibited normal hepatic cells each with well-defined cytoplasm, prominent nucleus, and radiantly arranged hepatocytes around the central vein (Figure-1a), whereas that of CCl<sub>4</sub> intoxicated group animal showed extensive liver injuries, characterized by severe hepatocellular degeneration and necrosis around the central vein, sinusoidal dilatation, loss of cellular boundaries, inflammatory cell infiltration, and cytoplasmic vacuolation (Figure-1b). Treatment with standard drug silymarin at a dose of 50 mg/kg and aqueous extract of three plants, *P. parviflorus*, *H. cordata* and *S. spirale* at a dose of 200 mg/kg b.w. showed moderate to weak activity in protecting the liver cells from CCl<sub>4</sub>-injury (Figure-1c to Figure-1f respectively) which indicated that *P. parviflorus*, *H. cordata* and *S. spirale* have antihepatotoxic effect. In addition, the possible antihepatotoxic mechanism of *P. parviflorus*, *H. cordata* and *S. spirale* have not been reported yet. It was assumed that the effect of *P. parviflorus*, *H. cordata* and *S. spirale* extract on liver protection was related to glutathione-mediated detoxification as well as free radical suppressing activity. From the overall result of the biochemical and histopathological examinations, it could be inferred that *Pogostemon parviflorus* showed the highest hepatoprotective activity among the three tested plant extracts.



**Figure-1: microscopic views of liver: (a) normal control group, (b) CCl<sub>4</sub>-control group, (c) standard group, (d) *P. parviflorus* treated group, (e) *H. cordata* treated group and (f) *S. spirale* treated group.**

**Table-2: Effects of aqueous extract of three plant materials on various biochemical parameters in rats with carbon tetrachloride induced hepatotoxicity.**

|                           | Normal Control | CCl <sub>4</sub> Control | Standard      | <i>P. parviflorus</i> | <i>H. cordata</i> | <i>S. spirale</i> |
|---------------------------|----------------|--------------------------|---------------|-----------------------|-------------------|-------------------|
| AST (U/L)                 | 34.35 ± 3.21   | 127.5 ± 5.68             | 42.58 ± 4.05* | 61.66 ± 5.24*         | 89.33 ± 6.47*     | 78.15 ± 6.05*     |
| ALT (U/L)                 | 47.50 ± 4.08   | 129.00 ± 5.21            | 52.16 ± 3.06* | 70.30 ± 4.22*         | 98.5 ± 7.09*      | 84.83 ± 6.52*     |
| ALP(U/L)                  | 11.50 ± 4.03   | 41.33 ± 4.71             | 11.16 ± 2.56* | 22.16 ± 3.31*         | 27.66 ± 2.94*     | 27.33 ± 4.41*     |
| Total Bilirubin (µg/dL)   | 0.35 ± 0.16    | 5.83 ± 0.64              | 0.48 ± 0.13*  | 0.59 ± 0.04*          | 0.79 ± 0.11*      | 0.62 ± 0.03*      |
| LPO (µM /mg protein)      | 2.39 ± 0.59    | 6.82 ± 0.41              | 2.33 ± 0.41*  | 3.24 ± 0.72*          | 4.30 ± 0.40*      | 4.76 ± 0.69*      |
| GSH (µM/gm tissue)        | 18.73 ± 0.98   | 07.01 ± 0.84             | 18.26 ± 0.84* | 16.42 ± 0.81*         | 16.20 ± 1.23*     | 14.49 ± 0.51*     |
| CATALASE (U/mg protein)   | 34.50 ± 1.00   | 13.83 ± 0.85             | 33.51 ± 1.54* | 27.92 ± 1.01*         | 26.34 ± 1.06*     | 21.70 ± 1.12*     |
| SOD (% inhibition of NBT) | 71.14 ± 3.66   | 24.08 ± 2.14             | 66.50 ± 2.03* | 52.20 ± 2.29*         | 46.99 ± 1.17*     | 43.48 ± 1.77*     |

Values were mean ± SD (n=6), P<0.05, where the significance was performed by one-way analysis of variance (ANOVA) followed by Bonferroni test. Values marked by (\*) within a column were not significantly different (P<0.05).

## CONCLUSION

The results from this study clearly reveal that these plants have significant hepatoprotective effect against CCl<sub>4</sub>-induced acute hepatotoxicity in rats,

as evidenced by the lowered tissue lipid peroxidation and elevated levels of enzymatic and non-enzymatic antioxidants in liver. The preliminary investigation and RP-HPLC analysis of the aqueous extracts of the three plants showed the presence of different phenolic compounds. Therefore, the protective effect of these plant extracts against CCl<sub>4</sub>-induced hepatotoxicity might be due to the presence of these phenolic compounds. These findings indicate that the

polyphenolic rich extracts of these plant species have a significant potential to allow future exploitation as a natural antioxidant and dietary source for the improvement of oxidative stress-induced liver injury.

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## CONFLICT OF INTEREST

The authors declare (no) personal or financial conflict of interest related to this work.

## REFERENCES

1. Ahsan, R., Islam, K.M., Haque, E., Hepatoprotective activity of methanol extract of some medicinal plants against Carbon Tetrachloride Induced Hepatotoxicity in Albino Rats. *Global Journal of Pharmacology*. 2009, 3 (3), 116-122.
2. De Feuids, F.V., Papadopoulos, V., Drieu, K., Ginko biloba extracts and cancer a research area in its infancy. *Fundamental & Clinical Pharmacology*. 2003, 17, 405-17.
3. Duairaj, A.K., Vaiyapuri, T.S., Mazumder, U.K., Gupta, M., Hepatoprotective activity of *Oxystelma esculentum* in against paracetamol-induced liver damage in rats. *Pharmacognosyonline*. 2007, 3, 5-72.
4. Galighor, A.E., Kozloff, E.N., In: *Essentials of practical Micro Technique*, 2nd edn. Lea and Febiger, New York. 1976.
5. Gowri Shankar, N.L., Manavalan, R., Venkappayya, D., David Raj, C., Hepatoprotective and antioxidant effects of *Commiphora berryi* (Arn) Engl bark extract against CCl<sub>4</sub>-induced oxidative damage in rats. *Food and Chemical Toxicology*. 2008, 46(9), 3182-3185.
6. Gul, M., Kutay, F.Z., Temocin, S., Hanninen, O. Cellular and clinical implications of glutathione, *Indian Journal of Experimental Biology*. 2000, 38, 625-34.
7. Hsiao, G., Shen, M.Y., Lin, K.H., Lan, M.H., Wu, L.Y., Chou, D.S., Lin, C.H., Su, C.H., Sheu, J.R. Antioxidative and hepatoprotective effects of *Antrodia camphorata* extract. *Journal of Agricultural and Food Chemistry*. 2003, 51(11), 3302-3308
8. Huang, B., Ban, X.Q., He, J.S., Tong, J., Tian, J., Wang, Y.W. Hepatoprotective and antioxidant activity of ethanolic extracts of edible lotus (*Nelumbo nucifera* Gaertn.) leaves. *Food Chemistry*. 2010, 120(3), 873-878.
9. Jain, A., Soni, M., Deb, L., Jain, A., Rout, S.P., Gupta, V.B., Krishna, K.L., Antioxidant and hepatoprotective activity of ethanolic and aqueous extracts of *Momordica dioica* Roxb. leaves. *Journal of Ethnopharmacology*. 2008, 115 (1), 61-66.
10. Liu, W.J.H. *Traditional Herbal Medicine Research Method: Identification, Analysis, Bioassays and Pharmaceutical and Clinical Studies*, John Wiley & Sons, Inc. Hoboken, New Jersey. 2011.
11. Lorke, D.A. A new approach to practical acute toxicity testing. *Archives of Toxicology*. 1983, 54, 275-287.
12. Lowery, O.H., Rosebrough, N.J., Far, A.L., Randall, R.J. Protein measurement with Folin Phenol reagent. *Journal of Biological Chemistry*. 1951, 193, 265-272.
13. Mohamed, S.T.S., Christina, A.J.M., Chidambaranathan, N., Ravi, V., Gauthaman, K. Hepatoprotective activity of *Annona squamosa* Linn on experimental animal model. *International Journal of Applied Research in Natural Products*. 2008, 1(3), 1-7.
14. Proestos, C., Chorianopoulos, N., Nychas, G.J.E., Komaitis, M. RP-HPLC analysis of the



- phenolic compounds of plant extracts. Investigation of their antioxidant capacity and antimicrobial activity. *Journal of Agricultural and Food Chemistry*. 2005, 53, 1190-1195.
15. Ranawat, L., Bhatt, J., Patel, J. Hepatoprotective activity of ethanolic extracts of bark of *Zanthoxylum armatum* DC in CCl<sub>4</sub> induced hepatic damage in rats. *Journal of Ethnopharmacology*. 2010, 127(3), 777-780.
  16. Recknagel, R.O., Glende, R.A.Dr., Hruszkewycz, A.M. In: Pryor, E. A. Jr. (Ed.), *Free Radicals in Biology*, Vol. II. Academic Press, New York. 1976, pp. 97-132.
  17. Sabir, S.M., Rocha, J.B.T. Antioxidant and hepatoprotective activity of aqueous extract of *Solanum fastigiatum* (false “Jurubeba”) against paracetamol-induced liver damage in mice. *Journal of Ethnopharmacology*. 2008, 120, 226-232.
  18. Sajem, A.I., Gosai, K. Traditional use of medicinal plants by the Jaintia tribes in North Cachar Hills district of Assam, northeast India, *Journal of Ethnobiology and Ethnomedicine*. 2006, 2, 33.
  19. Takeoka, G.R., Dao, L.T. Antioxidant constituent of almond (*Prunusdulcis* (Mill.) D.A.Webb) hulls. *Journal of Agricultural and Food Chemistry*. 2003, 51, 496-501.
  20. Tulipani, S., Mezzetti, B., Capocasa, F., Bompadre, S., Beekwider, J.C., De Vos, H.R., Capanoglu, E., Bovy, A., Battino, M. Antioxidants, Phenolic Compounds, and Nutritional Quality of Different Strawberry Genotypes. *Journal of Agricultural and Food Chemistry*. 2008, 56, 696–704.
  21. Winrow, V.R., Winyard, P.G., Morris, C.J., Black, D.R. Free radical in inflammation: Secondary messengers and mediators of tissue destruction. *British Medical Bulletin*. 1993, 49, 506-17.
  22. Wu, Y.H., Yang, L.X., Wang, F., Wu, X.M., Zhou, C.X., Shi, S.Y., Mo, J.X., Zhao, Y. Hepatoprotective and antioxidative effects of total phenolics from *Laggera pterodonta* on chemical-induced injury in primary cultured neonatal rat hepatocytes. *Food and Chemical Toxicology*. 2007, 45(8), 1349-1355.
  23. Yan, F., Zhang, Q.Y., Jiao, L., Han, T., Zhang, H., Qin, L.P., Khalid, R. Synergistic hepatoprotective effect of *Schisandrae* lignans with *Astragalus* polysaccharides on chronic liver injury in rats. *Phytomedicine*. 2009,16, 805–813.
  24. Yang, J.Y., Li, Y., Wang, F., Wu, C.F. Hepatoprotective effects of apple polyphenols on CCl<sub>4</sub>-induced acute liver damage in mice. *Journal of Agricultural and Food Chemistry*. 2010, 58, 6525–6531.

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