A Comprehensive Review on Herbal Hepatoprotective Plants

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ABSTRACT
Liver is the major organ responsible for metabolism of many synthetic chemical substances/ drugs thereby providing protection against foreign substances by detoxifying and eliminating them. Liver is vital organ which regulates homeostasis in the body. Hepatotoxicity can be caused by drugs which are used in their therapeutic range. Liver damage may be caused by reactive metabolite, immunologically mediated response affecting biliary epithelial cells, hepatocyte and/or liver vasculature

Key Words: Tilia platyphyllos, Hepatotoxicity, Gentiana veitchiorum

INTRODUCTION
Liver is the major organ responsible for metabolism of many synthetic chemical substances/ drugs thereby providing protection against foreign substances by detoxifying and eliminating them. Liver is vital organ which regulates homeostasis in the body. Detoxification of the drug and other toxins, protein synthesis, metabolism of hormones etc. are important function which are regulated by liver. Any dysfunction in these regulations may lead to liver diseases. Excessive drug therapy, environmental pollution, alcoholic intoxication is the main causes of liver diseases apart from virus. It is important to maintain a healthy liver for stability overall health of a person as it can lead to decrease in the deaths which are near about 20,000 every year due to liver disorder1. Disorders connected with liver diseases have no effective cure. When allopathic medical practices have no reliable cure for liver diseases herbs here plays important role in the remedy of various liver disorders. Various natural remedies and medical plants are still used all over the world for the treatment of various hepatic diseases. The liver weighed about 1.4kg (about 3lb) in normal age group, which makes it a heaviest gland of the body. Of the organs' majority of the body, it is second just to the skin in size. Hepatotoxicity is liver damage or liver dysfunction due to excessive use of drugs or xenobiotics is referred as Hepatotoxicity. The liver injury which is caused by chemicals or any drugs is known as hepatotoxins or Hepatotoxicants. The Hepatotoxicants are the foreign materials such as industrial chemicals, drugs, natural chemicals such as microcystins, dietary
supplements and herbal remedies. Hepatotoxicity can be caused by drugs which are used in their therapeutic range. Liver damage may be caused by reactive metabolite, immunologically mediated response affecting biliary epithelial cells, hepatocyte and/or liver vasculature. The liver toxicity which takes place by chemicals is due to parent compound or the toxic metabolite of parent compound, concentration gradient of cofactors in blood across the acinus and differential expression of enzyme. The symptoms of liver toxicity are: jaundice or yellowing of skin, mucous membrane, eyes due to increased level of bilirubin in the extracellular fluid, abdominal pain, nausea, vomiting, pruritus, severe fatigue, malaise, weakness, skin rashes, generalized itching, weight gain, dark urine and light colored urine. Biotransformation of Hepatotoxicants Liver plays a central role in biotransformation and disposition of xenobiotics. The close association of liver with the small intestine and the systemic circulation enables it increase the metabolism of absorbed nutrients and decrease the toxins and exogenous chemicals exposure of the body. The liver may come in contact with foreign substances and their metabolites very easily. Metabolism of exogenous compounds can modulate the properties of hepatotoxicant by either increasing its toxicity (toxication or metabolic activation) or decreasing its toxicity (detoxification). Most of the foreign substances are lipophilic thus enabling them to cross the membranes of intestinal cells. They are rendered more hydrophilic by biochemical processes in the hepatocyte, yielding water-soluble products that are exported into plasma or bile by transport proteins located on the hepatocyte membrane and subsequently excreted by the kidney or gastrointestinal tract. The hepatic biotransformation involves 4Phase I and Phase II reactions. Phase I involves oxidative, reductive, hydroxylation and demethylation pathways, basically with the help of cytochrome P-450 enzyme system located in the endoplasmic reticulum, which is the most important family of metabolizing enzymes in the liver.

Therefore, the present review article is about the herbal hepatoprotective plants published in 2014 till date. **Malva parviflora** - The hepatoprotective activity of methanolic extract of *Malva parviflora* was evaluated for the hepatotoxicity induced by paracetamol in mice. Two
doses of plant (250 mg/kg and 500 mg/kg) were administered in Paracetamol intoxicated mice and results were compared with Silymarin. Observational parameters were ALT, AST, ALP and total bilirubin. The results showed that the extract of *M. parviflora* produced significant reduction in liver enzymes and total bilirubin which was supported by histopathological investigation. Thus, the aqueous methanolic extract of *M. parviflora* possesses hepatoprotective activity.

**Tridax procumbens** - The hepatoprotective activity of flowers extract of *Tridax procumbens* Linn, against d-galectosamine induced hepatotoxicity in male Wister albino rats were evaluated. The flowers of *Tridex procumben* Linn. was extracted out by petroleum ether, methanol and chloroform water. The dose of the extract was fixed by acute oral toxicity as Per OECD guideline 423 and then it was subjected for Hepatoprotective activity on rats by d-galectosamine induced model and histopathological changes were also observed. In the Hepatoprotective Activity the extracts shows significant effect but as compared to aqueous extract, the Methanolic Extract shows potent effect.

**Gentiana veitchiorum** - The hepatoprotective activity of *Gentiana veitchiorum* Hemsl. against carbon tetrachloride-induced hepatotoxicity in mice was evaluated. The acute hepatic model was developed by injection of 20% CCl₄ in mice. ICR mice were divided into six groups, including control, CCl₄, CCl₄+Silymarin, and CCl₄+ MGV (100, 200, and 400 mg·kg⁻¹) groups. Oral administration of MGV at 200 and 400 mg·kg⁻¹ for 15 days dose-dependently inhibited the serum elevations of AST, ALT, and ALP, and recovered the reduction of SOD, CAT, and GPX in liver tissue. Hematoxylin and eosin staining examination performed in liver tissues suggested that MGV treatment ameliorated histopathological changes in CCl₄-induced mice. Western blotting analysis implied that MGV increased HO-1 expression and recovered TNF-α alternation. Thus, the current study showed that *G. veitchiorum* extract possesses hepatoprotective activity.

**Phlogacanthus thyrsiflorus** - The hepatoprotective activity of *Phlogacanthus thyrsiflorus* Nees. in
Streptozotocin induced Diabetic Mice were evaluated. The flower extract of *Phlogacanthus thyrsiflorus* in doses 100 and 200 mg/kg b.w was orally administrated for 7 days and SGPT, SGOT, ALP, Urea and Creatinine was estimated. It was found that there was significant reduction of Serum SGPT, SGOT, ALP, Urea, Creatinine. Thus, the flower of *Phlogacanthus thyrsiflorus* consists hepatoprotective activity.

*Cuscuta reflexa*- The hepatoprotective activity of ethanolic extract of aerial parts of *Cuscuta reflexa* Roxb. on liver damage due to Cisplatin in rats was evaluated. 100 male Wistar rats weighing 200±20g were randomly divided into 4 groups (25 rats each) as the following: Group 1, healthy control rats received isotonic saline solution (ISS, 10 ml/kg) intraperitoneally; Group 2 non-damaged rats were treated with 1000 mg/kg b.w. /day orally administration of CRE for 15 days; Group 3, damaged rats administered by ISS (10 ml/kg) orally for 15 days and received Cisplatin on day 10 at a dose of 5.7 mg/kg body weight mixed in 10mg/kg normal saline; Group 4, damaged rats were treated with CRE (1000 mg/kg b.w. /day, for 15 days orally). The animals of different groups were sacrificed under light anesthesia (diethyl ether) 1 day after the end of the treatment and the serum obtained was used for measurement of Albumin, total protein, total bilirubin, ALT and AST and ALP as well as antioxidant enzymes. CRE improved the liver function by decreasing the serum ALT, AST and alkaline phosphate levels in hepatotoxic rats.

*Viola odorata*- The hepatoprotective activity of aqueous methanolic extract of *Viola odorata* against paracetamol-induced liver injury in mice was evaluated. Aqueous methanolic extract of *V. odorata* (250 mg/kg and 500 mg/kg) was given to mice intoxicated with paracetamol. Obtained results demonstrated that the extract significantly reduced paracetamol induced increase levels of serum hepatic enzymes and total bilirubin and histopathological studies showed that the plant attenuated the hepatocellular necrosis and inflammation. Thus, it is concluded that *V. odorata* has hepatoprotective activity against paracetamol-induced liver injury in mice.

*Chenopodium murale*- The hepatoprotective activity of
Chenopodium murale in carbon tetrachloride-induced hepatic damage in rabbits was investigated. Whole plant extract of Chenopodium murale (500 and 750 mg/kg; orally) in carbon tetrachloride-induced (0.75 mL/kg; subcutaneously) hepatotoxic rabbit were given. Silymarin (100 mg/kg/day orally) was used as a standard drug. Hepatotoxic rabbits boosted levels of SGOT, SGPT, ALP and total bilirubin. Extracts of C. murale (both doses) proved to have hepatoprotective activity by reducing the elevated level of enzymes and histopathological study of liver tissues additionally authenticated these findings. Thus, it is concluded that extracts of C. murale can be used in liver disorders 10.

Allium paniculatum- The hepatoprotective activity of Allium paniculatum and Capparis spinosa on Thioacetamide induced hepatotoxicity in rats were investigated. Rats were administered the vehicle, silymarin or extracts orally for 21 days and simultaneously administered TAA (50 mg/kg, s.c.) 1 hr. after the respective assigned treatments every 72h. SC injection of TAA significantly elevated serum activities of ALT, AST, ALP and γ-GT, compared to normal controls. In the liver, significantly elevated level of malondialdehyde (MDA), lowered levels of reduced glutathione (GSH), catalase (CAT), glutathione peroxidase (GPx) and superoxide dismutase (SOD) were observed following TAA injection. Both extracts displayed hepatoprotective effect in a dose dependent manner as evident by reduced levels of serum ALT, AST, ALP, γ-GT and hepatic MDA concentration, as well as higher CAT, GPx, SOD activities and GSH concentration compared to TAA-intoxicated controls. The histopathological analysis suggested that both extracts obviously alleviated the degree of liver damage induced by TAA. In conclusion, A. paniculatum and C. spinosa extracts attenuate hepatotoxicity induced by TAA 11.

Crataeva magna- The hepatoprotective activity of leaves of Crataeva magna (Lour.) in different types of hepatotoxic rat models was investigated. Three different types of models used to examine the in-vivo hepatoprotective activity of the extract i.e. carbon tetrachloride, ethanol and paracetamol induced hepatotoxicity in rats and compared with silymarin (20 mg/kg) as reference standard. Two way analysis of variance study of the
estimated biochemical parameters to illustrate, aspartate aminotransferase, alanine amino transferase and alkaline phosphatase were revealed that there is significant difference exists between the different treatment groups. Severe hepatic lesions induced by carbon tetrachloride, ethanol and paracetamol were significantly lowered after the administration of CM 200 mg/kg to the respective control groups (carbon tetrachloride > paracetamol > ethanol) which was also evident from the histopathological study of liver sections.12

*Iris* spuriarhizome-* The hepatoprotective activity of *Iris spuria* against paracetamol induced toxicity at two different doses 100 and 200 mg/kg were evaluated. Administration of the plant extract restored the paracetamol induced elevated levels of serum marker and distorted hepatic tissue architecture. The lipid peroxides and glutathione levels were also restored towards normal in liver tissue significantly. Thus, it is concluded that *Iris spuria* possess significant protective effect against hepatotoxicity induced by paracetamol.13

*Ricinus communis-* The hepatoprotective activity of methanolic extracts of leaves of *Ricinus communis* in CCl4 induced hepatic damage in rats were evaluated. Methanolic extracts at doses of 100, 200, and 400 mg/kg were administered orally once daily for 7 days. The hepatoprotective activity was assessed using various biochemical parameters like SGOT and SGPT. The results substantially showed elevated serum enzymatic levels of SGOT and SGPT were significantly restored towards normalization by the extracts. Thus, it is concluded that *Ricinus communis* leaves possess significant protective effect against hepatotoxicity induced by CCl4.14

*Cestrum nocturnum-* The hepatoprotective activities of *Cestrum nocturnum* (Queen of Night) was evaluated against the paracetamol induced hepatotoxicity in the mice. Aqueous ethanol (30:70) extract of plant was obtained by maceration. Results showed that aqueous ethanol extract of *C. nocturnum* (250 mg/kg and 500 mg/kg) produced significant hepatoprotective activities against paracetamol induced liver injury in Swiss albino mice and the histopathalogical studies of liver further supported the hepatoprotective effects of *C. nocturnum*. Thus, it is
concluded that aqueous ethanol extract of leaves of *C. nocturnum* has hepatoprotective activity against the paracetamol-induced hepatotoxicity in albino mice.  

**Chenopodium murale**- The hepatoprotective effect of *Chenopodium murale* in mice was evaluated. The results showed that aqueous methanolic extract of Chenopodium murale (200 and 500 mg/kg) produced significant decrease in paracetamol induced increased levels of liver enzymes (alanin transaminase, aspartate transaminase, alkaline phosphatase) and total bilirubin and these findings were further supported by histopathological investigations by microscope. Thus, it is concluded that aqueous methanolic extract of C. murale possess hepatoprotective activity against paracetamol induced liver damage in mice.

**Thymus linearis**- The hepatoprotective activity of aqueous and ether extracts of *Thymus linearis* (250 and 500 mg/kg orally) was evaluated against carbon tetrachloride and paracetamol induced hepatic damage in mice. Serum levels of ALT, AST, and ALP were assessed. Antioxidant activity of both the extracts was also determined using 1-1-diphenyl-2-picryl hydrazine (DPPH) scavenging method. The results indicated that both the extracts significantly produce a dose dependent reduction in serum levels of ALT, AST, and ALP when compared to carbon tetrachloride and paracetamol treated groups. It is conceivable that the hepatoprotective activity of *T. linearis* might be due to the presence of certain pharmacologically active compounds.

**Morus nigra**- The hepatoprotective activity of aqueous methanolic extract of leaves of *M. nigra* were determined. Two doses of 250 mg/kg p.o and 500 mg/kg p.o showed that extract of M. nigra produced significant reduction in liver enzymes ALT, AST, ALP and total bilirubin induced by paracetamol and the results are comparable to Silymarin. Results were supported by histopathological investigations, phytochemical screening and detection of active constituents by HPLC. It was concluded from this study that *M. nigra* has hepatoprotective activity against paracetamol induced liver injury in mice.

**Bauhinia hookeri**- The hepatoprotective activity of *Bauhinia*
hookeri ethanol extract (BHE) against CCl₄ induced liver injury was investigated in mice. The hepatic marker enzymes: ALT, AST, and ALP were determined in the serum. BHE treatment significantly inhibited the CCl₄ induced increase in ALT, AST, ALP, and MDA levels at the tested doses, respectively and the histological observations confirmed the strong hepatoprotective activity. These results suggest that a dietary supplement of BHE could exert a beneficial effect against oxidative stress and various liver diseases by enhancing the antioxidant defense status, reducing lipid peroxidation, and protecting against the pathological changes of the liver¹⁹.

**Origanum elongatum**- The hepatoprotective effect of *Origanum elongatum* against CCl₄ induced toxicity in rats was evaluated. The methanolic extract of *Origanum elongatum* (OEME) given orally by gavage against i.p. injection a single dose of CCL₄ (0.6 ml/kg) induced hepatotoxicity in rats. The degree of protection was estimated by biochemical analysis of serum liver biomarkers: AST, ALT, ALP and by liver histopathological examination. The present study showed that OEME was dose dependently decreased hepatic histopathological changes and serum liver biomarkers levels in CCl₄ intoxicated rats. Thus, the present results revealed the hepatoprotection of OEME against hepatotoxic products or drugs²⁰.

**Rumex dentatusin**- The Hepatoprotective effect of aqueous methanolic extract of *Rumex dentatus* paracetamol induced hepatotoxicity in mice was evaluated. *R. dentatus* at doses 250 and 500 mg/kg significance decreased the elevated level of ALT, AST, ALP and bilirubin induced by paracetamol and results are comparable with silymarin and the results were supported by histopathological investigations, phytochemical screening and detection of hepatoprotective active constituents e.g quercetin, kaempferol, myricetin by HPLC. So, it is concluded that R. dentatus has hepatoprotective effect against paracetamol liver damage in mice²¹.

**Amorphophallus commutatus**- The hepatoprotective effect of polyphenols rich methanolic extract of *Amorphophallus commutatus* against CCl₄ induced hepatic injury in swiss albino mice were evaluated. Hepatic
injury was induced by injecting 0.2% CCl₄ in olive oil i.p. on 15th day of drug administration. Hepatoprotective activity was evaluated by estimating the levels of serum markers like ALT, AST, ALP, total and direct bilirubin and histopathological studies. Histopathological and biochemical results elicited the methanolic extract of A. commutatus has significant hepatoprotective activity comparable to the standard silymarin. The methanolic extract of A. commutatus showed significant hepatoprotective and antioxidant activity which might be attributed due to the polyphenolic compounds present in the extract.

**Rourea induta** - The hepatoprotective potential of *Rourea induta* Planch. against CCl₄-induced liver injury in female rats were investigated. Using samples from carbon tetrachloride-treated Wistar female rats treated orally with or without RIEE, the aspartate aminotransferase, alanine aminotransferase, and total bilirubin levels in plasma was evaluated. A histopathology study was performed. Oral administration of RIEE significantly reduced carbon tetrachloride-induced elevations in the levels of plasma markers of hepatic damage and lipid peroxidation. It also rescued histopathologic alterations observed in the liver and levels of oxidative stress markers. RIEE exhibits antioxidant and hepatoprotective activities in vivo, which may be attributable to its flavonoids composition.

**Hypericum perforatum** - The hepatoprotective effects of *Hypericum perforatum* on hepatic ischemia/reperfusion injury in rats were evaluated. The albino rats were subjected to 45 min of hepatic ischemia followed by 60 min of reperfusion period. *Hypericum perforatum* extract (HPE) at the dose of 50 mg/kg body weight (HPE50) was intraperitoneally injected as a single dose, 15 min prior to ischemia. Rats were sacrificed at the end of reperfusion period and then, biochemical investigations were made in serum and liver tissue. Liver tissue homogenates were used for the measurement of malondialdehyde (MDA), catalase (CAT) and glutathione peroxidase (GPx) levels. At the same time alanine aminotransferase (ALT), aspartate aminotransferase (AST) and lactate dehydrogenase (LDH) were assayed in serum samples and compared statistically. While the ALT, AST,
LDH activities and MDA levels were significantly increased, CAT and GPx activities significantly decreased in only I/R-induced control rats compared to normal control rats. MDA levels markedly increased activities of CAT and GPx in tissue homogenates compared to I/R-induced rats without treatment-control group. In oxidative stress generated by hepatic ischemia–reperfusion, *H. perforatum* L. as an antioxidant agent contributes an alteration in the delicate balance between the scavenging capacity of antioxidant defence systems and free radicals in favour of the antioxidant defence systems in the body\textsuperscript{24}.

**Pouteria campechiana**- The antioxidant and hepatoprotective effect of polyphenolic-rich *P. campechiana* fruit extract against acetaminophen-intoxicated rats were evaluated. The animals were treated with acetaminophen (250 mg/kg body weight; p.o.) thrice at the interval of every 5 days after the administration of *P. campechiana* aqueous extract and silymarin (50 mg/kg). Acetaminophen treatment was found to trigger an oxidative stress in liver, leading to an increase of serum marker enzymes. However, treatment with *P. campechiana* fruit extract significantly reduced the elevated liver marker enzymes (aspartate transaminase, alanine transaminase, and alkaline phosphatase) and increased the antioxidant enzymes (viz., superoxide dismutase and catalase) and glutathione indicating the effect of the extract in restoring the normal functional ability of hepatocytes. These results strongly suggest that *P. campechiana* fruit extract has strong antioxidant and significant hepatoprotective effect against acetaminophen-induced hepatotoxicity\textsuperscript{25}.

**Alcea rosea**- The effects of *Alcea rosea* against acetaminophen-induced hepatotoxicity in mice were evaluated. Aqueous methanolic extract of *A. rosea* were given orally for 7 consecutive days followed by daily toxic dose of acetaminophen. At the end of treatment period, evaluation of hepatoprotective activity of *A. rosea* was done on basis of levels of liver enzyme markers (aminotransferases, alkaline phosphatase and bilirubin) and histopathological examination of liver tissues. Acetaminophen significantly increased serum levels of liver enzyme markers whereas, the extract of *A. rosea* significantly reduced serum levels of elevated liver enzyme.
markers in dose-dependent manner compared to acetaminophen treated mice group. Histopathological examination of liver tissues also supported the protective effects of A. rosea on liver enzyme markers. Thus, it is concluded that extract of A. rosea has strong hepatoprotective effects against acetaminophen-induced hepatotoxicity.

**Mucuna pruriens** - The hepatoprotective activity of the hydroethanolic extract of *Mucuna pruriens* leaves in antitubercular and alcohol-induced hepatotoxicity in rats were investigated. In each of the models used, seven groups were allotted. The different groups received normal saline (10 mL/kg, p.o.); hepatotoxicant (isoniazid-rifampicin, INH-RIF, 100 mg/kg, i.p. or 20% ethanol 5 g/kg, p.o.) and normal saline (10 mL/kg, p.o.); hepatotoxicant and extract at doses of (100, 200, and 400 mg/kg, p.o.); hepatotoxicant and silymarin (50 mg/kg p.o.); and extract at (400 mg/kg p.o.). On the 21st day of treatment, blood was collected for assessment of serum biochemical parameters and harvested liver samples were assessed. The hepatotoxicants significantly increased the levels of ALT, AST, ALP, and bilirubin as compared to control. *M. pruriens* significantly reversed the elevation in the level of ALT, AST, ALP, and bilirubin caused by the hepatotoxicants. The extract (200 and 400 mg/kg) significantly reversed the diminution in the level of in vivo antioxidants and increased the level of MDA produced by INH-RIF. *M. pruriens* (100-400 mg/kg) elicited significant reduction in the level of MDA compared to the alcohol group. Silymarin also reversed the deleterious effects of the hepatotoxicants. The hydroethanolic extract of *Mucuna pruriens* leaves possesses hepatoprotective activity with enhancement of in vivo antioxidants as a possible mechanism of action.

**Viburnum punctatum** - The in vitro hepatoprotective activity of Chloroform and Methanol extracts of *Viburnum punctatum* (200 and 400 μg/ml) against carbon tetrachloride induced toxicity were investigated. The screening of hepatoprotective activity was based on the protection of human liver derived changed liver cells against CCl₄ induced damage determined by MTT assay [(3-(4,5 dimethylthiazole-2yl)-2,5-diphenyl tetrazolium bromide assay] using Silymarin as standard. The changed liver cells were treated with different
concentrations of chloroform and methanol extracts of *Viburnum punctatum*, showed a dose dependent increase in percentage viability and the results were highly significant, when compared with CCl₄ induced group. The methanolic extract exhibited more hepatoprotective activity when compared to chloroform extract. The results clearly demonstrate that *Viburnum punctatum* possess promising hepatoprotective effects.

**Malva sylvestris**- The hepatoprotective effects of *Malva sylvestris* against paracetamol-induced hepatotoxicity in mice were evaluated. Paracetamol significantly induced oxidative stress in the liver, ultimately leading to increased serum levels of liver enzyme markers like alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total bilirubin, and direct bilirubin. The extract of *Malva sylvestris* significantly reduced the serum levels of these elevated liver enzyme markers in a dose-dependent manner. Histopathological examination of liver tissues also showed hepatoprotective effects of *Malva sylvestris* in restoring normal functional ability of the liver. Thus, the results showed that the extract of *Malva sylvestris* has strong hepatoprotective effects against paracetamol-induced liver injury.

**Tilia platyphyllos**- The hepatoprotective activity of Linden (*Tilia platyphyllos* L.) infusion against ethanol-induced oxidative stress in Rats were evaluated by measuring liver damage serum biomarkers, aspartate aminotransferase (AST), alanine aminotransferase, lactate dehydrogenase (LDH), total protein, total albumin, and total cholesterol level. Rats were divided into four experimental groups: I (control), II (20 % ethanol), III (2 % LF), and IV (20 % ethanol + 2 % LF). According to the results, the level of serum marker enzymes, AST and LDH, was significantly increased in group alcohol and group LF as compared to control group, whereas decreased in group IV as compared to ethanol group. With regard to MDA content and ADS constituents, MDA contents of alcohol group in all tissues, except for erythrocytes and heart, and in brain, kidney, and spleen of LF group significantly increased compared to control group, whereas LF beverage extract supplementation did not restore the increased MDA towards close the control level. In addition, while ethanol caused fluctuation in antioxidant
defense system constituents level as a result of oxidative stress condition in the rats, it could have not been determined the healing effects of the LF against these fluctuations. The results indicated that LF beverage extract could not be as important as diet-derived antioxidants in preventing oxidative damage in the tissues by reducing the lipid oxidation or inhibiting the production of ethanol-induced free radicals in rats.  

**Thymus vulgaris** - The hepatoprotective effect of *Thymus vulgaris* Essential Oil in Experimental Model of Acetaminophen-Induced Injury were investigated. The hepatoprotective activity of TEO was determined by assessing serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) in mice. TEO reduced the levels of the serum marker enzymes AST, ALT, and ALP. The histopathological analysis indicated that TEO prevented acetaminophen-induced necrosis. These results suggest that TEO has hepatoprotective effects on acetaminophen-induced hepatic damage in mice.

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