The utilization of medicinal plants is inevitable in human society from the dawn of civilization in combating diseases. Herbal medicines are in great demand in the developed as well as developing countries for primary health care because of their wide biological and medicinal activities, higher safety margins and lesser costs. The use of natural remedies for the treatment of liver diseases has a long history and medicinal plants and their derivatives are still used all over the world in one form or the other for this purpose. Though several Indian medicinal plants have been extensively used in the traditional system of medicine, the management of liver disorder by a thoroughly standardized and evaluated natural, simple and precise herbal drug is still an intriguing problem and this prompted me to choose the plant *Hiptage benghalensis* belonging to the family of Malpighiaceae as my plant of interest based on literature reviews on its therapeutic efficiency and predominant occurrence to study its hepatoprotective potential.

In the present study, standardization techniques were carried out taking into consideration all aspects that contribute to the quality of the plant material, namely correct identity of the sample, organoleptic evaluation, pharmacognostic evaluation, volatile matter, quantitative evaluation (ash values, extractive values), phytochemical evaluation, toxicity testing, and biological activity. The results of pharmacognostical features, fluorescence and physicochemical analysis underline the correct identification and purity of the plant sample and can act as an important lead in the scientific validation and standardization of *H. benghalensis*.

In the present investigation, preliminary phytochemical screening of leaf extracts revealed the presence of flavonoids, tannins, coumarins, alkaloids, terpenoids and steroids. Flavonoids and terpenoids are known for their antioxidant and hepatoprotective activity. Alkaloids, tannins, and phenolic compounds have been associated with various degrees of anti-inflammatory, analgesic and antioxidant activities. The hepatoprotective potential of mono, di, triterpenoids and sesquiterpenoids has been well documented over the years. The hepatoprotective activity of ELEHB against CCl₄ induced toxicity may be attributed to the individual or combined effect of anti-oxidant and hepatoprotective activity of the phytoconstituents present in the plant. The assessment of inorganic constituents in *H. benghalensis* showed the presence of high and moderate levels of calcium (4.20%), potassium (3.62%), magnesium (2.63%), iron (14.2 ppm) and...
manganese (5.63 ppm) which are important minerals that help in maintenance of normal metabolic pathways.

The evaluation of anti-oxidant potential of *H. benghalensis* is the first of its kind and helped in identifying the efficient solvent ethanol for extraction of phytoconstituents which possessed better antioxidant property over aqueous extract. The quantification of the marker compounds would serve as an additional parameter in assessing the quality of the sample and the results of the present study showed a good match with the findings of qualitative and quantitative assessments. TLC profiles helps to characterize active principles in herbal material and the results of the present study confirmed the presence of terpenoids on selection of an appropriate mobile phase to suite the experimentation. This could possibly attribute to the antioxidant potential of the extract of choice. In the present study, GC-MS was carried out for the ethanol extract of the plant of interest to analyze its chemical constituents and the results revealed the presence of 55 constituents.

The ethanolic extract of *H. benghalensis* (ELEHB) was subjected to acute toxicity studies. The results of the observation showed no mortality even at the highest dose of 5000mg/kg/bw. Three submaximal doses (100, 200 & 300mg/kg.bw) which were found to be safe in rats were employed for further pharmacological and biochemical investigations.

Significant changes in the biochemical parameters in selected dose level of CCl\textsubscript{4} control reflect that the possibility of dynamic and compensatory cell proliferation. The hepatic injury induced by CCl\textsubscript{4} resulted in an increase in serum AST (36.7%), ALT (43.6%), ALP (33%) and LDH (41%) levels when compared with the normal control groups which may be due to the leakage of cellular enzymes into circulation. However, a significant decrease (p<0.05) in elevation of serum enzymes was notable following treatment with ELEHB in a dose dependent fashion when compared with the standard drug treated groups which may possibly be due to reduction in cell membrane disturbances and regeneration of hepatocytes.

CCl\textsubscript{4} induced stress resulted in membrane damage of the hepatocytes which was evident from the fluctuating levels of membrane bound ATPases in the present
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Impaired interaction between Na, K ions results in decreased levels of Na\(^+\)/K\(^+\)-ATPase activity (33%) accompanied by elevated levels of Ca\(^2+\)/Mg\(^2+\) ATPase (34%, 41% respectively) when compared with normal control groups which confirmed the dysfunctioning of the hepatocytes which on administration of ELEHB significantly restored the levels of (p≤0.05) the membrane bound ATPases which was on par with the effect of the standard drug treated groups silymarin suggestive of the fact that the structural integrity of the hepatocytes was restored.

The present study showed a collective depletion in the levels of antioxidants SOD, GR, GSH, GPx, GST, CAT which had a direct impact on the levels of LPO which was elevated (41%) suggestive of loss of structural integrity in the hepatocytes when compared with the normal control groups. Levels of SOD, GR, GSH, GPx, GST, CAT showed a depletion of (42%, 40%, 42%, 37%, 50% and 53% respectively) when compared with group 1 control animals which on treatment with ELEHB showed a significant increase (p≤0.05) in the enzymatic antioxidant values when compared with standard and a significant decrease (p≤0.05) in the LPO levels comparable to standard treated groups suggesting that ELEHB had a direct free radical scavenging property and also strengthens the enzymatic antioxidant defense system.

Decreased levels of protein in the present work on intoxication with CCL\(_4\) acted as an important marker to assess the extent of liver injury which showed a 3 fold decrease in the intoxicated groups when compared with the normal control groups which on treatment with ELEHB significantly elevated (p≤0.05) the levels of protein in a dose dependent manner and was well comparable with the standard drug treated groups suggestive of the restoration in the synthetic function of the liver. These also had a direct impact on the A/G ratio levels which showed a significant reversion (p≤0.05) in the levels of albumin and globulin when compared with the normal control groups revealing the deregulation in the biosynthetic process of the hepatocytes which was significantly reversed to near normalcy in the plant treated groups which was on par with the standard drug treated experimental animals.

Depletion in the levels of glycogen with elevated levels of hydroxyproline and bilirubin acted as important biochemical diagnostic tools in the present study. Glycogen...
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Levels accounted to a fall of 30% suggestive of deregulated metabolism with increase in hydroxyl proline and bilirubin levels to 45%, 28% respectively indicating the extent of liver impairment in comparison with the normal control groups. However, treatment with ELEHB at the increasing doses of 100, 200, 300 mg/kg bw. significantly decreased ($p<0.05$) the levels of hydroxyl proline and bilirubin and accelerated the process of glycogen synthesis enhancing the increase in the levels of glycogen that was on par with the effect of the standard drug treated groups.

CCl$_4$ induction caused fatty infiltration in liver which was well observed along with the changes noticed in the lipid profile and also with increase in weight of the liver tissue in the present study which showed marked elevations in total hepatic cholesterol (42%), TGL (29%), LDL (37%), PL (49%) and a decrease in the HDL (63%) levels. However, administration with ELEHB showed a significant reversal ($p<0.05$) in the levels of lipid profile and also a decrease in the weight of liver tissue which was comparable with the standard drug silymarin.

All the biochemical observations made in the present investigation was well supported by the histopathological examination of the liver tissue which produced confirmatory changes in the architecture of the hepatocytes on intoxication with CCl$_4$ which showed centrizonal necrosis, steatosis, vacuolar degeneration and glycogen depletion. However, groups treated of ELEHB reverted these histological changes in liver in a dose dependent manner.

The observations of in vivo investigation in the present study was supported by the in silico analysis. Compounds identified in the ELEHB through GC-MS studies were subjected to docking studies. Squalene, tetradecanoic acid and (E)-9-Octadecenoic acid ethyl ester present in the extract effectively docked with the target protein NS5B RdRp, with an effective bonding energy of -6.5 kcal/mol, -6.3 kcal/mol and -5.9 kcal/mol respectively. Protein-ligand interaction plays a significant role in structural based drug designing. Docking results of the present study revealed that all three compounds exhibited good interactions with the target protein and could act as good lead compounds as well as effective inhibitors for RNA dependent RNA polymerase (NS5B). These active principles identified in ELEHB might have probably been responsible for its
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hepatoprotective activity. However, further investigations would help in specifying compounds against hepatitis in order to confirm the present hypothesis.

In conclusion, the present investigation demonstrated that ELEHB has hepatoprotective effect against CCl₄ induced hepatotoxicity. However, it is necessary to isolate and purify the active principles involved in the pharmacological potency of this plant and determine its mechanism of action.