Liver damage induced by CCl₄ is commonly used model for the screening of hepatoprotective drugs. The rise in serum levels of AST, ALT and cholesterol has been attributed to the damaged structural integrity of the liver, because they are cytoplasmic in location and released into circulation after cellular damages (Slater, 1965).

Several reports reveal that rats treated with CCl₄ induced hepatotoxicity by metabolic activation and selectively causes toxicity in liver cells maintaining semi-normal metabolic function. CCl₄ is metabolically activated by the cytochrome P-450 dependent mixed oxidase in the endoplasmic reticulum to form trichloromethyl free radical (CCl₃) which combined with cellular lipids and proteins in the presence of oxygen to induce lipid peroxidation. These result in changes of structures of the endoplasmic reticulum and other membrane, loss of metabolic enzyme activation, reduction of protein synthesis and loss of glucose -6-phosphatase activation, leading to liver injury (Recknagel et al., 1976).

The hepatoprotective effect of the ethanol:water (1:1) extract of Eclipta alba was studied at subcellular levels in rats against CCl₄ induced hepatotoxicity. The loss of hepatic lysosomal acid phosphatase and alkaline phosphatase by CCl₄ was significantly restored by E. alba (Saxena et al., 1993).

The hepatoprotective activity of the Cleome viscosa extract was assessed in CCl₄ induced hepatotoxic rats. The extract was found to be effective in shortening the thiopental induced sleep in mice poisoned with CCl₄. The hepatoprotective effect of ethanolic extract was comparable to that of silymarin, a standard hepatoprotective agent (Gupta & Dixit, 2009).

Investigation of hepatoprotective potential of the ethanolic leaf extract of Pterospermum acerifoliumon rats induced with CCl₄ hepatotoxicity, revealed that in ethanol extract treated animals, the toxicity effect of CCl₄ was controlled significantly by restoration of the levels of serum bilirubin and enzymes as compared to the normal and standard drug silymarin treated groups (Kharpate et al., 2007).
It was observed that treatment with ethanolic leaf extract of *Wedelia calendulacea* in carbon tetrachloride induced hepatotoxicity showed a dose dependent reduction of CCl₄ induced elevated serum levels of enzymes with parallel increase in total protein and bilirubin, indicating the extract could restore the normal functional status of the liver (Murugaian *et al*., 2008).

It was found that the oral administration of hydroalcoholic extract of *Alocasia indica* (250 and 500 mg/kg bw.) effectively inhibited CCl₄ and paracetamol induced changes in the serum marker enzymes, cholesterol, serum protein and albumin in a dose dependent manner as compared to the normal and standard drug silymarin treated groups (Wahid Mulla *et al*., 2009).

An investigation on the ethanolic extract of *Aegle marmelos* at a dose of 500mg/kg bw. when given orally exhibited a significant (p≤ 0.05) hepatoprotective effect evidenced by lowering the levels of enzymes like serum glutamate pyruvate transminase, serum glutamate oxaloacetate transminase, alkaline phosphatase, bilirubin, total cholesterol, triglycerides, low density lipoprotein and very low density lipoprotein but there was an increase in the level of high density lipoprotein in CCl₄ induced rats (Sumitha & Thirunalasundari, 2011).

In a study elevated serum marker enzymes such as SGOT, SGPT, ALP, LDH, ACP and 5’ nucleotidase were observed due to CCl₄ treatment and the same were restored towards normalization in rats treated with *Eclipta alba* and seeds of *Piper longum*. The biochemical parameters like total protein, total bilirubin, total cholesterol, triglycerides, and urea were also restored towards normal levels by the treatment (Samudram *et al*., 2008).

The hepatoprotective activity of methanol extract of *Oldenlandia umbellata* was evaluated by measuring levels of serum marker enzymes like SGOT, SGPT, ALP, total protein and bilirubin in CCl₄ induced rats. Treatment of rats with CCl₄ led to a marked increase in lipid peroxidation as measured by malondialdehyde (MDA). This was associated with a significant reduction of the hepatic antioxidant system with reduced glutathione (GSH) and catalase. These biochemical alterations resulting from CCl₄
administration were significantly (\(p \leq 0.05\)) inhibited by treatment with methanol extract of *O. umbellata* (Malaya Gupta *et al.*, 2007).

It was found that the treatment with petroleum ether, alcoholic and aqueous extract of *Wrightia tinctoria*, respectively decreased the CCl\(_4\) induced elevated enzyme levels which suggested the protective role of the plant extract on the structural integrity of the hepatocyte cell membrane or regeneration of damaged liver cells. Reduction in the levels of SGOT and SGPT towards the respective normal value is an indication of the stabilization of plasma membrane and the repair of the hepatic tissue damages caused by CCl\(_4\) (Chandrasekhar *et al.*, 2004).

It was observed that the administration of CCl\(_4\) to rats produced a marked elevation in serum GOT, GPT and GGT levels. But treatment with *Psidium guajava* leaf extract at 500 mg/kg bw. resulted in significant recovery from the CCl\(_4\) intoxication as there was a reduction in the activity of the enzymes was noted in the plant extract treated group which may be attributed to the antioxidant potential of *P. guajava* and the results were comparable to the standard drug silymarin which is an established hepatoprotectant and antioxidant (Chanchal Roy *et al.*, 2006).

Several investigations have revealed that CCl\(_4\) induction in rats resulted in the disturbance of Ca\(^{2+}\) homeostasis, inhibition of mitochondrial respiration and excessive generation of ROS and serum GOT and GPT levels were elevated remarkably. The accumulation of ROS aggravates the heptocytes and mitochondrial damage resulting in membrane fragility, enzyme leakage and pathological degeneration. Treatment with *Terminalia catappa* chloroform extract showed a significant protection against CCl\(_4\) induced hepatotoxicity in mice which was evidenced by the reversal of serum GOT and GPT levels to near normal (Jing Gao *et al.*, 2004).

Santra *et al.*, (1998) demonstrated that the treatment with *Picrorhiza kurroa* in CCl\(_4\) treated mice significantly reversed the altered serum GOT, GPT, antioxidants and membrane bound ATPases. The lipid per oxidation was also significantly reduced in the drug treated animals.
Review of Literature

The protective effect of kolaviron, a biflavanoid fraction of the defatted alcoholic extract of *Garcinia kola* seeds was studied in CCl₄ induced lipid per oxidation which lead to membrane disruption. The Ca²⁺ ATPase activity was reduced in the CCl₄ treated group while kolaviron antagonized the effect of CCl₄ on the Ca²⁺ ATPase activity, by increasing the same (Oluwatosin *et al*., 2000).

Hepatoprotective activity of aqueous and petroleum ether extracts of the bark of *Diospyros cordifolia* were screened against carbon tetra chloride induced toxic hepatitis employing male wistar strains of rats as animal models. The toxic metabolite CCl₃ radical binds with the macromolecules and brings about per oxidative changes which results in the reduction of serum protein levels which was significantly increased after treating with petroleum ether and aqueous extract of *D. cordifolia* indicating the hepatoprotective efficacy of the plant drug (Krishna *et al*., 2005).

The ethanolic extract of *Adathoda vasica* was evaluated for its hepatoprotective potential in CCl₄ induced toxicity and was found to reduce the liver markers and increased the tissue protein levels. Phytochemical analysis of the plant source has shown the presence of flavanoids, tannins, alkaloids and saponins. The hepatoprotective effect may be attributed to the antioxidant effect of the flavanoids present in the plant source (Pandit *et al*., 2004).

Different doses of *Phyllanthus niruri* were tested against CCl₄ induced fatty liver in male albino rats. The fatty degeneration induced by CCl₄ has been correlated to the impaired protein synthesis and a consequent fall in the lipoprotein synthesis. Low serum albumin and high globulin concentrations were observed in the CCl₄ induced group. The alterations in the concentrations of the proteins led to marked decrease in the albumin-globulin ratio. The ratio was restored to near normal on administration of *P. niruri* extract at a dose of 100mg/100 g bw. (Chandra *et al*., 1985).

CCl₄ administration in male albino wistar rats increased the susceptibility of phospholipids to per oxidative attack leading to the enhancement of their breakdown. The combined effect of the breakdown and the impaired synthesis of the phospholipids in the liver may be responsible for the depletion of phospholipids. The treatment with the...
Review of Literature

methanolic extract of *Flaveria trinervia* reversed the changes in the lipid profile of the serum and prevented the depletion of phospholipids (Umadevi *et al*., 2004).

Administration of CCl$_4$ produced an increase in the liver weight. This is due to the infiltration of lipid to the liver causing accumulation of TGL and cholesterol causing fatty liver and thereby increasing the weight of the liver. This may be due to the blocking of secretion of hepatic triglycerides into the plasma. This phenomenon was tested with the induction of CCl$_4$ and the normalization in liver weight was observed on administration of the medicinal herb *Crassocephalum crepietiodes* (Yoko *et al*., 2005).

A significant reduction in the liver weight was observed in the group treated with *Psidium guajava* leaf extract. The study depicted a decrease in the weight of the liver, by aiding the release of TGL into the circulation and thus confirmed the hepatoprotective potentials of *P. guajava* leaf extract (Chanchal Roy *et al*., 2006).

*In vitro* and *in vivo* studies on *Tridax procumbens* have been conducted with the view of identifying a new safe common drug for CCl$_4$ induced liver diseases. Glutathione offers maximum protection to the liver against various types of injury since it is the major antioxidant and conjugation substrate to many xenobiotic. Depletion of glutathione in the CCl$_4$ treated rats decreased the capacity of the animals to detoxify CCl$_4$, which resulted in liver damage. Treatment with *T. procumbens* restored the antioxidant status of the animals by preventing free radical accumulation (Reddipalli Hemalatha, 2008).

2.2 PHYTOCONSTITUENTS AS HEPATOPROTECTIVE AGENTS

A large number of medicinal plants have been tested and found to contain active principles with curative properties against a variety of diseases. Scientific evaluation of plants has often shown that these active principles are responsible for therapeutic success. Liver protective plants contain a variety of chemical constituents like phenols, coumarins, lignans, essential oil, monoterpenes, carotenoids, glycosides, flavonoids, organic acids, lipids, alkaloids and xanthenes (Sharma *et al*., 2002). Phytoconstituents with elucidated structures or otherwise have been classified under appropriate chemical groups.

2.2.1 Phenols
Review of Literature

It has been reported that phenolic compounds from two arnica spices have been shown to be useful for treating CCl\textsubscript{4} induced toxic symptoms in rats. The activity of serum enzymes was restored and the level of SGOT was reduced by the seventh day and the activities of SGPT and alkaline phosphatase normalized. The arnica treatment also restored the bile forming function of liver and improved the secretion of cholates and bilirubin and the excretion of cholesterol (Hikino et al., 1984).

There are a number of coumarin derivatives namely 7-hydroxy, 7-s- hydroxy, 4-hydroxy, 4,7-dihydroxy and 4,7-dimethyl-5-hydroxy coumarin, coumarin-3-carboxylic acid and dicoumarol which were shown to stimulate choleresis in rats (Miwa, 1954).

2.2.2 Lignans

Silymarin obtained from the seeds of *Silybum marianum* is the most thoroughly investigated. Silymarin possess anti hepatotoxic activity. Silymarin is a mixture of isomeric flavolignans- silybin, silydianin and silychristen. The protective effect of silymarin is brought by competitively blocking the binding of phalloidin to receptors on the hepatocyte membrane surface and hindering α-amanitin to penetrate through the membrane into the cell nucleus. *In vitro* studies conducted with nuclei and nucleoli from rat liver point to another mechanism for the protective action of silymarin (Hikino et al., 1984).

2.2.3 Terpenoids

2.2.3.1 Monoterpenoids

Borneol, a bicyclic monoterpenoid, or its esters with fatty acids of dicarboxylic acids isolated from *Dryobalanops aromaticus* were reported to be cholertics (Pandy and Chaturvedi, 1970).

2.2.3.2 Sesquiterpenoids

Extracts of various samples of the crude drug prepared from the rhizomes of *Atracylodes macrophala* and was studied for hepatoprotective activity and it was observed that the major sesquiterpenoid active components atractylon, β-eudemol and hinesol exhibited significant liver protecting effect (Doreswamy and Sharma, 1995).

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Scientific validation and evaluation of hepatoprotective potential of leaf extract of *Hiptage benghalensis* (L.) Kurz
2.2.3.3 Di and Tri terpenoids

Antihepatotoxic effects of papyriogenins and their glycosides, isolated from the leaves of Tetrapanax papyriferum were studied. Papyriogenin A, papyriogenin B, papyriogenin C, propapyriogenin A, 11-dehydro propapyriogenin A, 16-episkogenin C and propapyriogenin A were the chemical constituents (triterpenoids) of this plant and were found to be responsible for its hepatoprotective action. Zygophillin, a bitter principle and quinovic acid, a triterpene compound both of which are water insoluble and isolated from Zygophyllum coccineum had anti-inflammatory and choleretic activity in experimental animals while the development of experimental cirrhosis in rats was shown to be prevented by glycyrrizin and glycyrrhetic acid, the constituents of Glycyrrhiza glabra (Valan, 2010).

2.2.4 Glycosides

2.2.4.1 Iridoid glycosides

Extracts of Picorrhiza kurroa popularly known in India as Kutaki have shown marked protective action on liver against CCl$_4$ intoxicated rats. Iridoid glycosides like picroside I and picroside II isolated from this species showed protective effects against liver intoxication of mice with CCl$_4$. A glycone of loganin and iridoid glycoside, isolated from the methanolic extract of Patrinia villosa roots showed choleretic activity. Similar activity has been observed in syringopicroside isolated from the leaves of Syringa oblata (Bonati and Mustich, 1978).

2.2.5 Saponins

The saponins of the gypsogenic series have been isolated from Dianthus superbus and D. ginseng were proved to be effective orally to decrease the elevated SGOT and SGPT levels in CCl$_4$ intoxicated rabbits (Valan, 2010).

2.2.6 Flavonoids


The flavonoids in plants such as *Colinium goggyria*, *Anemone hepatica*, *Convallaria majalis* and *Omonus arvenis* were found to have hepatoprotective activity. (Pasechnik et al., 1970).

Flavonoids like Kaempferol-3-rhamnoglucoside, Quercetin-3-rhamnoglucoside, stepposide, steppogenin-7-β-D-glucopyranoside and robidnol-3-gallate isolated from *Euphorbia stepposa* were found to have curative effect on liver. (Pasechnik et al., 1970).

*Helichrysum arenarium*, *Artemisia capillaries* and *Tageles patula* contained Flamin, quercetin, kaempferol, narringenin and isohelichrysin, eupatolin, arcapallin, capillartemisin A, capillartemisin B and patuletin that showed promising hepatoprotective activity (Pasechnik et al., 1970).

### 2.2.7 Alkaloids

Several alkaloids like berberine, colchicamine, oxycathine, berbamine, yatroricine, atropine, isoquinoline, boldine, pilocarpine, protopine and reserpine have been analyzed for their hepatoprotective activity and showed prominent choleretic activity (Quireshi et al., 1983).

### 2.2.8 Xanthines

*Theasinesis* a well known xanthine isolated from Ternstroeminaceae exhibited appreciable hepatoprotective activity in mice, rats and pigs by increasing bile secretion. Other xanthines like theophylline and atractylodin were also found to have hepatoprotective and choleretic activity (Valan, 2010).

### 2.3 PHARMACOLOGICAL POTENTIAL OF SPECIES IN MALPIGHIACEAE

The antimicrobial activity of the organic extracts from roots and stems of *Byrsonima crassifolia* has been described by Martinez-Vasquez et al., (1999) whereas Berger et al., (1998) reported the trypanocidal activity of this species. Heinrich (2003) also proved the antispasmodic activity from this plant in a fraction rich in flavonoids. Another species, *B. verbascifolia* was shown to possess antiviral activity (Lopez et al., 2001).
The family Malpighiaceae consists of about 60 genera and 1200 species of climbers, shrubs or trees native to tropical regions and well developed in South America. They are known to contain tannins, proanthocyanins, and indole alkaloids. The Malpighiaceae is the most archaic family of the polygalales and form a link between this order and the linales, but are not considered ancestral to the rest of the polygalales. A classical example of Malpighiaceae is *Malpighia glabra* (Barbados cherry) the drupes of which are palatable and well known to contain large amounts of ascorbic acid. Malpighiaceae have attracted a great deal of interest due to the indole alkaloids which are neuroactive. Thus far, these alkaloids are found in *Banisteria caapi*, *Banisteria rusbyana*, *Hiptage benghalensis* and *Tetrapteris methystica* (Finnegan, 1968).

Phytochemical investigations from *B. crassifolia*, *B. microphylla* and *B. verbascifolia* revealed the occurrence of sulphonoglycolipids, steroids, triterpenes, aromatic esters, amino acids and proanthocyanidins (Gottlieb *et al.*, 1975).

Chemical analyses of *B. verbascifolia* revealed the presence of triterpenoids in the bark and tannins, flavonoids, triterpenes, aromatic esters, naphthoquinones, and amentoflavone in the leaves (Sannomiya *et al.*, 2004), which proves that this species has a variety of phytotherapeutical components.

It has been reported that *Heteropteris aphrodisiaca* a plant endemic to the Brazilian scrubland regions, traditionally used in folk medicine as an aphrodisiac, stimulant and in the treatment of nervous weaknesses (Pott and Pott, 1994).

Mattei *et al.*, (2001) observed the antioxidant effect of *H. aphrodisiaca* extracts young and old rat brains and demonstrated that its extract reduced the oxidative stress in young and old rat brains.

Guilhon-Simplicio *et al.*, (2012) evaluated the pharmacological potential of an aqueous extract of the bark of *Byrsonima japurensis* to scientifically verify its traditional use and concluded that bark of *B. japurensis* has significant and safe anti inflammatory activity, which is closely related with their potent antioxidant activity, supporting the folk medicinal use of this species.
Byrsonima intermedia known for its antimicrobial, anti-hemorrhagic, anti-diarrheal and anti-inflammatory was studied by Orlandi et al., (2011) to evaluate the scientific basis for the traditional use of B. intermedia as an anti-inflammatory and antinociceptive agent. The study showed that the plant markedly exhibits anti-inflammatory action in rats and antinociceptive activity in mice and thus may be useful in the treatment of inflammatory hyperalgesic disorders, which supports previous claims of its traditional use.

An ethnopharmacological study on the leaves of B. intermedia, a medicinal species commonly found in the Brazilian Cerrado revealed that the plant leaves had gastroprotective, healing and antidiarrheal activities and can be used against gastroduodenal disorders, such as gastric ulcers and diarrhoea (Santos et al., 2012).

Herrera-Ruiz et al., (2011) evaluated the anticonvulsant, antidepressant, sedative effects produced by the extracts of B. crassifolia and their influence on motor activity in ICR mice and reported that the methanolic extract of B. crassifolia produced a significant (p<0.05) antidepressant effect in the forced swimming test in mice at 500 mg/kg bw. dose but did not possess, sedative, or anticonvulsant properties, and did not cause a reduction of mice locomotion(p>0.05). He suggested that flavonoids, such as rutin, quercetin and hesperidin isolated from the plant may be involved in the antidepressant effects.

A study on the anti Helicobacter pylori activity of extracts from B. crassa and its effects on reactive oxygen/nitrogen intermediates induction by murine peritoneal macrophages was carried out and the results indicated that the methanolic and chloroformic extracts inhibited, in vitro, the growth of H. pylori with a MIC value of 1024 μg/ml. The methanol extract induced the production of hydrogen peroxide (H₂O₂) and nitric oxide (NO), but the chloroform extract produced only nitric oxide (Cibele Bonacorsi et al., 2009).

The antioxidant activities of different solvent extracts of the leaves of Flabellaria paniculata were screened by different methods using free radical scavenging against DPPH and hydroxyl radicals, ex vivo lipid peroxidation, ferrous ion chelating activity, reducing power and total antioxidant capacity in phosphomolybedum assay. The extracts
Review of Literature

(10 to 100 μg/ml) showed varying degrees of antioxidant activity in different test systems. The leaves and root extracts showed significant inhibition of lipid peroxidation and scavenging of hydroxyl radicals exhibiting their antioxidant capability (Margaret et al., 2000).

2.4 PHARMACOLOGICAL POTENTIALS OF Hiptage benghalensis

Ornamental plants like Mimusops elengi, Madhuca indica, Hiptage benghalensis and Polyalthia longifolia have been analyzed for their furfural contents by colorimetric spectrophotometry after hydrolysis in 13 % HCl and extraction with 50 % ethanol and the results revealed that the furfural concentration in these plants was in the range of 3.9 - 10.3 % indicating the potential of these plants as good source of pentosans and furfural. Many furfural derivatives have been used as pharmaceuticals, fungicides and herbicides (Sattar et al., 2007).

An investigation on the ethanol and aqueous extract of H. benghalensis showed the presence of carbohydrate, proteins, amino acids, saponins, tannins, phenolic compounds and flavonoids in acetone extracts. Carbohydrates, proteins, amino acids, saponins, tannins, glycosides, phenolic compounds and flavonoids in ethanol extract and carbohydrates, proteins, amino acids, saponins, tannins, glycosides, phenolic compounds and flavonoids in aqueous extract (Kumudhavalli et al., 2009).

The LD50 determination for the extracts of H. benghalensis was done in mice by OECD guidelines and LD50 value of the ethanolic and aqueous extract was found to be 2000 mg/kg bw. and the ED50 was calculated as 200 mg/kg bw. (Kulkarni et al., 1986).

The anti-inflammatory activity of the ethanolic and aqueous leaf extracts of H. benghalensis (200mg/kg bw.) was evaluated against the carrageenan induced paw edema of rats were compared with the standard drug Diclofenac sodium and the edema suppressant effect of ethanol extract was found to be 66.66% whereas aqueous extract was found to be 60% which was nearly equivalent to that of 10kg/mg bw. of Diclofenac sodium. The Compound 2 (3,4dihydroxyphenyl) -3 (4,6dihydroxy- 3methoxy tetra hydro-2H-pyran-2carbaldehyde) -5hydroxy, 7methoxy-4H-chromen-4one were isolated and
might be responsible for the pharmacological activities of *H. benghalensis* (Kumudhavalli *et al*., 2009).

Jonville *et al*., (2010) studied the anti-inflammatory activity of *H. benghalensis* and the results showed that the DCM leaf extract showed promising nitric oxide inhibitory activity (IC50 =38 g/ml) indicating the anti-inflammatory potency of this plant.

The antioxidant potential of methanolic extracts of the leaves of *Caesalpinia coriaria*, *Flacourtia cataphracta*, *Hiptage benghalensis*, *Sesbania sesban*, *Persea macrophylla* and tubers of *Gloriosa superba* was studied using phospho-molybdenum antioxidant assay and free radical scavenging assay (DPPH). A positive correlation was seen between the phenolic content and total antioxidant activity of the different plant extracts while *H. benghalensis* showed a prominent antioxidant activity over other extracts (Amudha and Shanthi, 2011).

Phytochemicals from the leaves and bark of *Bauhinia purpurea* and *H. benghalensis* were extracted using different solvents of various polarities such as petroleum ether, chloroform, acetone, methanol and water. The methanol extract of leaf and bark of *H. benghalensis* revealed the presence of alkaloids, anthraquinones, catechin, coumarin, flavonoids, phenols, steroids, tannins, terpenoids and xanthoprotein. Petroleum ether extract of *H. benghalensis* leaf showed antibacterial activity against *S. aureus*, *B. subtilis*, *P. aeruginosa* and *S. typhi*; whereas, bark extract showed activity against *K. pneumoniae*, *E. coli* and *S. typhi*. Chloroform extract of leaf of *H. benghalensis* exhibited antibacterial activity against *S. aureus*, *K. pneumoniae*, *E. coli*, *P. aeruginosa* and *S. typhi*, whereas, bark extract did not inhibit the growth of *B. subtilis* and *P. aeruginosa*. Acetone extract of leaf showed the activity against all the tested pathogenic bacteria except *B. subtilis*, whereas, bark extract did not inhibit the growth of *S. aureus*, and *E. coli*. Methanol extracts of leaf and bark of *H. benghalensis* exhibited activity against all the tested pathogenic bacteria. Chloroform extract of leaf of *H. benghalensis* showed the maximum inhibition zone against *E. coli* (Murugan and Mohan, 2011).

Chenthurpandy *et al*., (2009) investigated the pharmacognostical, physico-chemical and phytochemical properties of *H. benghalensis*. Various parameters like
Review of Literature

Microscopy, physicochemical, fluorescence analyses and phytochemical profile for leaf part was studied and the salient diagnostic features were documented to align with the WHO guidelines for herbal drug standardization.

The stems of the plant *H. benghalensis* was extracted by hot percolation and subjected to antidiabetic activity. The acute oral toxicity studies followed by OECD guidelines fixed dose procedure, showed that ethanolic extract up to 2000 mg/kg bw. are non toxic and safe. On the basis of pharmacological studies 200 mg /kg bw. of extract of stems of the *H. benghalensis* exhibited significant antidiabetic activity than the lower dose level with standard drug as glebinclamide. The antidiabetic activity of the plant has been further confirmed by biochemical parameters and histopathological studies. The phytochemical studies revealed the presence of phenols, tannins, flavonoids, steroids and triterpenoids. These components may be responsible for the antidiabetic activity (Janorious winka *et al.*, 2012).

An anti-asthmatic activity of *H. benghalensis* leaves was studied on total leukocytes counts (TLC) and differential leukocyte counts (DLC) using bronchoalveolar lavaged (BAL) fluid of guinea pigs sensitized by egg albumin and PAF acether and the results showed that treatment with *H. benghalensis* for 15 days resulted in significant decrease in total leukocytes count (TLC) as well as differential leukocytes count (DLC) in BAL fluid of guinea pigs sensitized by egg albumin and PAF acether. It was comparable to standard drug ketotifen fumarate (Biren Shah *et al.*, 2012).

The methanolic extract of leaves of *H. benghalensis* (MEHB) was screened for the analgesic (using hot plate test and acetic acid-induced writhing test in mice) and anti-inflammatory (using rat paw edema test) activity at the doses of 200 and 400 mg/kg bw. A significant (p≤0.0005) analgesic effect was observed with 200 mg/kg bw. and 400 mg/kg bw. in both tests. The maximum anti-inflammatory response was produced at 3 hr. and 2 hr. with MEHB doses of 200 and 400 mg/kg bw. respectively. These results suggest that the methanolic extract of *H.benghalensis* has exhibited significant analgesic and anti-inflammatory effects, which were comparable with standard drugs (Baburao Bhukya *et al.*, 2009).

It has been reported that in Burma, the leaves of *H. benghalensis* are used to treat skin diseases. In Indonesia, the bark is used to heal wounds. In India, the leaves of *H.*
Review of Literature

*H. benghalensis* is used to treat cough, asthma, leprosy, to heal and to quench thirst (Finnegan, 1968).

A study was conducted to evaluate hepatoprotective activity of methanolic extract of *H. benghalensis* (MEHB) in rats. Hepatic damage was induced by administration of carbontetrachloride (1 ml/kg, bw.) in combination with liquid paraffin (1:1) as a single dose on 7th day. The extent of liver damage was studied by estimating biochemical parameters. Administration of MEHB (200 mg & 400 mg/kg bw.) for 6 days before carbontetrachloride administration showed a significant reduction ($p \leq 0.01$) of serum liver damage enzymes markers-aspartate transaminase, alanine transaminase, total bilirubin and alkaline phosphatase (ALP). Histopathological changes of hepatic tissue were observed to revert to normalcy in MEHB treated groups. Results also indicated that MEHB possessed potential antioxidant effect by increasing the levels of glutathione and also possessed free radical scavenging activities. The hepatoprotective effect of *H. benghalensis* was comparable to standard drug silymarin (50 mg/kg bw.) (Maheshwari et.al., 2012).

In a study conducted on a list of 20 endangered medicinal plants to analyze their phytochemical constituents and evaluate their antihepatotoxic potential, *Hiptage benghalensis* was one of the plant enlisted to possess hepatoprotective activity that needs to be further explored and standardized (Handa *et al.*, 1986).

Scientific validation and evaluation of hepatoprotective potential of leaf extract of *Hiptage benghalensis* (L.) Kurz
The pharmacological potentials of *H. benghalensis* still remain unexplored, but one might set the hypothesis that the above mentioned uses can be attributed to the presence of mangiferin, which is known to be anti-inflammatory, hepatoprotective, antioxidant and antimicrobial (Shibnath, 1996)

The above reviews illustrate various pharmacological activities of the Malpighiaceae family and the species *H. benghalensis*, however the hepatoprotective potentials of *H. benghalensis* still remain unexplored which has prompted the selection of this plant to screen and validate its hepatoprotective activity against CCl₄ induced hepatic damage.