2. REVIEW OF LITERATURE

Mahalingam Gayathri et al. evaluated antidiabetic and ameliorative potential of Ficus benghalensis bark extract in streptozotocin induced diabetic rats. The long term use of FB bark aqueous extract at a dose of 500 mg/kg b.w per day for better control of blood glucose and restoration of diabetes associated changes.

The antioxidant effect of aqueous extract of the bark of FB has been evaluated in hypercholesterolaemic rabbits. The water extracts of the bark of Ficus benghalensis at a dose of 50 mg/kg body weight per day in addition to cholesterol suspended in oil. There results show that the water extract of the bark of Ficus benghalensis has significant antioxidant effect, in addition to hypolipidaemic effect.

The antimicrobial potential of extracts of FB aerial roots was studied on three different non-pathogenic bacterial strains. Three different concentrations (25, 50 and 75 mg/ml) of aqueous and hexane aerial roots extracts showed sustained activity against all the bacterial strains.

Venkatesh et al. performed hepatoprotective activity of Ficus carica linn. Leaves extract against carbon tetrachloride-induced hepatotoxicity. The methanol extract of the leaves of Ficus carica Linn. (Moraceae) was evaluated for hepatoprotective activity in rats with liver damage induced by carbon tetrachloride. The extract at an oral dose of 500 mg/kg exhibited a significant protective effect by lowering the serum levels of aspartate aminotransferase, alanine aminotransferase, total serum bilirubin, and malondialdehyde equivalent, an index of lipid peroxidation of the liver.

Hepatoprotective activity of Annona squamosa Linn on experimental animal model done by Mohamed Saleem et al. the extracts of Annona squamosa were not
able to revert completely hepatic injury induced by INH + RIF, but it could limit the
effect of INH + RIF to the extent of necrosis. As the two extracts EEAS and AEAS
produced same effect it is concluded that there is no difference in the extract
treatment.

Antioxidant and antibacterial activities of *Ficus microcarpa* L fil has been
performed by *Shinkichi Tawata et al.* 27. The methanol extracts of bark, fruits and
leaves of *Ficus microcarpa* exhibited excellent antioxidant activities and also possessed
antibacterial activity against tested Gram-positive and Gram-negative bacteria. Ethyl acetate fraction of bark extract (BE) exerted strong antioxidant and antibacterial effects and contained high amount of total phenolics (436 GAE mg/g extract).

*Manian et al.* 28 studied the antioxidant activity and free radical scavenging
potential of two different solvent extracts of *Camellia sinensis* (L.) O. Kuntz, *Ficus benghalensis* L. and *Ficus racemosa* L. The methanol and 70% acetone (acetone: water, 70:30) extracts of *Ficus benghalensis* (aerial roots) and *Ficus racemosa* (stem bark) were evaluated for their antioxidant activity and radical scavenging capacity in comparison with *Camellia sinensis* (L.) O. Kuntz (green tea). Methanol extracts of green tea and *Ficus benghalensis* and 70% acetone extract of *Ficus racemosa* contained relatively higher levels of total phenolics than the other extracts.

Effect of variable doses of aqueous extract of *Ficus benghalensis* aerial roots on
blood glucose level (BGL) of normal, sub and mild-diabetic models have been studied
and the results were compared with the reference drug Glipizide and elemental Mg\textsuperscript{2+} and Ca\textsuperscript{2+} intake as glycemic elements.29

Administration of aqueous extract of *Ficus religiosa* at a dose of 100 and
200mg/kg orally decreased the fasting blood glucose induced type 2 diabetic rats. The
drug had enzyme induction effect with respect to catalase and glutathione peroxidase activity. *Ficus religiosa* group of plant drug having anti-diabetic activity along with antioxidant potential was beneficial in treatment of type 2 diabetics.30

**Vikas V Patil et al.**31 reviewed *Ficus benghalensis* linn. In traditional system of medicine various plant parts such as stem bark, roots bark aerial roots, vegetative buds, leaves, fruits and latex are used in dysentery, diarrhoea, diabetes leucorrhoea, menorrhagia, nervous disorders, tonic and astringent. According to Ayurvedic system of medicine *Ficus benghalensis* Linn (Banyan tree) is well known to be useful in diabetes. The present review is therefore, an effort to give a detailed survey of the literature on its Pharmacognosy, phytochemistry, traditional and pharmacological uses.


**Baby joseph et al.**33 reviewed the phytopharmacological and phytochemical properties of three *Ficus* species, namely *Ficus racemosa, Ficus religiosa* and *Ficus benghalensis*, are important ingredients in many Ayurvedic and traditional formulations. The barks, leaves, fruits and latex are considered to be very effective in various treatments, such as diabetes, skin diseases, ulcers, dysentery, diarrhohea,
stomach ache, piles and as carminative, astringent, anti inflammatory, antioxidant and anticancer agent.

Kubsad Parameshwarappa et al.\textsuperscript{34} evaluated antioxidant and hepatoprotective properties of \textit{Ficus glomerata} extracts. The methanol extract of the bark of \textit{Ficus glomerata} showed potent \textit{in vitro} antioxidant activity when compared to the roots methanol extract. In the \textit{in vivo} studies, the CCl\textsubscript{4} treated control rats showed a significant alteration in the levels of antioxidant and hepatoprotective parameters. The methanol extract of the bark when given orally along with CCl\textsubscript{4} at the doses of 250 and 500 mg/kg body weight showed a significant reversal of these biochemical changes towards the normal when compared to CCl\textsubscript{4} treated control rats in serum, liver and kidney. The results were comparable to those observed for standard sylimarin. Histological studies also confirmed the same. The results indicated the potent hepatoprotective and antioxidant nature of the bark extract.

Gabha et al.\textsuperscript{35} studied the potential immunomodulatory activity of various extracts of the aerial roots of \textit{Ficus benghalensis} by using \textit{in vitro} polymorphonuclear leucocyte (human neutrophils) function test. The methanol extract was evaluated for immunomodulatory activity in in vivo studies, using rats as the animal model. The extracts were tested for hypersensitivity and hemagglutination reactions, using sheep red blood cells (SRBC) as the antigen. Distilled water served as a control in all the tests. The methanolic extract shows significant immunoodulatory activity.

Gond et al.\textsuperscript{36} performed hepatoprotective activity of \textit{Ficus} carica leaves extract on rifampicin-induced hepatic damage in rats. \textit{Ficus} carica were extracted using pet.ether and testes for antihepatotoxic activity on rats treated with 50mg/kg of rifampicin orally. The parameters assessed were serum levels, liver weight and pentobarbitone sleeping time as a functional parameter were also monitored. There
was significant reversal of biochemical, histological and functional changes induced by rifampicin treatment in rats by pet ether extract treatment.

Anthelmintic activity of *Ficus benghalensis* performed by Manoj aswer et al. In this study methanolic, aqueous, chloroform and pet ether extract were studied for paralysis and death of earth worm. All the extract was found not only to paralysis (vermifuge) but also to kill the earthworms (vermicidal).

Anti-inflammatory activity of *Ficus deltoidea* was studied by using three different *in-vitro* assays like lipoxygenase, hyaluronidase and TPA-induced oedema. The results of this study indicate that extracts of leaves of *Ficus deltoidea* possess anti-inflammatory properties might be due to presence of active principles vitexin and iso-vitexin.

Zafar Iqbal et al. studied the *in-vitro Anthelmintic Activity of Allium sativum, Zingiber officinale, Curcurbita mexicana and Ficus religiosa*. Results revealed that *Zingiber officinale* killed all the test worms (*Haemonchus contortus*) within two h post exposure being 100% effective. *Ficus religiosa* was 100 % effective by 4 h post exposure, and was as good as *A. sativum* and *Z. officinale* by 6 h post exposure. Majority of the worms exposed to control (normal saline) remained alive till 4 h post exposure, and thereafter, 50 % of them died by 6 h post exposure.

Antidiabetic potential of alcoholic and aqueous extracts of *Ficus racemosa* linn. Bark in normal and alloxan induced diabetic rats done by Nikhil K.Sachan et al. Alcoholic and aqueous extract of bark of *Ficus racemosa* at a dose of 400 mg/kg was given to normal and alloxan induced diabetic rats and the blood sample taken from the retero orbital plexus vein were analyzed for blood glucose level. Aqueous and
alcoholic extract of *Ficus* racemosa reduce the glucose level to 27.01 and 45.03 % respectively.

Mast cell stabilizing and anti-Inflammatory activity of *Ficus benghalensis* L. Bark was performed by Dnyaneshwar *et al.* 41 and also they studied antiasthmatic activity by various extracts of *Ficus benghalensis* bark using clonidine induced mast cell degranulation in mice and carrageenan induced paw edema in rats. In clonidine induced mast cell degranulation, aqueous extract (74.0 ± 1.1), ethyl acetate extract (64.0 ± 1.5) and methanol extract (65.3 ± 1.8) significantly protect mast cell from degranulation while chloroform and pet.ether extract fails to show statistical significance.

Hypoglycemic activity of *Ficus hispida* (bark) in normal and diabetic albino rats was performed by Ghosh *et al.* 42. Water-soluble portion of the ethanol extract of *Ficus hispida* bark 1.25 g/kg Standard antidiabetic drugs, glibenclamide (0.5 mg/kg) administrate to diabetic albino rat. Blood glucose was estimated by the glucose oxidase method in both normal and alloxan-induced diabetic rats before and 2 h after the administration of drugs. *Ficus hispida* has significant hypoglycemic activity. Increased glycogenesis and enhanced peripheral uptake of glucose are the probable mechanisms involved in its hypoglycemic activity.

Analgesic and Antipyretic Activities of *Ficus benghalensis* Bark done by Vikas *et al.* 43 the preliminary Phytochemical screening of the various extracts showed the presence of flavonoids, alkaloids, triterpenoids, tannins, saponins and steroids. The ethanolic extract was similar to aspirin (p<0.001) while the pet ether, chloroform, and water were weaker than the aspirin in analgesic as well as antipyretic activity. The higher analgesic effects of various extracts tested might back to the presence of
flavonoids and phenolic compounds. The various extracts produced a significant inhibition of temperature elevation.

The anti-ulcer activity and acute toxicity of *Ficus arnottiana* leaves methanolic extract for the first time. Wistar rats were orally administered with different doses of the extract with the reference drug omeprazole for 10 days. It is clear that *Ficus arnottiana* leaves extract had significant anti-ulcer activity in animal models. It had muco protective activity and gastric anti secretory activity. The extract is non-toxic even at relatively high concentrations confirmed by Marslin Gregory et al. 44

A comparative evaluation of anti-inflammatory activity of the bark of *Ficus benghalensis* in plants of different age were evaluated by rat paw edema model induced by carrageenan for acute inflammation and cotton pellet granuloma model for chronic inflammation. Indomethacin was used as a standard drug. The ethanolic extract of younger plant showed a greater anti-inflammatory effect compared with the standard drug indomethacin Vikas V Patil et al. 45

Natural rubbers was identified for the first time from the latex of *Ficus benghalensis* by Hunseung Kanga et al. 46 and the rubber biosynthetic activity in latex and rubber particles was investigated. The rubber content in the latex of *Ficus benghalensis* was approximately 17%. Gel permeation chromatography revealed that the molecular mass of the natural rubber from *Ficus benghalensis* was approximately 1500 kDa. The high rubber content and large molecular size suggest that *Ficus benghalensis* is a good candidate for an alternative rubber source.

Kallappa et al. 47 determined *Ficus benghalensis* is a rich source of oil containing unusual fatty acids which could be used for industrial utilization. *Ficus benghalensis* seed oil is found to contain vernolic acid (8.2 %), malvalic acid (3.7 %)
and sterculic acid (1.6 %) along with the other normal fatty acids like lauric acid (1.5 %), myristic acid (1.3 %), palmitic acid (35.2 %), stearic acid (4.2 %), oleic acid (20.3 %), linoleic acid (15.4 %) and linolenic acid (8.7%). Vernolic, malvalic, sterculic and other normal fatty acids have been identified and characterized by UV, FTIR, 1H NMR, MS, TLC, GLC-techniques and chemical degradations.

*In-vitro* antimicrobial activity of four *Ficus carica* latex against human pathogens was performed by Houda lazreg aref et al. Methanolic, hexanoic, chloroformic and ethyl acetate extracts of *Ficus carica* latex were investigated for their *in vitro* antimicrobial proprieties against five bacteria species and seven strains of fungi was evaluated and based respectively on the inhibition zone using the disc – diffusion assay, minimal inhibition concentration (MIC) for bacterial testing. The methanolic extract had no effect against bacteria except for *Proteus mirabilis* while the ethyl acetate extract had inhibition effect on the multiplication of five bacteria species (*Enterococcus fecalis, Citobacter freundei, Pseudomonas aeruginosa, Echerchia coli* and *Proteus mirabilis*).

Temporal and seasonal variations of polycyclic aromatic hydrocarbons (PAHs) concentrations in leaves of *Ficus benghalensis* were investigated in Varanasi city (India). Leaves samples were collected from six sites from urban area of Varanasi and from a control site performed by Santosh Kumar Prajapati et al. PAH extraction was done by sonication in dichloromethane-acetone and quantification by GC-MS. These results support biomonitoring ability of *Ficus benghalensis* leaves to temporal variations in PAHs contamination.

Damanpreet Singha et al. Anticonvulsant activity of figs extract (25, 50 and 100 mg/kg, i.p.) was studied in seizures induced by maximum electro shock (MES), picrotoxin and pentylenetetrazol. Effect of extract on pentobarbitone induced sleep
time also studied. Extract showed no toxicity, potentiated pentobarbitone induced sleep and inhibited seizures induced by MES and picrotoxin in a dose dependent manner. These findings suggested that the methanolic extract of figs of *Ficus religiosa* had anticonvulsant activity.

In order to unveil the reasons behind the successful survival of *Ficus religiosa* L. grown under normal and adverse habitats (AH), i.e., on concrete roof tops were subjected to biochemical, histochemical and physiological studies with a focus on reactive oxygen species (ROS) and oxidative stress enzymes (OSE). The specific objectives were: to localize the OSE, peroxidase and catalase; to localize and quantify the main ROS, hydrogen peroxide; to estimate the activities of POX, CAT and glycolate oxidase; and to study the diurnal variations in stomatal activity by scanning electron microscopy (SEM).51

*Rathish et al.*,52 performed antibacterial activities of ten medicinal plants of the western region of India, namely *Commiphora wightii*, *Hibiscus cannabinus*, *Anethum gravelons*, *Emblica officinalis*, *Ficus religiosa*, *Ficus racemosa*, *Ficus benghalensis*, *Ficus tisela*, *Mentha arvensis* and *Mimusops elengi*. These plants were screened for potential antibacterial activity against medically important bacterial strains. The antibacterial activity was determined in aqueous and ethanol extracts using both agar disc diffusion and agar well diffusion methods.

Antidiabetic effect of *Ficus benghalensis* aerial roots in experimental animals was done by *Singh et al.*,53 The hypoglycemic effect in normoglycemic and antidiabetic effect in sub- and mild-diabetic models of aqueous extract of aerial roots of *Ficus benghalensis* are due to the presence of these glycemic elements in high concentration with respect to other element.
Victor Kuetea et al.\textsuperscript{54} performed antimicrobial activity of the crude extract, fractions and compounds from stem bark of \textit{Ficus ovata} (Moraceae). The antimicrobial activities of the methanol extracts from the stem bark of \textit{Ficus ovata}, fractions (FOB1–6) and compounds isolated following bio-guided fractionation [3-friedelanone (1), taraxeryl acetate (2), betulinic acid (3), oleanoic acid (4), 2-hydroxyisoprunetin (5), 6, 7-(2-isopropenyl furo)-5, 2, 4-trihydroxyisoflavone (6), Cajanin (7) and protocatechuic acid (8)].

A novel antimicrobial triterpenic acid from the leaves of \textit{Ficus benjamina} (var. comosa) has been identified and its antibacterial activity was confirmed. The chloroform extract of the leaves of \textit{Ficus benjamina} (Moraceae) afforded a new triterpenic acid named as (9,11), (18,19)-disecoolean-12-en-28-oic acid (1) along with bamyrin (2). Their structures were established on the basis of chemical and physical evidences (IR, \textsuperscript{1}H NMR, and MS data).\textsuperscript{55}

An ancient and modern source for ethno pharmacological uses of \textit{Ficus} (fig) species, specifically for employment against malignant disease and inflammation. Chemical groups and compounds underlying the anticancer and anti-inflammatory actions, the relationship of fig wasps and fig botany, extraction and storage of fig latex, and traditional methods of preparing fig medicaments including fig lye, fig wine and medicinal poultices was reviewed by Ephraim Philip Lansky et al.\textsuperscript{56}

Flavonoids are found to have antioxidant, anti-allergenic, and anti-inflammatory effects. Abida Taskeen et al.\textsuperscript{57} isolated flavonoids from two different \textit{Ficus specis}. Kaempferol, rhamnetin, myricetin, isorhamnetin and quercetin were used as standards. Results showed that quercetin was most abundant flavonol present and it was extracted in diethyl ether layer after fractionation.
Mohamed Sharaf et al. Exudate flavonoids from *Ficus altissima*. *Ficus* species were investigated for their surface flavonoids. Dried plant materials were briefly rinsed with 70% EtOH. The chromatographic tests of the four extracts indicated that only one ethanol rinse contained methylated flavonoids as aglycones high Rf values in BAW (n-butanol: acetic acid: water (BAW, 4: 1: 5, upper layer) and dark absorbance in UV light]. The injection temperature was 250°C using DB-5 column (5% phenyl) methyl polysiloxane, 30 m, I.D. 25 mm; helium was the carrier gas, with programmable temp. 503, 3 min; 503003, 53/min, 50 min; 3003, 15 min. The mass spectra were recorded in EI mode at 70 eV. The repetition rate was 0.5 scan over a mass range of 40-500 amu.

Volatile compounds from extracts of figs of *Ficus carica* extracts from receptive figs of both sexes are characterised by benzyl alcohol, linalool and linalool oxides (furanoid), cinnamic aldehyde, cinnamic alcohol and indole. Extract from female receptive figs has in addition large amounts of pyranoid (linalool oxides), whereas an extract from male receptive figs contains eugenol and an unidentified sesquiterpene hydrocarbon. Differences between extracts from male and female figs appear to be mainly qualitative due to pyranoid compounds, sesquiterpenes 1, 2 and 3 for female figs and eugenol and sesquiterpene 5 for male. 59

Isoprene emission from tropical tree species Foliar emission of isoprene was measured in nine commonly growing tree species of Delhi, India performed Padhy et al. Dynamic flow enclosure technique was used and gas samples were collected onto Tenax-GC/Carboseive cartridges, which were then attached to the sample injection system in the gas chromatography (GC). Eluting compounds were analysed using a flame ionisation detector (FID). Out of the nine tree species, isoprene emission was found in six species (Eucalyptus sp., *Ficus benghalensis*, *Ficus religiosa*. in this study
on the annual biogenic VOC emission from India may probably be the first of its kind from this part of the world.

**Pateh et al.** isolated stigmasterol, B-Sitosterol And 2-Hydroxyhexadecanoic Acid Methyl Ester From The Rhizomes of *Stylochiton lancifolius* Pyer and Kotchy (Araceae) Phytochemical screening of the rhizome of *Stylochiton lancifolius* Kotschy and Peyr (Araceae) revealed the presence of steroids/triterpenes, saponins, fatty acids and tannins. Extensive Phytochemical investigation of the petroleum ether extract of the rhizome afforded white crystalline mixture of β-sitosterol, stigmasterol and 2-hydroxy hexadecanoic acid methyl ester which were identified by IR, 1HNMR, 13CNMR and FABS-MS. The compounds are reported for the first time from this plant.

**Sudhamalla et al.** carried out Molecular dynamics simulation and binding studies of beta-sitosterol with human serum albumin and its biological relevance. Beta-sitosterol is a naturally occurring phytosterol that is widely used to cure atherosclerosis, diabetes, cancer, and inflammation and is also an antioxidant. Molecular docking studies revealed that the beta-sitosterol can bind in the large hydrophobic cavity of subdomain IIA, mainly by the hydrophobic interaction but also by hydrogen bond interactions between the hydroxyl (OH) group of carbon-3 of beta-sitosterol to Arg(257), Ser(287), and Ala(261) of HSA, with hydrogen bond distances of 1.9, 2.4, and 2.2 Å, respectively.

**Singh et al.** isolated alpha amyrin acetate (alpha-AA) from the aerial roots of the *Ficus benghalensis* and its anti-diabetic activity was studied by using normal and diabetic rats.

The *Ficus benghalensis* leaves extract showed highest percentage of inhibitory effects on seed germination, shoot and roots length in *Ipomoea pentaphylla*, when
compared with the bark extract in bioassay treatment. The GC analysis of phenolic acid in *Ficus benghalensis* leaves and bark extract result revealed that the total and individual phenolic content is more in leaves than the bark extract.\textsuperscript{64}

&Srivastav\textit{s et al.}\textsuperscript{65} studied comparative evaluation of hepatoprotective activity of leaves and stems of *Ficus benghalensis*. Hepatoprotective activity was carried out by CCl\textsubscript{4} induced hepatotoxicity model respectively at 100 and 200 mg/kg doses. Finally they concluded that the stem was more potent hepatoprotective activity than leaves of *Ficus benghalensis*.

&Manisha \textit{et al.}\textsuperscript{66} evaluated the hepatoprotective potentials of the ethanolic extract of the *Ficus benghalensis* Linn. leaves against carbon tetrachloride (CCl\textsubscript{4}) and ethanol -induced liver damage in rats. Treatment with the ethanolic extract of *Ficus benghalensis* (EEFB) 100,200 and 400 mg/kg ameliorated the effects of the hepatotoxins and significantly ($P<0.05$) reduced the elevated levels of the biochemical marker enzymes.

&Mathew \textit{et al.}\textsuperscript{67} studied Hypolipidaemic effect of leucodelphinidin derivative from *Ficus benghalensis* Linn. on cholesterol fed rats. Administration of leucodelphinidin derivative isolated from the bark of *Ficus benghalensis* and another flavonoid quercetin (100 mg/kg/day) in hypercholesterolemic rats provoked significant reduction in serum total cholesterol, LDL-cholesterol and an increase in the HDL-cholesterol levels. The study demonstrated that the flavonoids exerted their hypocholesterolemic effects by increasing fecal bile acids and cholesterol excretion. Acute toxicity studies with the leucodelphinidin derivative showed no toxic reactions up to a dose of 4 g/kg dose level.
Pharmacognostical parameters for the leaves of *Ficus benghalensis* were studied with the aim of drawing the pharmacopoeial standards for this species: macroscopical and microscopical characters, physio-chemical constants, extractive values with different solvents. Preliminary phytochemical studies on the *Ficus benghalensis* leaves were conducted. The ethanolic and petroleum ether extracts of *Ficus benghalensis*, significantly reduced (P<0.05) carrageenan-induced paw edema in rats. The ethanolic and petroleum ether extracts showed a greater anti-inflammatory effect compared with the standard drug Indomethacin. The present results indicated the ethanolic extract of *Ficus benghalensis* exhibited more significant activity than petroleum ether in the treatment of inflammation researched by Patil *et al.*

Based on the literature survey it has been found that the selected plant of *Ficus* species (aerial roots of *Ficus benghalensis* and Leaves of Ficus religiosa) possesses various pharmacological activities. The hepatoprotective effect of bark, stem and leaves of *Ficus benghalensis* and bark of *Ficus religiosa* has been well documented by using CCl₄ induced hepatotoxicity. Till date no one reported the hepatoprotective activity of these plants with respective parts (aerial roots and leaves). So, the present research was designed to evaluate the hepatoprotective activity aerial roots of *Ficus benghalensis* and Leaves of *Ficus religiosa* in oxidative stress induced hepatotoxicity to bring the novel hepatoprotective herbal drugs.