A review of pharmacognostic, physicochemical, phytochemical and pharmacological studies on Ficus bengalensis L.

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Abstract

Since the birth of humans on this planet, plants have been utilized for diagnosis, treatment and prevention of various ailments. Ficus bengalensis L., belonging to family Moraceae, commonly known as Banyan tree, is one the most utilized plants. It is a very large tree with spreading branches bearing multiple aerial roots hanging downward. In traditional systems of medicines, various plant parts such as stem bark, aerial roots, vegetative buds, leaves, fruits and latex are used in diabetes, dysentery, seminal weakness, menorrhagia, leucorrhoea, erysipelas, nervous disorders, burning sensation, hemorrhages and applied topically on pimples, abscesses, wounds, ulcers, sores, cracked soles of the feet and rheumatic inflammations. Pharmacognostic studies have been done to set its quality control parameters and various phytochemicals viz. phytosterols, anthocyanin derivatives, fatty acids, amino acids, polysaccharides, flavonoids, flavonols, leucoanthocyanidins and triterpenoids have been identified and isolated. This plant is reported to possess many useful pharmacological activities also viz. antihyperglycemic, antidiabetic, Antihyperlipidemic, hypocholesterolemic, anti-inflammatory, analgesic, antibacterial, antifungal, larvicidal, anti-diarrhoeal, antimitogenic, antioxidant, hepatoprotective, anti-arthritis, anti-allergic and immunostimulatory. The present review is an effort to give a detailed survey of the literature on its ethnomedical uses, pharmacognosy, physicochemical parameters, phytochemistry, pharmacological studies and other commercial uses.

Keywords: Ficus bengalensis, Banyan tree, Bargad, Bohar.

INTRODUCTION

Plants are the oldest and the most important source of medicines [1]. At the end of nineteenth century, after synthesis of aspirin, research on herbal products was halted and researchers started focusing on synthetic and semi-synthetic drugs. But from last few decades, there is an upsurge in the use and research of natural origin, especially botanical drugs. About 25% of the prescribed drugs are derived from higher plants and this value is increased to 50%, if animal and microbial products are also included [2].

Ficus bengalensis L., belonging to family Moraceae, is commonly known as Banyan tree (English), Darakht-e-Reesh and Bargad (Unani medicines) and Bohar (Urdu) [3, 4]. It is native to a wide area of Asia i.e. India, Burma, Southeast Asia, Southern China, Thailand, and Malaysia. The tree is cultivated in botanical gardens and parks throughout the tropical regions of the world [5]. Many pharmacological activities and useful phytoconstituents of this plant have been reported. Besides other useful chemical constituents, the tree also contains a high amount of good quality natural rubber [6]. Brief taxonomic information about F. bengalensis is;

Kingdom: Plantae; Phylum: Tracheophyta; Class: Magnoliopsida; Order: Rosales; Family: Moraceae; Genus: Ficus; Species: bengalensis [7]. Various stages of the plant are shown in figure 1.

![Ficus bengalensis stages](image1.jpg)

Figure 1: Ficus bengalensis: a) mature tree; b) leaf and leaf primordium; c) aerial roots; d) fruits
Uses in traditional medicine systems

The plant has been extensively used in Ayurvedic and Unani medicines to treat various health problems. Infusion of the bark is used in dysentery, diabetes, seminal weakness, menorrhagia, leucorrhoea, erysipelas, nervous disorders and burning sensation. Decoction of the buds in milk is given in hemorrhages. Aerial roots are antiemetic and also applied topically to pimples. A paste of the leaves or milky juice is applied topically to abscesses and wounds for promoting suppuration. Milky juice and seeds are applied topically to ulcers, sores and rheumatic inflammations. Young stem is used as tooth brush (miswak) and stem latex is applied topically to cracked soles of the feet. Latex from aerial parts of plant mixed with honey is used orally to control hyperglycemia in Pakistan.

Morphology of the plant

*F. bengalensis* is a lati c ferous tree, up to 30 m in height with widely spreading branches bearing many aerial prop roots. Bark is greenish white. Leaves are simple, alternate and arranged often in clusters at the ends of branches. They are stipulate, 5-12 cm broad and 10-18 cm long, entire, broadly elliptic to ovate. Fruits are achenes, which are small, crussateous and enclosed in the common fleshy receptacles, having red outside color. The young bark is somewhat smooth having transverse and longitudinal row of lenticles, while in the older bark, the lenticles are numerous and closely spaced. Outer bark flakes off easily. The fresh cut surface of the bark is pink to flesh colored and exudes plenty of latex. The inner most part of the bark adjoining the wood is nearly white and fibrous.

Pharmacognostic characters

**Stem bark**

Shade dried stem bark is of brownish grey color with dark patches from outer surface and reddish brown to yellowish brown on inner surface possessing stimulant odor, astringent taste and rough texture due to the presence of lenticles. Thickness of bark varies with the age of the tree; normally 0.8 to 2.5 cm. Fracture is brittle in outer bark and fibrous in inner portion.

Microscopically, stem bark is differentiated into outer and inner bark having width of 288-576 and 2.9-3.5 mm respectively. Periderm consisting of phellem and phelloderm originates from the deeper portion of the secondary phloem. Phellem cells are thin walled, homogeneous, rectangular and suberized. Phelloderm is distinct and wide, its cells are turned into radially arranged cubical sclereids. Next to the vascular cambium, secondary phloem forms a distinct zone consisting of companion cells, sieve tube members and axial parenchyma. Most of these parenchyma cells have abundance of tannin. Outside of this zone phloem appears collapsed, consisting of collapsed and destroyed sieve elements and wide dilated rays. In the peripheral part of the bark, cells of these rays are turned into thick walled lignified sclerechyma cells. The phloem rays may be uniseriate, multisierate, homocellular or heterocellular. Breadth and height of multisierate rays is up to 72 mm and 900 mm respectively and height of sieve tube members is about 288-360 mm. Large and vertically oblong p-proteins can be found consistently, adjacent to sieve plates. Laticifers are abundant in the inner bark and each laticiferous canal is surrounded by distinct epithelial cells.

**Leaf**

Leaves are coraceous having slight bitter taste, green in color, opposite in arrangement, ovate to elliptic in shape (lanceolate shape) with obtuse apex and reticulately pinnate venation. Length and width are 10-30 cm and 7-20 cm respectively with2.5-5 cm long petiole. Powder of leaf is pale green colored and odorless possessing a slightly bitter taste. Trichomes, fibers, calcium oxalate crystals, spiral thickenings and epidermal cells with anticlinal walls are visible under microscope.

Leaf primordium

Fresh leaf primordium has light green thick outer covering. Leaf primordia are arranged alternatively and occur in predictable positions. Length and width of primordium are 2-4 cm and 0.4-0.6 mm respectively. In dry form, these possess abundant trichomes on outer surface. Primordia have agreeable odor and slight bitter taste. In transverse section, different sequence of arrangements in concentric rings is visible. Abundant uniseriate trichomes are present on epidermis. Thin walled, elongated and compactly arranged parenchymatous cells with chloroplastic form the ground tissue and later on develop into spongy and palisade parenchymatous cells. These parenchymatous cells have clustered crystals of calcium oxalate. Small rounded vascular bundles with poorly developed phloem and xylem are present in between these parenchymatous cells. Lignified, thick walled, rectangular and elongated stone cells with narrow and broad lumen are also present.

Physicochemical parameters

**Stem bark**

Physicochemical parameters of *F. bengalensis* stem bark are as follows:

- Foreign matter (1.53% w/w); Total ash (11% w/w); Acid insoluble ash (2.46% w/w); Water soluble ash (5.13% w/w); Loss on drying (10% w/w); Water soluble extractive (13% w/w); Alcohol soluble extractive (8.2% w/w).

**Leaf**

Physicochemical parameters of *F. bengalensis* leaf are as follows:

- Vein termination number (12.6/mm²); Vein islet number (10.7/mm²); Stomatal index (lower epidermis) (16/mm²); Stomatal index (upper epidermis) (7.5/mm²); Total ash (11.63% w/w); Acid insoluble ash (4.5% w/w); Water soluble ash (7.56% w/w); Water soluble extractive (6.4% w/w); Ethanol soluble extractive (4.8% w/w); Chloroform soluble extractive (1.2% w/w); Petroleum ether soluble extractive (1.8% w/w).

**Leaf primordium**

Physicochemical parameters of *F. bengalensis* leaf primordium are as follows:

- Foreign matter (0.65%); Moisture (10.75%); Total ash (10.95% w/w); Acid insoluble ash (0.75% w/w); Water in soluble ash (1% w/w); Water soluble extractive (0.63% w/w); Benzene soluble extractive (0.54% w/w); Chloroform soluble extractive (0.23% w/w); Petroleum ether soluble extractive (2.19% w/w).

**Phytochemistry of *F. bengalensis***

General phytochemical screening of *F. bengalensis* is enlisted in table 1. Detail of various phytoconstituents in different parts of the plant is described below and summarized in table 2.
Table 1: Phytochemical analysis of *F. bengalensis*

<table>
<thead>
<tr>
<th>Phytoconstituents</th>
<th>Leaves</th>
<th>Stem bark</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloids</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Glycosides</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Terpenoids</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Phenols</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Xanthoproteic</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tannins</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Table 1:** Phytochemical analysis of *F. bengalensis*

**Stem bark**

**Phytosterols**

From methanolic extract of stem bark, lanostadienylglycosyl cetoleate (01), bengalensteroic acid acetate(02), α-aminyl acetate (03) and lupeol (04) were isolated from the silica gel packed column with chloroform, chloroform: methanol (97:3), petroleum ether: chloroform (1:1) and petroleum ether:chloroform (1:1) respectively [17].

**Anthocyanin derivatives**

From the water soluble fraction of the ethanolic extract of the defatted stem bark, 5,7-dimethylether of leucopelargonidin-3-O-α-L-rhamnoside (05) and from water insoluble fraction, 3',5,7-trimethyl ether of delphinidin-3-O-α-L-rhamnoside(06), 3',5,7-trimethylether of leucocyanidin (07) and 3',5-dimethyl ether of leucocyanidin-3-O-β-D-galactosylcellobioside (08) have been isolated by silica gel column. No NMR data was reported and these compounds were characterized by methylation, demethylation, acetylation, use of color reagents, degradation methods and elemental analysis by UV spectroscopy.

From hot ethanol extract of the defatted stem bark, meso inositol (09) and from hot petroleum ether extract, β-sitosterol-α-D-glucose (10), 6-heptatriacontene-10-one (11), 20-tetracontene-2-one (12) and pentatriacontan-5-one (13) have been isolated by column chromatography on silica gel [18].

**Fruit and seed**

**Fatty acids**

Seed oil is found to contain many unusual fatty acids viz. palmitic acid (35.2%) (14), oleic acid (20.3%) (15), linoleic acid (15.4%) (16), linolenic acid (8.7%) (17), vernolic acid (8.2%) (18), stearic acid (4.2%) (19), malvalic acid (3.7%) (20), sterculic acid (1.6%) (21), lauric acid (1.5%) (22) and myristic acid (1.3%) (23) [19].

**Amino acids**

Analysis of the concentrated aqueous extract of the fresh fruits revealed the presence of many amino acids in fruit proteins i.e. cysteine(24), glutamine(25), methionine(26), tryptophan(27), arginine(28), methionine(29), citrulline (30) and hydroxyproline(31). Isolation of glutathione (32) from fruits is also reported in earlier works [18].

**Polysaccharide**

The hot ethanolic extract, after dissolving in water, revealed the presence of D-glucose(33), D-fructose (34) and D-galactose (35) by paper chromatography. From water insoluble residue, xylan was precipitated after extraction with chloroform. Hydrolysis of the xylan with acid and analysis by paper chromatography showed the presence of mainly D-arabinose (36) and D-xylene (37) together with traces of galactose and glucose [19].

**Heart wood**

From benzene extract of the heartwood, tiglic acid ester of taraxasterol (38) has been isolated; characterized by mixed melting point, IR spectra and co-spot TLC of alkaline hydrolysis products with authentic tiglic acid and taraxasterol [18].

**Leaf**

**Flavonoids**

Two flavonoids catechin (39) and genistein (40) were isolated from methanol extracts of the leaves of Sudanese varieties of *F. bengalensis* by using column chromatography and their structures were identified by IR, 1H-NMR, 13C-NMR, MS spectral data, UV and comparison with published data [20].

**Flavonols**

Flavonols quercetin-3-galactoside (41) and rutin (42) have been isolated from ethyl acetate extract of the leaves [18].

**Leucoanthocyanidins**

A leucoanthocyanidin leucocyanidin (43) was isolated from the leaf and its hypoglycemic effect was testified [21, 22].

**Triterpenoids and sterols**

A triterpene friedelin (44) and a sterol β-sitosterol (45) have been isolated from the leaves by column chromatography using petroleum ether and benzene respectively, as eluants. Their structures were determined by mass spectral data, elemental analysis, mixed melting point and co-spot TLC with that of an authentic sample [18].

**Aerial root**

**Triterpenoids**

From methanolic extract of the aerial roots, Bengaleninsone (46) and benganoic acid (47), possessing cholinesterase inhibitory activity, have been isolated [23].
Table 2: Summary of phytochemistry of *F. bengalensis*

<table>
<thead>
<tr>
<th>Chemical class</th>
<th>Plant part</th>
<th>Components</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytosterols</td>
<td>Stem bark</td>
<td>Lanostadienylglucosyl ceteolate (01); bengalensisteroic acid acetate (02); α-amyrin acetate (03); lupeol (04)</td>
<td>[17]</td>
</tr>
<tr>
<td>Anthocyanin derivatives</td>
<td>Stem Bark</td>
<td>5,7-dimethylether of leucopelargonidin-3-O-α-L-rhamnoside (05); 3',5,7-trimethyl ether of delphinidin-3-O-α-L-rhamnoside (06); 3',5,7-trimethyl ether of leucocyanidin (07); 3',5-dimethyl ether of leucocyanidin-3-O-β-D-galactosy cellulobioside (08)</td>
<td>[18]</td>
</tr>
<tr>
<td>Fatty acids</td>
<td>Seed oil</td>
<td>Palmitic acid (14); oleic acid (15); linoleic acid (16); linolenic acid (17); vernolic acid (18); stearic acid (19); malvalic acid (20); sterculic acid (21); lauric acid (22); myristic acid (23)</td>
<td>[19]</td>
</tr>
<tr>
<td>Amino acids</td>
<td>Fruits and Seeds</td>
<td>Cysteine (24); glutamine (25); methionine (26); tryptophan (27); arginine (28); methionine (29); citrulline (30); hydroxyproline (31)</td>
<td>[18]</td>
</tr>
<tr>
<td>Polysaccharides</td>
<td>Fruits and seeds</td>
<td>D-glucose (33); D-fructose (34); D-galactose (35); D-arabinose (36); D-xylene (37)</td>
<td>[18]</td>
</tr>
<tr>
<td>Sterols</td>
<td>Leaf</td>
<td>β-sitosterol (45)</td>
<td>[18]</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Leaf</td>
<td>Catechin (39), genistein (40)</td>
<td>[20]</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Leaf</td>
<td>Quercetin-3-galactoside (41); rutin (42)</td>
<td>[18]</td>
</tr>
<tr>
<td>Leucoanthocyanidins</td>
<td>Leaf</td>
<td>Leucocyanidin (43)</td>
<td>[21, 22]</td>
</tr>
<tr>
<td>Triterpenes</td>
<td>Leaf</td>
<td>Friedelin (44)</td>
<td>[18]</td>
</tr>
<tr>
<td>Aerial root</td>
<td>Bengalensinone (46), benganoic acid (47)</td>
<td>[23]</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Stem Bark</td>
<td>Meso inositol (09); β-sitosterol-α-D-glucose (10); 6-heptatriacontene-10-one (11); 20-tetraatriacontene-2-one (12); Pentatriacontan-5-one (13)</td>
<td>[18]</td>
</tr>
<tr>
<td>Fruits and seeds</td>
<td>Glutathione (32)</td>
<td>[18]</td>
<td></td>
</tr>
<tr>
<td>Heart wood</td>
<td>Tiglic acid ester of taraxasterol (38)</td>
<td>[18]</td>
<td></td>
</tr>
</tbody>
</table>
Pharmacological activities

Antihyperglycemic and antidiabetic activity

Antihyperglycemic activity of α-amyrin acetate, isolated from aerial roots of *F. bengalensis* was testified in STZ-induced diabetic rats and in db/db mice at dose level of 50 mg/kg p.o. Antihyperglycemic results were compared with the same dose of metformin. α-amyrin acetate caused 22.3% improvement of glucose tolerance in normoglycemic rats and 35.6% (comparable to metformin 37.8%) fall in blood glucose of STZ-induced diabetic rats. Multiple dose oral administration in db/db mice, lowered blood glucose level on day 3, 5, 7 and 10 by 18.7%, 27.1%, 40.0% and 51.6% respectively, comparable to the effect of metformin i.e. 17.8%, 30.5%, 39.4% and 52.5% respectively. Average antihyperglycemic effect of α-amyrin acetate on glucose tolerance in db/db mice was calculated to be around 35.6%, comparable to that of metformin 43.2% [24].

In a comparative study, using glibenclamide (5 mg/kg) as reference standard, ethanolic extract of stem bark showed relatively more hypoglycemic activity in alloxan induced diabetic rats than that of aerial roots, at same dose level i.e. 100 mg/kg [25].

Inhibitory activities of the aqueous extracts of the heat treated and untreated stem bark was studied on α-amylase, α-glucosidase and sucrase. Honda and Hara method was used to evaluate inhibitory potential [26]. Both heat treated and untreated extracts showed significant inhibitory activities. Heat treated extracts showed IC₅₀ values of 77 and 141 µg/ml and untreated extracts showed IC₅₀ values of 158 and 193 µg/ml for α-glucosidase and sucrase respectively. This is the possible mechanism of antidiabetic effect of this plant [27].

Antidiabetic and ameliorative potential of aqueous extract of the stem bark at dose level of 500 mg/kg/day p.o. was studied in streptozotocin induced diabetic rats by using tolbutamide (100 mg/kg/day p.o.) as reference standard. Results revealed the hypoglycemic activity comparable to that of tolbutamide and restoration of hepatic cytochrome P-450 dependent enzymes (PNPH, PROD and EROD), kidney and liver lipid peroxidation (malondialdehyde and hydroperoxides) and glycolytic enzymes to near normal levels; also decrease in the levels of serum electrolytes (potassium, sodium and calcium) was observed. Histological examination revealed reduction in swelling and inflammation of pancreatic tissue [28].
In another study, using the same extract and experimental conditions, results with regard to total protein (g/dl), albumin (g/dl), urea (m mol/l), uric acid (m mol/l), creatinine (µ mol/l), Hb (g/dl), RBC, WBC and platelets were almost equivalent to that of tolbutamide [39].

Antidiabetic effect of aqueous extract of *F. bengalensis* aerial roots at dose level of 300 mg/kg p.o. was studied in streptozotocin induced diabetic rats using glipizide (2.5 mg/kg p.o.) as reference standard. Results revealed 43.8% reduction in BGL of normal rats at 6 h, 40.7%, 54.8% and 51.7% improvement in glucose tolerance of normal, sub diabetic and mild diabetic rats respectively, was observed at 3 h during GTT [30].

Aqueous extract of the stem bark at dose level of 50 mg/kg/day p.o. when tested on normal, alloxan recovered, mildly diabetic and severely diabetic rabbits caused improvement in glucose tolerance in alloxan recovered and mildly diabetic rabbits. It also caused 55.8% and 68% fall in FBG in mildly diabetic and severely diabetic rabbits respectively [31].

In a comparative study performed on alloxan induced diabetic rats, ethanolic extract of fruit, at a dose of 120 mg/kg/day p.o., showed more diabetic activity than that of aerial root and stem bark. Glibenclamide at a dosage of 0.5 mg/kg/day p.o. was used as reference standard [32].

A partially purified preparation from aqueous extract of the stem bark demonstrated significant hypoglycemic and hypcholesterolemic effect on diabetic rabbits. ED50 and LD50 were determined to be 10 mg/kg and 1000 mg/kg p.o. respectively. For chronic toxicity studies, 50 mg, 100 mg and 150 mg/kg of this preparation, about 5, 10 and 15 times of the ED50 value respectively, were given to diabetic rats for three months. Fall in FBG, cholesterol and triacylglycerol and improvement in GTT were similar to those of normal control group. Weight gain and values of SGOT, SGPT, S. alkaline phosphatase, serum protein, blood urea, serum cholesterol, hemoglobin, total leukocyte count, differential count were not affected. So, partially purified aqueous extract of stem bark is nontoxic and safe even in a dose of 5, 10 and 15 times of the ED50, but the crude extract is hepatotoxic [33].

**Antihyperlipidemic and hypcholesterolemic activity**

Administration of α-amyrin acetate, isolated from aerial roots of *F. bengalensis*, to dd/d mice for 10 consecutive days decreased triglycerides, cholesterol and LDL-C by 21.5%, 24.1% and 21.2%; increased HDL-C and HDL-C to TC ratio by 21.0% and 59.1% respectively. It is concluded that α-amyrin acetate improves plasma lipid profile not only by lowering total plasma cholesterol and LDL-C levels significantly but also by increasing HDL-C level and HDL-C/TC ratio [34].

Hypolipidemic and antioxidant effect of aqueous extract of the stem bark at dose level of 50 mg/kg/day p.o. was studied in hypercholesterolaemic rabbits (rabbits fed with cholesterol suspended in groundnut oil at a dose of 100 mg/kg/day, for 6 weeks). Results of this study revealed a decrease in triacylglycerol, serum cholesterol and LDL+VLDL cholesterol by 54%, 59% and 60% respectively, increase in levels of catalase, glutathione reductase, superoxide dismutase and glutathione peroxidase 30%, 22%, 36% and 90% respectively, compared to untreated animals [35]. In another study, under the same experimental conditions, HDL-C increased to 30.6 mg% and TAG decreased to 89 mg% while in untreated group these values were 25.6 mg% and 188 mg% respectively. 48% decrease in TC level after four weeks was also observed [36].

**Anti-inflammatory**

Anti-inflammatory activity of methanolic extract of the stem bark and the leaf in Carrageenan induced and formalin induced hind paw edema in rats, was comparable to that of potent drugs i.e. diclofenac sodium and aspirin [36-39]. Ethanolic extract of the stem bark also possesses anti-inflammatory activity [37].

Anti-inflammatory activity of bark of young plant of *F. bengalensis* was compared with that of mature plant using carrageenan induced hind paw edema for acute inflammation and cotton pellet induced granuloma for chronic inflammation, in rats. Ethanolic, chloroform and petroleum ether extracts at dose level of 300 and 600 mg/kg/day p.o. were studied using indomethacin at dose level of 10 mg/kg/day p.o. as standard drug. Ethanolic extract of younger plant at dose level of 300 and 600 mg/kg/day p.o. caused 37.64% and 69.04% reduction in paw volume after 3 h, while mature plant caused 55.03% and 65.54% reduction respectively, in carrageenan induced paw edema model. In cotton pellet granuloma model, ethanolic extract of younger plant at dose level of 300 and 600 mg/kg/day p.o. caused 19.27% and 39.03% reduction in paw volume after 3 h, while mature plant caused 14.12% and 34.25% reduction respectively. So, younger plant possesses relatively more anti-inflammatory activity than mature plant. Chloroform and petroleum ether extracts did not possess significant anti-inflammatory activity [40].

**Analgesic activity**

Analgesic activity of methanolic extract of the leaf and the stem bark in Acetic acid induced writhing and Eddy’s hot plate method in rats, was comparable to that of potent drugs i.e. diclofenac sodium and aspirin [37-39].

**Antibacterial activity**

Catechin and genistein, isolated from methanol extracts of the leaves of Sudanese varieties *F. bengalensis* were tested for their antimicrobial activity by using disc diffusion method at dose level of 100 µg/ml. Streptomycin sulphate and nystatin at dose level of 25 µg/discs and 50 µg/discs respectively, were used as reference standard. Both compounds showed antibacterial activity, comparable to that of streptomycin and nystatin, against *Bacillus cereus* and *Pseudomonas aeruginosa*. No antifungal activity was found against *Aspergillus ochraceus*, *Saccharomyces cerevisae*, *Candida lipolytica* and *Saccharomyces lipolytica* [20].

Antibacterial activity of aqueous extracts of the stem bark, leaf and root was evaluated by agar diffusion technique. Among the three extracts, stem bark extract showed maximum antibacterial activity against *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Staphylococcus aureus* and *Escherichia coli* [40].

Antibacterial activity of hydroalcoholic (70% methanol) extract of the stem bark at concentration of 0.01-0.10 mg/ml was tested against *Actinomyces viscosus* using cup plate diffusion method and broth dilution technique. MIC was found to be 0.08 mg/ml and zone of inhibition at this concentration was 9.4 mm. No zone of inhibition was found at concentration of 0.01-0.07 mg/ml [41].

Antibacterial activity of methanolic extract of the stem bark determined by disc diffusion method at the dose of 200 mg/ml against Enterotoxigenic *E. coli* was comparable to that of standard drug amikacin at the dose of 10 µg/disc [42].
Antibacterial activity varies with a change in environmental conditions and geography. [43].

**Antifungal activity**

Antifungal activity of aqueous extracts of the stem bark, leaf and root was evaluated by agar diffusion technique at dose level of 30 mg/ml using nystatin (30 µg/ml) as reference standard. Among the three extracts, stem bark extract showed antifungal activity against *Trichophyton rubrum* and *Candida albicans* comparable to that of nystatin. *T. rubrum* was resistant to the leaf extract and *K. pneumonia* was resistant to both leaf and root extracts [10].

In another study, water and Ethanolic extracts of the stem bark increased breaking strength and decreased period of epithelialization and percentage wound contraction in incision and excision model respectively [46].

**Larvicidal activity**

Larvicidal activity of methanolic extract of the leaf was studied against early 2nd, 3rd and 4th instar larvae incorporated in different concentrations in glass beakers. Results revealed LC50 values against early 2nd, 3rd and 4th instar larvae of *Culex quinquefasciatus*, *Anopheles stephensi* and *Aedes aegypti* as 41.43, 58.21 and 74.32 ppm, 60.44, 76.41 and 89.55 ppm and 56.54, 70.29 and 80.85 ppm respectively. LC50 values against early 3rd instar larvae of *Culex tritaeniorhynchus* and *Anopheles subpictus* were 100.88 and 159.76 ppm respectively [45, 46].

**Anti-diarrhoeal activity**

Anti-diarrhoeal effect of Ethanolic extract of *F. bengalensis* hanging roots (EEFB) was evaluated at dose level of 400 mg/kg p.o. against castor oil induced diarrhea, PGE2 induced enter pooling and GI motility in charcoal meal test in rats using diphenoxylate (5 mg/kg p.o) and atropine (0.1 mg/kg i.p) as reference standards. In castor oil induced diarrhea, mean defections per animal in 4 hours, treated with diphenoxylate and EEFB were 1.37 and 2.21 respectively and mean number of wet faeces per animal were 0.0 and 1.96 respectively. In PGE2 induced enteropooling, volume of intestinal fluid in PGE2 and PGE2+EEFB was 2.97 and 1.25 ml respectively. Movement of charcoal meal with atropine and EEFB was 34.2 and 50.2 respectively [47].

**Antimitogenic and antioxidant activity**

Aqueous extract of heat treated stem bark was used to determine antimitogenic and antioxidant activity by using Ames test (standard plate incorporation assay) and ex-vivo inhibition of lipid peroxidation in liver microsomes of rats respectively. Extract concentration of 500 µg inhibited mutagenic activity of sodium azide (NaN3) in *Salmonella typhimurium* with IC50 value of 70.24 µg/ml and inhibited microsomal lipid peroxidation with IC50 value of 80.24 µg/ml [48].

**Antioxidant (free radical scavenging) activity**

*F. bengalensis* possesses antioxidant activity which is mostly due to phenolic compounds. [49]. Anti-oxidant and free radical scavenging activity of methanolic and acetone:water (70:30) extracts of *F. bengalensis* aerial roots was studied. Antioxidant potential of the methanol extract, estimated by using potassium ferric cyanide reduction method, was comparable to that of tannic acid. DPPH free radical scavenging activity (%) of the 70% acetone and methanol extracts was about 50, nearer to each other, at concentrations of 46.79 µg and 39.3 µg respectively. The values of TAA determined by ABTS+ radical cation scavenging activity of the 70% acetone and methanol extracts were 6182.7 and 6096.1 µmol/g respectively. Hydroxyl radical scavenging activity (%) of the 70% acetone and methanol extracts at concentration of 250 µg was 24.2 and 32.4 respectively. Lipoic acid peroxidation inhibition of both extracts was comparable to that of α-tocopherol. Antihemolytic activity (%) and metal chelating activity (mg EDTA/g sample) of 70% acetone and methanol extracts was 75.0, 70.5 and 19.9, 7.4 respectively [50].

**Cytotoxic activity**

Fruits of *F. bengalensis* have cytotoxic activity demonstrated by brine shrimp bioassay with LC50 value of 900 and by potato disc bioassay with 48% tumor inhibition [51].

**Hepatoprotective activity**

Methanolic extract of the aerial root was tested for hepatoprotective activity against isoniazid-rifampicin induced liver injury in rats using Liv 52 at dose level of 10 mg/kg p.o as reference standard. Results of MEFB at dose level of 100, 200 and 300 mg/kg p.o with regard to bilirubin level, total protein level, albumin level, AST and ALT were almost same as that of Liv 52. Histopathological results with regard to hepatocytic necrosis, inflammation and neutrophil infiltration were also comparable to that of Liv 52 [52].

Hepatoprotective effect of leucopelargonin derivative, isolated from the bark of *F. bengalensis*, at dose level of 100 mg/kg/day i.p. was evaluated in CCl4 induced hepatotoxic rats, using vitamin E at dose level 50 mg/kg/day i.p as reference standard. Result with regard to decrease in biochemical parameters like total cholesterol, HDL, LDL, FFA, TAG; decrease in the activities of glucose 6-phosphate dehydrogenase, HMGCoA reductase in the liver and enzymes like ALT, ALP and AST in serum and liver; increase in the levels of antioxidant enzymes in liver; inhibition of fatty infiltration and fibrosis, was comparable to that of vitamin E [53].

**Anti-arthritic activity**

Anti-arthritic activity of methanolic extract of the stem bark (MESB) at dose level of 400 mg/kg/day p.o was studied in formalin and Complete Freund’s adjuvant (CFA) induced arthritis in rats by using arthritis score, oxidative stress, radiographic pattern of hind legs and biomarkers vE/€, lipid peroxidation, antioxidants (non-enzymatic and enzymatic), nitric oxide, serum lysosomal enzymes (ALT, AST, and LDH), connective tissue biomarkers (sialic acid, hydroxyproline and glucosamine) and pro-inflammatory mediators (IL-6 and TNF-α). Diclofenac sodium, dexamethasone and methotrexate at dose level of 10, 0.03 and 0.007 mg/kg/day p.o respectively were used as reference standards. Anti-arthritic activity of MESB was slightly better than that of diclofenac sodium and less effective than that of dexamethasone and methotrexate [54].

**Antiallergic potential**

Aqueous, ethyl acetate and ethanol extracts of the stem bark at dose level of 50 mg/kg i.p., showed antiallergic and antistress activity against milk induced asthma in male Swiss albino mice by decreasing leucocytes and eosinophils. Bhargava and Singh method was used in this study [55].
**Immunostimulatory effect**

Immunostimulatory effect of the aerial roots was testified by using feed containing 5% aerial root powder, in fish models (*Channa punctatus*). Levels of ALT and AST remained almost same. Serum lysozyme, SOD, phagocytotic index, %age phagocytosis, total serum protein, nitric oxide and immunoglobulin increased significantly [56].

The aqueous extract of *F. bengalensis* aerial roots was evaluated for immunostimulatory activity, using in vitro polymorphonuclear (PMN) function test and hypersensitivity and hemagglutination reactions in rats. Maximum percentage phagocytosis i.e. 64% was observed at 1.0 mg/ml, compared to 34% in the control. Maximum early and delayed hypersensitivity reactions and an increase in the antibody titer in rats were observed at a dose of 100 mg/kg p.o. for five days [57].

In another study, the hydroalcoholic extract of the leaves and its four fractions (n-hexane, chloroform, n-butanol and water) showed prominent immunostimulatory activity in phagocytosis of killed *C. albicans* and candidacidal assay [58].

**Wound healing potential**

Wound healing capacity of aqueous and ethanolic extract of the root

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### Table 3: Summary of pharmacological studies on *F. bengalensis*

<table>
<thead>
<tr>
<th>Activity tested</th>
<th>Extract</th>
<th>Plant part</th>
<th>Experimental design</th>
<th>Dose</th>
<th>Effect</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antihyperglycemic and antidiabetic</td>
<td>EtOH</td>
<td>Aerial roots</td>
<td>STZ-induced diabetic rats and db/db mice. Metformin (50 mg/kg p.o.) used as reference standard.</td>
<td>50 mg/kg p.o.</td>
<td>Antihyperglycemic effect (caused by α-amyrin acetate) was comparable to that of metformin</td>
<td>[24]</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>Stem bark</td>
<td>Streptozotocin induced diabetic rats. Tolbutamide (100 mg/kg/day p.o.) used as reference standard</td>
<td>500 mg/kg/day p.o.</td>
<td>Hypoglycemic activity was equivalent to that of tolbutamide. Restored glycolytic enzymes, serum electrolytes, hepatic P-450 dependent enzyme systems and formation of kidney and liver lipid peroxides to normal levels. 43.8% reduction in BGL of normal rats at 6 h. 40.7%, 54.8% and 51.7% improvement in glucose tolerance of normal, sub diabetic and mild diabetic rats respectively at 3 h during GTT. Improvement in GT in alloxan recovered and mildly diabetic rabbits. 55.8% and 68% fall in FBG in mildly diabetic and severely diabetic rabbits respectively.</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>Aerial roots</td>
<td>Streptozotocin induced diabetic rats. Glipizide (2.5 mg/kg p.o.) used as reference standard</td>
<td>300 mg/kg p.o.</td>
<td>Decreased triacylglycerol, serum cholesterol and LDL-VLDL cholesterol by 54%, 59% and 60% respectively, increased levels of catalase, GR, SOD and GSH.Px by 30%, 22%, 36% and 90% respectively, compared to untreated animals. HDL-C increased to 30.6 mg% and TAG decreased to 89 mg% (in untreated group, 25.6 mg% and 188 mg% respectively). 48% decrease in TC level. TC, LDL and TG decreased from 176 to 118 mg%, 118 to 51.7 mg%, 27 to 5 mg% and 121 to 45 mg% respectively in subdiabetic rabbits and from 118 to 51.7 mg%, 95 to 29 mg% and 416 to 81 mg% respectively in diabetic rabbits.</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>Stem bark</td>
<td>Normal, alloxan recovered, mildly diabetic and severely diabetic rabbits.</td>
<td>50 mg/kg/day p.o.</td>
<td>Decreased triacylglycerol, serum cholesterol and LDL-VLDL cholesterol by 54%, 59% and 60% respectively, increased levels of catalase, GR, SOD and GSH.Px by 30%, 22%, 36% and 90% respectively, compared to untreated animals. HDL-C increased to 30.6 mg% and TAG decreased to 89 mg% (in untreated group, 25.6 mg% and 188 mg% respectively). 48% decrease in TC level. TC, LDL and TG decreased from 176 to 118 mg%, 118 to 51.7 mg%, 27 to 5 mg% and 121 to 45 mg% respectively in subdiabetic rabbits and from 118 to 51.7 mg%, 95 to 29 mg% and 416 to 81 mg% respectively in diabetic rabbits.</td>
<td>[27]</td>
</tr>
<tr>
<td>Antihyperlipidemic and Hypocholesterolemic</td>
<td>Water</td>
<td>Stem bark</td>
<td>Hypercholesterolaemic rabbits (rabbits fed with cholesterol suspended in groundnut oil at a dose of 100 mg/kg/day, for 6 weeks).</td>
<td>50 mg/kg/day p.o.</td>
<td>Alloxan induced subdiabetic and diabetic rabbits.</td>
<td>[28]</td>
</tr>
<tr>
<td>Activity</td>
<td>Extr.</td>
<td>Part</td>
<td>Description</td>
<td>Concentration</td>
<td>Results</td>
<td>Reference</td>
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<tr>
<td>Anti-inflammatory</td>
<td>MeOH</td>
<td>Stem bark</td>
<td>Carrageenan induced hind paw edema and cotton pellet induced granuloma in rats. Diclofenac sodium (10 mg/kg/day p.o.) for 8 days used as reference standard.</td>
<td>400 mg/kg/day</td>
<td>Results were comparable to that of diclofenac sodium</td>
<td>[37]</td>
</tr>
<tr>
<td></td>
<td>EtOH</td>
<td>Stem bark</td>
<td>Carrageenan induced hind paw edema in rats. Diclofenac sodium (5 mg/kg i.p.) used as reference standard.</td>
<td>200 mg/kg p.o.</td>
<td>Results were comparable to that of diclofenac sodium</td>
<td>[38]</td>
</tr>
<tr>
<td></td>
<td>MeOH</td>
<td>Leaf</td>
<td>Carrageenan induced hind paw edema in rats. Aspirin (20mg/kg p.o.) used as reference standard.</td>
<td>100 mg/kg p.o.</td>
<td>Results were comparable to that of aspirin</td>
<td>[37]</td>
</tr>
<tr>
<td></td>
<td>MeOH</td>
<td>Leaf</td>
<td>Formalin induced hind paw edema in rats. Diclofenac sodium (10 mg/kg p.o.) used as reference standard.</td>
<td>200 mg/kg p.o.</td>
<td>Results were comparable to that of diclofenac sodium</td>
<td>[38]</td>
</tr>
<tr>
<td>Analgesic</td>
<td>MeOH</td>
<td>Stem bark</td>
<td>Acetic acid induced writhing in rats. Diclofenac sodium (10 mg/kg/day) for 8 days used as reference standard.</td>
<td>400 mg/kg/day</td>
<td>Results were comparable to that of diclofenac sodium</td>
<td>[39]</td>
</tr>
<tr>
<td></td>
<td>MeOH</td>
<td>Leaf</td>
<td>Acetic acid induced writhing and Eddy’s hot plate method in albino mice. Aspirin (20mg/kg p.o.) used as reference standard.</td>
<td>100 mg/kg p.o.</td>
<td>Results were comparable to that of aspirin</td>
<td>[37]</td>
</tr>
<tr>
<td></td>
<td>MeOH</td>
<td>Leaf</td>
<td>Eddy’s hot plate method in rats. Diclofenac sodium (10 mg/kg p.o.) used as reference standard.</td>
<td>200 mg/kg p.o.</td>
<td>Results were comparable to that of diclofenac sodium</td>
<td>[38]</td>
</tr>
<tr>
<td>Antibacterial</td>
<td>MeOH</td>
<td>Leaf</td>
<td>Disc diffusion method. Streptomycin sulphate and nystatin (50 μg/discs) used as reference standard.</td>
<td>100 μg/ml</td>
<td>Antibacterial activity (caused by catechin and genistein) was comparable to that of streptomycin and nystatin, against B. cereus and P. aeruginosa</td>
<td>[20]</td>
</tr>
<tr>
<td></td>
<td>Hyd-alc</td>
<td>Stem bark</td>
<td>Cup plate diffusion method and broth dilution technique.</td>
<td>0.01-0.10 mg/ml</td>
<td>MIC against A. viscosus was 0.08 mg/ml and zone of inhibition at this concentration was 9.4 mm.</td>
<td>[41]</td>
</tr>
<tr>
<td></td>
<td>MeOH</td>
<td>Stem bark</td>
<td>Disc diffusion method. Amikacin (10µg/discs) used as reference standard.</td>
<td>200 mg/ml</td>
<td>Results against Enterotoxigenic E. coli were comparable to that of amikacin.</td>
<td>[42]</td>
</tr>
<tr>
<td></td>
<td>EtOH</td>
<td>Stem bark</td>
<td>Cup and plate method. Ofloxacin (25 mg/ml) used as reference standard.</td>
<td>1000 μg/ml</td>
<td>Zone of inhibition was comparable to that of ofloxacin, against E. coli and S. aureus.</td>
<td>[43]</td>
</tr>
<tr>
<td>Antifungal</td>
<td>Water</td>
<td>Stem bark</td>
<td>Agar diffusion technique. Nystatin (30µg/ml) used as reference standard.</td>
<td>30mg/ml</td>
<td>Zone of inhibition against T. rubrum and C. albicans was comparable to that of nystatin.</td>
<td>[38]</td>
</tr>
<tr>
<td>Larvicidal</td>
<td>MeOH</td>
<td>Leaf</td>
<td>Early 2nd, 3rd and 4th instar larvae incorporated in different concentrations in glass beakers</td>
<td>25 to 200 ppm concentration</td>
<td>LC_{50} values against early 2nd, 3rd and 4th instar larvae of C. quinquefasciatus, A. stephensi and A. aegypti were 41.43, 58.21 and 74.32 ppm, 60.44, 76.41 and 89.55 ppm and 56.54, 70.29 and 80.85 ppm respectively LC_{50} values against early 3rd instar larvae of C. tritaeniorhynchus and A. subpictus were 100.88 and 159.76 ppm respectively</td>
<td>[44]</td>
</tr>
<tr>
<td>Anti-diarrhoeal</td>
<td>EtOH</td>
<td>Aerial roots</td>
<td>Castor oil induced diarrhoea in rats. Diphenoxylate (5 mg/kg p.o.) used as reference standard PGE_{2} induced enteropooling in rats</td>
<td>400 mg/kg p.o.</td>
<td>MDPA in 4h, treated with Diph and EEFB was 1.37 and 2.21 and MNWFPA was 0.0 and 1.96 respectively. Value of VIF for PGE_{2} (100 μg/kg) and PGE_{2}+EEFB was 2.97 ml and 1.25 ml respectively. Value of MCM for atropine and EEFB was 34.2 and 50.2 respectively.</td>
<td>[47]</td>
</tr>
<tr>
<td>Antimutagenic</td>
<td>Water</td>
<td>Stem bark (heat treated)</td>
<td>Ames test (standard plate incorporation assay).</td>
<td>500 μg (extract concentration)</td>
<td>Inhibited mutagenic activity of sodium azidein S. typhimurium with IC_{50} value of 70.24 μg/ml</td>
<td>[44]</td>
</tr>
<tr>
<td>Antioxidant</td>
<td>Water</td>
<td>Stem bark (heat treated)</td>
<td>Ex-vivo inhibition of lipid peroxidation in liver microsomes of rats.</td>
<td>500 μg (extract concentration)</td>
<td>Inhibited microsomal lipid peroxidation with IC_{50} value of 80.24 μg/ml</td>
<td>[44]</td>
</tr>
<tr>
<td>Antioxidant (Free radical scavenging)</td>
<td>MeOH</td>
<td>Aerial root</td>
<td>Antioxidant potential (potassium ferric cyanide reduction method), DPPH free radical scavenging activity, ABTS+ radical cation scavenging activity, hydroxyl radical scavenging activity, linoleic acid peroxidation inhibition, anithemolytic activity and metal chelating activity. DPPH radical scavenging activity, hydroxyl radical scavenging activity, reducing capacity, hydrogen peroxide activity, determination of total phenolic content using Folin-Ciocalteu’s phenolic reagent.</td>
<td>Showed good antioxidant, free radical scavenging, metal chelating and antihemolytic potential.</td>
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<tr>
<td>Cytotoxic</td>
<td>CF</td>
<td>Fruit</td>
<td>Brine shrimp bioassay and potato disc bioassay</td>
<td>LC50 value of 900 and 48 % tumor inhibition respectively.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatoprotective</td>
<td>MeOH</td>
<td>Aerial root</td>
<td>Isoniazid-rifampicin induced liver injury in rats. Liv 52 (10 mg/kg p.o.) used as reference standard.</td>
<td>Results with regard to bilirubin, total protein level, albumin level, AST, ALT and histopathological results with regard to hepatic necrosis, inflammation and neutrophil infiltration were comparable to that of Liv 52.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-arthritic</td>
<td>MeOH</td>
<td>Stem bark</td>
<td>Formalin and CFA induced arthritus in rats using paw edema volume and arthritic score. Diclofenac sodium, dexamethasone and methotrexate (10, 0.03 and 0.007 mg/kg/day p.o. respectively) used as reference standard.</td>
<td>LC50 value of 900 and 48 % tumor inhibition respectively.</td>
<td></td>
<td></td>
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<tr>
<td>Antiallergic in asthma</td>
<td>Water</td>
<td>Stem bark</td>
<td>Milk-induced (4 mg/kg s.c.) leucocytosis and eosinophilia in mice feed containing 5% root powder.</td>
<td>Significant reduction in eosinophils and leucocytes compared to untreated group.</td>
<td></td>
<td></td>
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<tr>
<td>Immunostimulatory</td>
<td>Water</td>
<td>Aerial root</td>
<td>Fish models (Channa punctatus) and (Channa tritaeniorhynchus)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Wound healing</td>
<td>Water</td>
<td>Root</td>
<td>In vitro PMN function test and hypersensitivity and hemagglutination reactions in rats.</td>
<td>Levels of ALT and AST remained almost same. Serum lysozyme, SOD, phagocytotic index, %age phagocytosis, total serum protein, NO and immunoglobulin increased significantly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection against IBD</td>
<td>Water</td>
<td>Stem bark</td>
<td>Incision model, excision model and dead space wound model in rats. Povidone iodine used as reference standard.</td>
<td>Both the extracts increased breaking strength and decreased period of epithelialization and percentage wound contraction in incision and excision model respectively, compared with placebo</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. aegypti: Aedes aegypti; Act-Wtr: acetic acid water (70:30); AEFB: aqueous extract of F. bengalenlis; A. h: Aeromonas hydrophila; ALT: alanine aminotransferase; A. subpictus: Anopheles subpictus; A. stephensi: Anopheles stephensi; AST: aspartate aminotransferase; A. viscosus: Actinomyces viscosus; B. cereus: Bacillus cereus; BGL: blood glucose level; C. albicans: Candida albicans; CF: Chloroform; CFA: Complete Freund’s Adjuvant; CMDH: colon mucosa damage index; C. quinquefasciatus: Culex quinquefasciatus; C. tritaeniorhynchus: Culex tritaeniorhynchus; Ctrl: control; DAI: disease activity index; DipH: Diphenylolate; E.coli: Escherichia coli; EEFB: ethanolic extract of F. bengalenlis; EtAc: ethyl acetate; EtOH: ethanol; GR: glutathione reductase; GSH-Px: glutathione peroxidase; GT: glucose tolerance; GTT: glucose tolerance test; h: hour; Hyd-alc: hydroalcoholic (70% methanol); IBD: inflammatory bowel disease; i.p.: intraperitoneally; LC: lethal concentration; MCM: movement of charcoal meal; MDPA: mean defecations per animal; MeOH: methanol; MNWPPA: mean number of wet faeces per animal; NO: nitric oxide; Pred: prednisolone; P. aeruginosa: Pseudomonas aeruginosa; SOD: superoxide dismutase; S. typhimurium: Salmonella typhimurium; STZ: Streptozocin; TNBS: trinitrobenzenesulfonic acid; T. rubrum: Trichophyton rubrum; VIF: volume of intestinal fluid.
Other diverse activities and uses

Silver nanoparticles synthesis

In the synthesis of silver nanoparticles, aqueous extract of the leaf reduced silver ions into silver nanoparticles with the reaction time of five minutes and without any harsh conditions. Antibacterial activity of these nanoparticles against *Escherichia coli* was verified by bacterial growth method showing MIC of 25 µg/ml [64].

Serine protease enzyme

A serine protease enzyme named benghalensin was isolated from the latex of the plant. This enzyme is very stable and retains more than 80% of its activity in the temperature (°C) and pH range of 20-80 and 5.5-10 respectively [65].

Food for animals

Leaves are food for goats [66].

As indicator of lead pollution

Lead contents of *F. bengalensis* can be measured as the sensitive indicator of lead pollution [67-69].

As source of natural rubber

*F. bengalensis* contains good quality natural rubber in high amounts, comparable to the commercial rubber tree *Hevea brasiliensis* [68].

As biomonitor of polycyclic aromatic hydrocarbons

*F. bengalensis* leaves can be used as biomonitor of polycyclic aromatic hydrocarbons in the atmosphere [70].

CONCLUSION

Plants have been serving the humanity for centuries by providing a good source of medicines. Active constituents from plants are isolated and being used for diagnosis, treatment, mitigation, and prevention of various diseases, but many crude drugs are also in use. *Ficus bengalensis* L. is one of the most important plants of traditional medicines and is still in use, to treat various diseases, particularly diabetes, reproductive system disorders, inflammatory conditions and abscesses. Because of its importance in traditional medicines, its quality control parameters are established by pharmacognostic studies and various phytochemicals have also been isolated and identified. Pharmacological studies on various parts of the plant have verified its use in traditional medicines. Many aspects of this plant are to be uncovered, for example, toxicity studies, proper dose for a particular disease when the plant is used in crude form, isolation of further phytoconstituents, synergistic studies, drug-drug interactions and drug-food interactions.

Conflict of interest

We declare that we have no conflict of interest.

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