*British Journal of Pharmaceutical Research*
*8(3): 1-17, 2015, Article no.BJPR.20130*
*ISSN: 2231-2919*

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# Screening of Pharmacognostical, Phytochemical Profile and Traditional Application of *Ficus benghalensis*

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author SNT designed the study and wrote the protocol. Author MBR wrote the first draft of the manuscript and analyses of the study. Author SP managed the literature searches and identified the species of plant. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/BJPR/2015/20130
Editor(s):
(1) Elena G. Zavyalova, Chemistry Department, Moscow State University, Russia.
Reviewers:
(1) Anonymous, Shanghai University of Traditional Chinese Medicine, China.
(2) Anonymous, USC School of Pharmacy, USA.
Complete Peer review History: http://sciencedomain.org/review-history/11206

***Review Article***

***Received 13th July 2015***
***Accepted 6th August 2015***
***Published 1st September 2015***

## ABSTRACT

*Ficus benghalensis* belonging to Moraceae family is mostly familiar as "Banyan tree" or "Indian fig" with several vernacular names. Gigantic in appearance, as a colossal evergreen tree, it is extended by spreading branches through the substantiation of aerial roots. As an indigenous plant of South Asia, it is considered as a sacred plant in certain regions because of its numerous roles in its history, culture, heritage, religion as well as inhabitant's life style from ancient time. Its legendary remedial potency is also bolstered by enormous phytotherapeutical features recommended by local practitioner for long years and verified by epic ayurvedic classic "Charak Samhita". Extensive presence of certain potent secondary metabolites including flavonoids, alkaloids, glycosides, phenolic compounds etc. has been screened out from its several portions including bark, root, leaf, fruit and latex. Current pharmacognostical evaluations unravel its effective functions as antioxidant, anti-diabetic, analgesic, anti-diarrheal agent and role in relieving

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several skin diseases. This review based on *Ficus benghalensis* is a compendium of its recent advancements in the field of phytopharmacognosy along with its ethnobotanically established therapeutical roles.

*Keywords: Ficus bengalhensis; traditional use; pharmacognosy; phytochemicals*.

## ABBREVIATIONS

| | |
|---|---|
| *µg* | *Microgram* |
| *µl* | *Microliter* |
| *hr* | *Hour* |
| *kg* | *Kilogram* |
| *mg* | *Milligram* |
| *min* | *Minute* |
| *mm* | *Millimeter* |
| *ml* | *Milliliter* |
| *sec* | *Second* |
| *DIC* | *Disc diffusion method* |
| *DPPH* | *1, 1- Diphenyl- 2- picrylhydrazyl* |
| $ED_{50}$ | *Median effective dose* |
| *FB* | *Ficus benghalensis* |
| *FCA* | *Freund's Complete Adjuvant agent* |
| *FeCSA* | $Fe^{2+}$ *chelating activity assay* |
| *HCSM* | *Human red blood cell membrane stabilization method* |
| *HepG2* | *Hepatocellular human tumor cell line* |
| *HPSA* | *Hydrogen peroxide scavenging activity assay* |
| *HRSA* | *Hydroxyl radical scavenging activity assay* |
| $IC_{50}$ | *Half maximal inhibitory concentration* |
| $LD_{50}$ | *Median lethal dose* |
| *MCF-7* | *Brest human tumor cell line* |
| *MTT* | *Mitochondrial toxicity test* |
| *NOSA* | *Nitric oxide scavenging activity assay* |
| *OECD* | *Organization for Economic Co-operation & Development* |
| *SASA* | *Superoxide anion scavenging activity assay* |
| *SGOT* | *Serum glutamic-oxalacetic transaminase* |
| *SGPT* | *Serum glutamic pyruvic transaminase* |
| *STZ* | *Streptozotocin* |
| *TBARS* | *Thiobarbituric acid reactive substances* |

## 1. INTRODUCTION

*Ficus benghalensis* is laticiferous, moraceaeous, massive ever green tree included in ficus genus containing more than 800 species and 2000 sub-varieties (Fig. 1) [1-5]. Commonly known as "Indian banyan tree", it has several vernacular name including bawt, jatala, nyagrodha, rohina, avrohi, vitapi, rakatphala, skandaruha, mandali, mahachchya, yaksavasa, yakshataru, padrohina, nila, kshiri, shipharuha, bahupada, vanaspati [6,7]. Native to South Asia, It grows in dry regions throughout in India, Sri Lanka, Pakistan and Bangladesh and cultivated widely in almost every wet tropical area over the world [6,8] Its massive appearance is on average about 23-34 m tall supported by numerous aerial roots grows from low altitudes to 2,000 ft (610 m) [9]. Its obtusely cuspidate, oval shaped leaves are approximately 10-20 cm in length and 5-12.5cm in breadth. It has three types of flowers including males, females and imperfect females which are unisexual having about 1.3-1.8 cm diameter [9,10]. Its barks are smooth, greyish white exuding a milky latex after cutting leaves and fruits are dark reddish with fleshy pericarp [11]. Besides convensional propagation by seed, it can also propagated by cuttings. It is revered as sacrosanct plant in certain regions of South Asia specifically in India due to its inevitable presence in the myth and literature of this area verified by its nomination as the national plant of India.

**Fig. 1. Whole tree of *Ficus benghalensis* (Left) and its leaves with flower (Right)**
*Photo credit: http://www.indiaonlinepages.com/national-symbols/national-tree.html*
*http://lifescience-chandrakumar.blogspot.com/2012/05/ficus-benghalensis-baniyan-tree-bargad.html*

Its ethanomedicinal uses are validated from ancient time by traditional practitioners in various medical purposes [12-14]. Because of containing enormous phytochemicals such as flavonoids, alkaloids so on, as a medicinal plant it is very functional for curing many diseases [15-18]. This review is a condensation of current phytopharmacognostical profile with its established folk use.

## 2. TRADITIONAL APPLICATION

Folk use of *Ficus benghalensis* (FB) established from ancient time in South Asia is summarized in Table 1. Infusion of its bark is applied in dysentery, nervous disorders, leucorrhoea and diarrhea [12,13,19]. Traditional physicians used milky sap from bark and boiled bark for curing gonorrhea, snake bite, dermatitis, joint pain, indigestion, gum swelling and cold, cough, asthma [12]. For curing urinary problem, its bark mixed with the root of *Asparagus racemosus*, fruits of *Annona squamata*, and shoot of *Colebrookea oppositifolia* and taken during empty stomach [12]. Dried stem bark or root bark was very helpful for diabetes (quarter glass of stem bark juice in daily morning) [14,20]. In Jaundice prop root juice (50 ml) taken once a day for 3 days [4,21]. Leaf paste is applied externally in abscesses and wound [22,23]. Leaf powder is mixed with coconut oil and applied once a day for 3 days for the treatment of wounds. Leaf also has taken orally in diarrhea [24,25]. Milky latex is used for the treatment of sexual impotency, rheumatism, diarrhoea, dysentery, gonorrhea, maggot wound, bleeding, boils, toothache, earache, tonsils, lumbago and heel cracks [11,13,24-33]. Latex also act as blood purifier [34]. Whole plant is used as inhibitor in prolonged menses, bleeding of nose, tumor growth on bone and as stimulator of sexual weakness [7,21,35]. In diarrhea, dysentery, heamoptysis and haemorrhage its bud is used [9,11,27]. In food scarcity and billiary complication fruits can be eaten directly [10,36].

## 3. PHYTOCHEMICAL AND NUTRIENT PROPERTIES

*Ficus benghalensis,* rich in phytochemicals and nutrients, acts as remedies for some deadliest diseases. Its bark contains several primary metabolites such as carbohydrates, proteins, fats and oils [15,43,44]. Alkaloids, glycoside (bengalenoside,leucopelargonidin,3-o-beta-D-galactosylcellobioside, 3-0-alpha-L-rhamnoside, leucocyandin), saponins, flavonoid (leucopelargonin,5,7-dimethyl ether of leucopelargonidin-3-0-L-rhamnoside, 5,3'-dimethyl ether of leucocyanidin 3-0-D-galactosylcellobioside), steroids, phenolic compounds, tannins, terpenoids, phlobatannins and anthroquinones are also present in bark detected by different phytochemical tests [15-18, 43,45-51]. Latex contains not only proteins but also cardiac glycosides, anthroquinone glycoside, reducing glycoside, flavonoids, steroid, alkaloids, tannins, phenolic compounds and rubber [52,53]. Several secondary metabolites such as tannin, lignin, terpinoids, phenols, sterols, flavonoids, saponin and few primary metabolites (starch and protien) are

found in leaves measured by different qualitative tests [54,55]. Reducing sugars, glycosides, tannins are found in different extracts of its root [56,57]. Fruits and seeds contain protein and saccharide (lectin) too [9,58]. A brief summary of phytochemical analysis are given Table 2.

**Table 1. Traditional utilization of *Ficus bengalhensis***

| Plant Part | Diseases/Disorder | Application mode | References |
|---|---|---|---|
| Bark | Dysentery | infusion of the bark | [19] |
| | Urinary problem | applied by formulation | [12] |
| | Diabetes mellitus | dried stem bark or root bark | [14] |
| | Gonorrhea | milky sap from bark | [12,13] |
| | Snake bite | milky sap from bark | [12] |
| | Nervous disorders | infusion of the bark | [19] |
| | Cold and cough | boiled bark | [12] |
| | Leucorrhoea | infusion of the bark | [13,19] |
| | Dermatitis , joint pain and gum swelling | milky sap from bark | [12] |
| | Diarrhea | infusion of the bark or milky sap from bark | [12,19] |
| | Diabetes | quarter glass of stem bark juice in daily morning | [20] |
| | Indigestion | milky sap from bark | [12] |
| | Asthma | boiled bark | [12] |
| Leaf | Diarrhea | taken orally | [24,25] |
| | Wounds | leaf powder is mixed with coconut oil | [37] |
| | Abscess | crushed or paste leaves are applied | [22,23] |
| | Wound | paste form applied externally | [22] |
| Latex | Aphrodisiac | orally taken | [24,34] |
| | Rheumatism | milky latex externally applied | [11,26-30] |
| | Diarrhoea and dysentery | milky juice with sugar | [28,31] |
| | Pains and bruises | applied externally | [11,13] |
| | Gonorrhea | not specified | [32] |
| | Maggot wound | white latex is applied | [33] |
| | Bleeding and Boils | directly applied | [25] |
| | Blood purifier | not specified | [34] |
| | Toothache | externally applied | [27-30] |
| | Earache | directly applied | [25] |
| | Tonsils | latex rubbed on swelling twice daily for a week | [4] |
| | Heel cracks | stem latex directly | [38] |
| | Lumbago | milky latex applied externally | [11,13,26] |
| Aerial root | Morning sickness of pregnant women | fine powder boiled with goat's milk | [39] |
| | Excessive bleeding during menstruation | roots are mixed with de-husked seeds of *oryza sativa* and sugar to take three times for a day only | [8] |
| | Hair-fall | roots with coconut oil | [40] |
| | Menstruation | aerial root juice act as inhibitor | [12] |
| | Obstinate vomiting | tender ends of the aerial root | [11] |
| | Body pain and Joint pain | aerial root juice applied externally | [12] |
| | Abortion | prop roots | [41] |
| | Diarrhea | decoction from aerial roots and water obtained from rice wash | [12,42] |
| | Leucorrhoea | formulated root bark | [12,18] |
| | Jaundice | root juice (50 ml) taken once a day for 3 days. | [4,21] |
| Whole plant | Female prolonged menses and Sexual weakness | not specified | [21] |

| Plant Part | Diseases/Disorder | Application mode | References |
|---|---|---|---|
| | Bleeding of nose | 3 gm bark, bud and aerial root each boiled with water and then mixed with milk | [7] |
| | Tumor growth on bone | mixed with *saussurealappa* and applied | [35] |
| Bud | Diarrhoea and Dysentery | juice form of young bud | [27] |
| | Heamoptysis | infusion of the small branches | [9] |
| | Haemorrhage | a decoction of leaf buds in milk | [11] |
| Fruit | Food scarcity | directly eaten | [36] |
| | Billiary complication | not specified | [10] |

**Table 2. Phytochemical analysis of *Ficus bengalhensis***

| Plant Part | Phytochemicals | Qualitative analysis | Reference |
|---|---|---|---|
| Bark | Carbohydrate | Not specified (Pe, B, A, Ea, M, E, Aq) | [15, 43] |
| | Proteins | Not specified (A, M, E, Aq) | [15, 16] |
| | Alkaloids | Not specified (A, Ea, M, E, Aq),Hager's reagent (C, Ea, M ), Wagner's reagent (Pe, C, M), Mayer's reagent (B, C, Ea), Dragendorff's reagent (M) | [15-18] |
| | Fat | Not specified(Pe) | [44] |
| | Glycoside(bengalenoside,3-O-β–D-galactosyl cellobioside,3-O-α-L-rhamnoside, leucocyandin, leucopelargonidin) | Not Specified (Aq, E), Baljet test (Pe, B, M), Legal test (B, C), Keller Killani test (Ea, M), Borntrager's test (C), | [15, 17, 43, 45, 47-49] |
| | Volatile oils | Not specified (PE) | [44] |
| | Flavonoid(leucopelargonin, 5,7-dimethyl ether of leucopelargonidin-3-O-L rhamnoside, 5,3'-dimethyl ether of leucocyanidin 3-O-D galactosyl cellobioside) | Not specified (B, A, Ea, M, E, Aq),Alkali reagent (M, Pe),TLC(EA),Lead acetate test (C,Ea,M), Sodium hydroxide test (C), Magnesium ribbon test (B,C,M), Ammonia test (Pe,B) | [15-17, 43-46, 50, 51, 59] |
| | Steroids | Not specified (Pe, B, A,Ea, M, E, Aq) | [15] |
| | Phenolic compounds and Tannins | $FeCl_3$ test (Pe, C, MEa,Aq), Lead acetate test (C, E), Gelatin solution (M), Bromine water (B, M), Acetic acid solution (Pe, M), Dichromate test (Pe, B, Ea), Diluted nitric acid (B, Ea) | [15, 17, 43, 46] |
| | Saponins | Frothing test (M, Pe, B,Aq ,A, M, E) | [15, 16, 43, 46] |
| | Terpenoids | Not Specified (E) | [43] |
| | Phlobatannins | Not Specified (E) | [15] |
| | Anthroquinones | Not Specified (E) | [43] |
| Latex | Cardiac glycosides | Legal test, Keller - Killiani test(M) | [52] |
| | Anthroquinone glycoside | Brontrager test(M) | |
| | Reducing glycoside | Benedict's test(M) | |
| | Flavonoids | Shinoga test(M) | |
| | Steroid | Salkowshi reaction(M) | |
| | Alkaloids | Dragendraff's test(M), Hager test(M) | |
| | Tannins and phenolic compounds | 5% $FeCl_3$ solution(M), Diluted iodine solution(M), Diluted $HNO_3$ test(M) | |

| Plant Part | Phytochemicals | Qualitative analysis | Reference |
|---|---|---|---|
| | Proteins | Nihydrin test(M), Biuret test(M) | |
| | Rubber | Centrifuged | [53] |
| Leaves | Starch | Not specified(E) | [54] |
| | Tannin | $FeCl_3$ test(E, M) | [54, 55] |
| | Protien | Xanthoproteic test(M) | [55] |
| | Lignin | Not specified(E) | [54] |
| | Terpinoids | $H_2SO_4$ test (M) | [55] |
| | Phenols | $FeCl_3$ test(M) | [55] |
| | Sterols | Not specified(E) | [54] |
| | Flavonoids | NaOH test (E) | [54, 55] |
| | Saponin | Forth test(M) | [55] |
| Root | Reducing sugars | Benedict's test(Aq,E) | [56, 57] |
| | Glycosides | Legal's test(Aq,E) | |
| | Tannins | $FeCl_3$ test(Aq,E) | |
| Fruits and seeds | Protein and Saccharide (lectin) | Not specified | [9, 58] |

*Petroleum ether=Pe, Benzene=B, Acetone=A, Ethyl acetate=Ea, Methanol=M, Ethanol=E, Water=Aq, Chloroform=C*

## 4. PHARMACOGNOSTICAL PROPERTIES

A brief summary of the pharmacognostical properties of *Ficus benghalensis* is given in Table 3.

### 4.1 Analgesic Activity

Methanolic extract (100 mg/kg) of leaves provided 43% inhibition of acetic acid-induced writhings and showed highest basal reaction in 15 min in hot plate method [60]. Diclofenac and methanolic extract (200 mg/kg) showed 11.00±0.36 and 20 sec increasing of reaction time after 90 min treatment in hot plate method [61]. Significant analgesic activity was revealed by methanolic extract of stem bark in acetic acid induced writhing [62].

### 4.2 Anti-allergic Activity

Aqueous, ethanol, and ethyl acetate extracts showed significant decrease in leucocytes and eosinophilsin asthma by milk-induced leucocytosis and milk-induced eosinophilia [63,64].

### 4.3 Antiatherogenic Activity

Treatment of isolated flavonoids form bark (100 mg/kg/day) was significantly reversed or restored atherogenic index, HMGCoA reductase, lipoprotein lipase activity, incorporation of labeled acetate into free and ester cholesterol, adipose tissue and plasma LCAT activity in cholesterol diet fed rats [50]. In cholesterol fed rat anti-atherogenic index was 1.69±0.008 TC/HDL for isolated (100 mg/kg body weight) leucodelphinidin collected from bark [51].

### 4.4 Antibacterial Activity

Aqueous and ether extract (10gm/100ml) reveal good inhibition zone against *E.coli* (8mm, 5mm), *S.typhi,* (6 mm, 5 mm) and *L.acidophilus* (5mm, 7mm). At same concentration of methanol extract displayed 6mm inhibition zone against *E.coli* [65]. Aqueous, methanol and chloroform extract of root at 0.4 mg/well provided significant activity by producing highest inhibition zone against *Staphylococcus aureus* (7.82+0.03 mm), *Pseudomonas aeruginosae* (11.7+0.1 mm) *and E.coli*mutants (10.55+0.12 mm), respectively [66]. Ethanolic extract of FB provided 6.5mm inhibition zone against *B.cereus* [67]. Methanolic extract of FB showed 11 mm inhibition zone of both *S. epidermidis* and *B. subtilis* detected by DIC [68]. Significant inhibition zones were found against *B. cereus* (16mm) and *S. aureus* (12mm) by methanolic extract of FB [18]. Methanolic extract of flavonoid (100 µg/ml) isolated from bark of FB showed potent antibacterial activity against *E. coli, Proteus vulgaris, Staphylococcus aureus, Bacillus subtilis*and *Pseudomonas auruginosa* as 13.9±0.54, 15.4±0.36, 14.3±0.5, 23.7±0.32 and 23.9±0.7 mm inhibition zone [46].

0.08, 0.09 and 0.10 mg/ml concentration of hydro alcoholic extract of bark showed inhibition zone as 9.4, 13.6 and 15.2 mm against *Actinomycets viscosus by* cup plate diffusion Method [69]. Amikacin and methanolic extract provided inhibition zone as 20 and 16 mm, respectively against *E. coli* [70]. Highest inhibition zones were 30, 24 and 22 mm for ethanolic extract (75 mg/ml) and 14, 12 and 14 mm for aqueous extract of root against *Staphylococcus aureus, Escherichia coli* and *Klebsiella pneumonia,* respectively [71]. Ethanolic extract of bark showed 6.5 mm inhibition zone against *B. cereus* [72].

## 4.5 Anticancer Activity

Methanolic extract of leaves displayed 22.1and 16.4% cytotoxicity on HepG2 and MCF-7at 100ppm, respectively and branch extract showed 8.27 and 14.8% cytotoxicity on HepG2 and MCF-7 cytotoxicity, respectively at 100 ppm [73].

**Table 3. Pharmacognostical properties of *Ficus benghalensis***

| Activity | Plant part | Extract | Details | Reference |
|---|---|---|---|---|
| Analgesic | Leaves | Methanol | Showed 43% inhibition of acetic acid-induced writhings and 15 min increased in basal reaction time in hot plate method. | [60] |
| | Leaves | Methanol | 200 mg/kg showed 20 sec increasing of reaction time after 90 min treatment in hot plate method. | [61] |
| | Bark | Methanol | Displayed significant activity in acetic acid induced writhing. | [62] |
| Anti-allergic | Bark | Aqueous, Ethanol, Ethyl-acetate | Reduced leucocytes and eosinophilsin milk-induced leucocytosis and eosinophilia. | [63, 64] |
| Anti-atherogenic | Bark | Not specified | Significant activity observed from the treatment of leucopelargonin derivative (100 mg/kg/day) in cholesterol diet fed rats. | [50] |
| | Bark | Not specified | Isolated leucodelphinidin displayed 1.69 TC/HDL activity in cholesterol fed rat model. | [51] |
| Anti-bacterial | Root | Aqueous, Methanol, Chloroform | Among them chloroform extract showed highest inhibition zone against *E. coli* mutants as 10.55+0.12 mm examined by cup plate method | [66] |
| | Fruit | Aqueous Methanol Ether | Aqueous and methanol extract showed highly response against *E.coli* and ether extract showed against *L. acidophilus* detected by DIC | [65] |
| | Not specified | Ethanol | Extract showed 6.5 mm inhibition zone against *B. cereus.* | [67] |
| | Root | Aqueous Ethanol | Aqueous and ethanolic extract showed 14 mm and 30 mm inhibition zone against *S. aureus,* respectively. | [71] |
| | Not specified | Methanol | Extract showed 11 mm inhibition zone of both *S. epidermidis* and *B. subtilis* detected by DIC | [68] |
| | Bark | Methanol, | Methanolic extract showed 16 mm | [70] |

| Activity | Plant part | Extract | Details | Reference |
|---|---|---|---|---|
| | | Aqueous, Chloroform Petroleum ether | inhibition zone against *E. coli* compare with amikacin (20 mm). | |
| | Not specified | Methanol | Inhibition zones were 16 and 12 mm against *B. cereus* and *S. aureus*. | [18] |
| | Bark | Ethanol | Showed 6.5 mm inhibition zone against *B. cereus* | [72] |
| | Not spcified | Methanol | Showed highest activity against *Bacillus subtilis* (23.7±0.32 mm) and *Pseudomonas auruginosa* (23.9±0.7mm) by DIC method. | [46] |
| | Bark | Alcohol | Extract (0.10 mg/ml) showed inhibition zone as 15.2 mm against *Actinomycets viscosus* by cup plate diffusion method. | [69] |
| Anti-cancer | Leaf | Methanol | Not significant on HepG2 and MCF-7 cell line. | [73] |
| | Branch | Methanol | Did not show cytotoxicity on human on MCF-7 and HepG2 cell line. | [73] |
| Anti-diabetic | Bark | Not specified | Glibenclamide and leucodelphinidin improved glucose tolerance in diabetic rat model as 70% and 35%, respectively. | [74] |
| | Bark | Not specified | Isolated leucocyandin 3-0-beta-D-galactosyl cellobioside treatment inhibited insulin degradative processes in alloxan-induced diabetic rat model. | [48] |
| | Root Bark Fruit | Ethanol | Among those extracts fruits had more reduction ability. | [77] |
| | Bark | Not specified | Isolated leucopelargonidin and glibenclamide demonstrated similar significant hypoglycemic and insulin raising effects in moderately diabetic rat model. | [49] |
| | Bark | Aqueous | Observation of STZ- induced diabetic rat model provided equivalent decreasing blood glucose levels of extract and tolbutamide. | [75] |
| | Bark | Not specified | Isolated leucopelargonin derivative (100 mg/kg/day) reduced blood sugar (34%) and glycosylated haemoglobin (28%) in alloxan diabetic dogs. | [50] |
| | Stem bark | Aqueous | Extract treatment provided better reduction (52%) of fasting blood glucose than tolbutamide (32%). | [76] |
| | Bark | Ethanol | Bengalenoside revealed more efficacy than crude extract. | [47] |
| Anti-fungal | Root | Aqueous, Methanol, Chloroform | Among of them chloroform extract showed highest inhibition zone against *Aspergillus niger (*8.61±0.09) | [66] |

| Activity | Plant part | Extract | Details | Reference |
|---|---|---|---|---|
| | | | by cup plate method. | |
| Anti-helmintic | Latex | Not Specified | 26.3 min time taken for death of *Pheritima posthuma*. | [78] |
| | Fruit | Aqueous | *Pheritima posthuma* became dead after 8 min treatment. | [79] |
| Anti-inflammatory | Bark | Aqueous, Methanol | Methanol extract (200 µg/ml) showed 67.24±1.01% inhibition where diclofenac (100 µg/ml) showed 79.25±1.31%. | [80] |
| Anti-mutagenic | Bark | Not specified | Inhibited micronucleus formation and chromosomal aberrations. | [81] |
| Antioxidant | Stem bark | Methanol | 100 µg/ml exhibited 85.46% and 88.62% inhibition of DPPH and $H_2O_2$ by DPPH and hydrogen peroxide model. | [15] |
| | Leaf | Methanol | Activity showed as $ED_{50}$ (49.7) and $ED_{90}$ (66.7). | [73] |
| | Branch | Methanol | Showed activity as $ED_{50}$ (47.3) and $ED_{90}$ (79.2). | [73] |
| | Leaf | Ethyl acetate | Fraction showed activity as $ED_{50}$ (49). | [73] |
| | Bark | Ethanol | $IC_{50}$ of scavenging of superoxide anion, hydroxyl radical, nitric oxide, hydrogen peroxide and metal chelating were found to be, 63, 46, 47 and 53 µg/ml, respectively by SASA, HRSA, NOSA, HPSA, FeCSA, respectively. | [43] |
| | Latex | Methanol | Highest scavenging of $IC_{50}$ of DPPH radical, $FeCl_3$ and phosphor-molybdenum were found to be 28.63±0.16, 49.82±1.00 and 31.84±0.12 µg/ml, respectively detected by above assay. | [52] |
| | Bark | Aqueous | Extract (500 mg/kg) decreased the lipid peroxidation index significantly | [75] |
| Anti-rheumatic | Stem bark | Methanol | 300 mg/kg exhibited activity in FCA-induced edema arthritis in rat model. Extract and ASA showed 78.42 and 67.54% inhibition, respectively in formalin-induced arthritis in rat model. | [15] |
| | Bark | Pet Ether Chloroform Ethanol, Aqueous | Ethanolic extract showed highest (63%) inhibition where indomethacin showed 62% by FCA-induced paw edema rat model. | [44] |
| Anti-ulcerogenic | Leaf | Aqueous | Ranitidine (50 mg/kg) and extract (500 mg/kg) displayed 73.21 and 63.24% reduction in pylorus ligation induced ulcer model. 64.91and 47.36% reduction was occurred by extract (500 mg/kg) and sucralfate inaspirin induced gastric ulcers model. | [82] |

| Activity | Plant part | Extract | Details | Reference |
|---|---|---|---|---|
| CNS depressant | Leaf | Ethanol | In hole cross test, open field test, thiopental sodium-induced sedative test and beam walking test, extract (250 and 500 mg/kg) possessed significant activity. | [83] |
| Cytotoxic | Bark | Aqueous | Partially purified hypoglycemic preparation of extract had high $LD_{50}$. | [84] |
| | Not specified | Methanol | 100% cell viability showed at 40 µl extract by MTT assy. | [85] |
| | Arial root | Methanol | $LD_{50}$ was more than 2000 mg/kg body weight. | [86] |
| | Bark | Ethanol Aqueous | No signs of toxicity or mortality were observed at 2000 mg/kg. | [87] |
| | Bark | Methanol | No toxicity was observed up to 4g/kg dose. | [15] |
| Heamatological | Bark | Aqueous | Hematological parameters were returned to normal after administration of the extract for 12 weeks in STZ-induced diabetes rat model. | [89] |
| Hepatoprotective | Aerial root | Methanol | 300 mg/kg treatment increased GSH (89.6±0.25 nmol/g) and reduced TBARS (292.91±0.32 nmol/g) in isoniazid-rifampicin induced hepatotoxic rats. | [88] |
| | Bark | Methanol, Ethyl acetate | Extracts of bark reduced SGOT and SGPT enzymes significantly in $CCl_4$ induced rat model. | [90] |
| | Bark | Methanol | Showed reduction of liver marker enzymes. | [91] |
| Hypo-lipidemic | Bark | Not specified | Isolated leucopelargonidin showed significant hypolipidemic activity. | [49] |
| | Bark | Not specified | Isolated leucodelphinidin derivative reduced total cholesterol and LDL as 108.2 and 36.6 mg/100 ml where increased HDL 63.9±0.53 mg/100ml in hypercholesterolemic rats. | [51] |
| Immuno modulatory | Arial root | Methanol, Aqueous | Methanolic extract (0.5 mg/ml) and control exhibited phagocytosis whereas 53 and 31%. 55% and 32% phagocytosis occurred by aqueous extract (1 mg/kg) and control, respectively in *in vitro* phagocytosis test. 200mg/ kg possessed early and delayed type hypersensitivity as 0.92±0.28 and 0.76±0.28, respectively in rat model. | [86] |
| Renal protective | Stem Bark | Aqueous | Biochemical parameters were returned to normal after administration of the extract for 12 weeks in STZ-induced diabetes rat model. | [89] |
| Wound-healing | Bark | Ethanol Aqueous | Both extract (200 mg/kg) and control provided healing in 17.16, 18.33 and | [87] |

| Activity | Plant part | Extract | Details | Reference |
|---|---|---|---|---|
| | | | 21.50 days, respectively in excision wound model. Also increased wound-breaking strength at same doses in incision wound model. | |

### 4.6 Antidiabetic Activity

Leucodelphinidin derivative (250 mg/kg) isolated from the bark of FB and glibenclamide (2 mg/kg) showed 30% and 70% glucose tolerance, respectively [74]. 2 hours treatment of dimethoxy derivative (250 mg/kg) isolated from bark increased serum insulin level in blood [48]. Aqueous extract (500 mg/kg body weight/day) of bark decreased the blood glucose level as 169±2.65, 168±1.54 and 173±2.03 mg/dl after 5 hrtreatment in STZ-induced diabetic fasted, fed and glucose loaded rats,respectivelywhich was equivalent to tolbutamide (100 mg/kg body weight/day)and this reduction was occurred for restoring serum enzymes level [75]. Aqueous extract of bark (20 g/kg) and tolbutamide (15 mg/kg) showed 52% and 36% reduction on fasting blood glucose, respectively [76]. Ethanolic extracts of fruit, aerial root and bark of FB at 120 mg/kg for 15 days decreased blood glucose level as 31.73, 18.33, and 28.84%, respectively where glibenclamide (0.5 mg/kg) showed 34.4% reduction [77]. Bengalenoside isolated form bark provided more efficacious than crude extract and half as potent as tolbutamide [47]. Leucopelargonidin, a glycoside detected from the bark provided significant hypoglycemic and serum insulin raising effects displaying closely similar effect of glibenclamid [49]. Isolated glycoside viz. leucopelargonin derivative (100 mg/kg/day) form bark helped in reducing blood sugar (34%) and glycosylated haemoglobin (28%) of alloxan diabetic dogs [50].

### 4.7 Antifungal Activity

Aqueous, methanol and chloroform extract of root at 0.4 mg/well showed activity against *Aspergillus niger* as 6.35±0.07, 6.35±0.16 and 8.61±0.09 mm inhibition zone, respectively [66].

### 4.8 Antihelmintic Activity

*Pheritima posthuma* took time 26.3 and 13.2 min for death after treatment of latex of FB (250 µl) and metronidazole (10 mg/ml), respectively [78]. Aqueous extract (37.5 mg/ml) of fruits of FB showed paralyzed and death condition at 5.30 and 8.00 min of *Pheretima posthuma* [79].

### 4.9 Anti-inflammatory Activity

Four hours treatment of metanolic extract (300 mg/kg), indomethacin (100 mg) and indomethacin (100 mg/kg) with extract (100 mg/kg) showed reduction ability as 40.37, 42.66 and 44.50%,respectively in agar-induced paw edema in rat model [15]. Methanol extract (200 µg/ml) and diclofenac (100 µg/ml) showed 67.24±1.01 and 79.25±1.31% inhibition, respectively in HCSM [80]. Methanolic extract of leaves 100 mg/kg, 200 mg/kg and diclofenac (10 mg/kg) showed 59.42, 65.21 and 62.31% inhibition of formalin induced paw edema in rats [61]. Methanolic extract of bark possessed significant exhibition of both acute (acetic acid induced vascular permeability and carrageenan induced hind paw edema) and sub-chronic (cotton pellet-induced granuloma) animal models [62].

### 4.10 Anti-mutagenic Activity

Bark extract at 800, 500 and 250 mg/kg body weight provided anti-mutagenic activity by significant inhibition of micronucleus formation and significant inhibition of chromosomal aberrations after 24 hr oral administration [81].

### 4.11 Anti-oxidant and Free Radical Scavenging Activity

Methanolic extract at 100 µg/ml exhibited 88.62 and 85.46% inhibition of hydrogen peroxide and DPPH free radicals, respectively where $IC_{50}$ values were 44.73 and 51.83 µg/ml respectively [15]. Methanolic extract of FB leaves provided $ED_{50}$ (49.7) and $ED_{90}$ (66.7) of DPPH scavenging where branch of FB reveal $ED_{50}$ (47.3) and $ED_{90}$ (79.2). Insoluble fraction from ethyl accetate of FB leaves showed activity as $ED_{50}$ (49) and $ED_{90}$ (94.2) [73]. The $IC_{50}$ values of scavenging of superoxide anion, hydroxyl radical, nitric oxide, hydrogen peroxide and metal chelating were found to be 26, 63, 46, 47 and 53µg/ml, respectively of ethanolic extract of bark detected by SASA, HRSA, NOSA, HPSA, FeCSA, respectively [43]. $IC_{50}$ values of methanolic extract of latex for scavenging DPPH, ferric

chloride and phosphor-molybdenum were found to be 28.63±0.16, 49.82±1.00 and 31.84±0.12 µg/ml respectively [52]. Bark extract (500 mg/kg body weight/day) decreased the lipid peroxidation index significantly within 12 weeks [75].

### 4.12 Anti-rheumatic Activity

Methanolic extract (300 mg/kg) of bark exhibited significant efficacy in Freund's FCA-induced edema arthritis in rat model. In formalin-induced arthritis in rat model provided 78.42 and 67.54% inhibition after 15-30 min by same dose of bark extract and acetyl salicylic acid (100 mg/kg), respectively [15]. Indomethacin (10 mg/Kg), pet-ether, ethanol, chloroform and aqueous extract of bark at 300 mg/Kg inhibited paw edema as 62.34, 58.43, 63.64, 61.69 and 31.82% after four week treatment in FCA-induced arthritis in rat model [44].

### 4.13 Anti-ulcerogenic Activity

Treatment of ranitidine (50 mg/kg), aqueous extract of leaf at 500 and 250 mg/kg displayed 73.21, 63.24 and 51.28% reduction of ulcer indexin pylorus ligation induced ulcer model in rat. Aspirin induced gastric ulcers model revealed 64.91, 28.94 and 47.36% reduction by aqueous extract (500 and 250 mg/kg) and sucralfate [82].

### 4.14 CNS Depressant Activity

In hole cross test and open field test, ethanolic extract of leaves (250 and 500 mg/kg) provided significant decrease of movement from its initial value 0 to 120 min. At same dose treatment decreased onset of thiopental sodium action and increased the duration of sleep in thiopental sodium-induced sedative test. In beam walking test, extract (500 mg/kg) induced motor coordination deficit in mice model [83].

### 4.15 Cytotoxic Activity

According to OECD no mortality was observed by methanolic extract treatment of Stem bark up to 4 g/kg dose [15]. Partially purified hypoglycemic preparation of bark at 1.1 and 1.3 gm/kg dry weight of preparation provided 60% and 70% mortality, respectively [84]. Methanol extract at 40 µl of FB provided 100% cell viability detected by MTT assay [85]. Methanolic extract of aerial root provided $LD_{50}$ as 2000 mg/kg body weight [86]. At 2000 mg/kg dose of ethanolic and aqueous extract of bark did not displayed toxicity or mortality [87]. Moreover, no mortality and signs of behavioral changes were observed after oral administration of methanol extract of areal root up to 5000 mg/kg body weight [88].

### 4.16 Hematological Activity

Administration of extract at 500 mg/kg of body weight per day for 12 weeks in STZ-induced diabetes rat model returned hematological parameter (hemoglobin, red blood cell, and white blood cell) to normal [89].

### 4.17 Hepatoprotective Activity

Methanolic extract (300 mg/kg) of aerial root increased total bilirubin (0.73±0.11 mg/dl), total protein (13±0.31 mg/dl), albumin (4.4±0.09 mg/dl) and decreased glutamic-oxalacetic transaminase (170±2.6 IU/dl), Serum glutamic pyruvic transaminase (67±1.7 IU/dl) and TBARS (292.91±0.32 nmol/g) in isoniazid-rifampicin induced hepatotoxic rats [88]. Ethyl acetate fraction (50 mg/kg) and methanolic extract (100 mg/kg and 250 mg/kg) of barks showed significant reduction of SGOT and SGPT enzymes in $CCl_4$ induced rat model [90]. Treatment of methanolic extract (250 mg/kg) of bark reduced SGOT, SGPT and bilirubin levels as 59.04±3.40 U/ml, 106.65±4.83 U/ml,19.18±0.37 U and 1.4±0.19 mg/dl in the $CCl_4$ treated groups [91].

### 4.18 Hypolipidemic Activity

Significant hypolipidemic activity was evaluated by leucopelargonidin isolated from bark [49]. Reduction in serum total cholesterol (108.2±1.81 mg/100 ml), LDL-cholesterol (36.6±0.63mg/100 ml) and stimulation in the HDL-cholesterol levels (63.9±0.53 mg/100 ml) had observed after the treatment of leucodelphinidin derivative (100 mg/kg/day) in hypercholesterolemic rats. It also significantly increased hepatic bile acids, fecal excretion of bile acids and neutral sterols [51].

### 4.19 Immuno-modulatory Activity

Methanol extract of aerial root at 0.5, 1.0, 2.0 mg/ml and control exhibited 53, 49, 46 and 31% increasing of phagocytosis, where as 55% and 32% phagocytosis increase occurred by aqueous extract (1 mg/kg) and control. Extract at 200mg/kg treatment also showed in early (4 hr) and delayed (24 hr) type hypersensitivity as 0.92±0.28 and 0.76±0.28, respectively in rat model [86].

### 4.20 Renal Protective Activity

Total protein, albumin, urea, uric acid, creatinine were returned to normal level after administration of the extract at 500 mg/kg of body weight per day for 12 weeks in STZ-induced diabetes rat model [89].

### 4.21 Wound Healing Activity

Aqueous extract (200 mg/kg), ethanolic extract (200 mg/kg) and control provided healing in 17.16, 18.33 and 21.50 days, respectively in excision wound model. At same dose treatment of ethanolic and aqueous extract of bark displayed significant increasing of wound-breaking strength when compared with the control in incision wound model [87].

## 5. CONCLUSION

In era of the extensive outgrowth of genetic engineering and nanotechnology in pharmaceutical sectors, plant based research is still prevailing to find out new remedies from various diseases globally for having less side effects and eco-friendliness. Moreover, medications prepared from plant are comparatively inexpensive and impoverished people over the world are still relying on their local medicinal plants for relief from light fever to lethal diseases. It is clear that, *F. benghalensis* provides us shelter not only under its canopy but also therapeutically from prehistoric times. Latest pharmacological and pharmacognostical evaluations also substantiate its huge potential against several disorders including diabetes, diarrhea, skin diseases etc. Therefore, this review is although not enough to delineate its diverse therapeutical features but this abridged edition will be helpful to those who are carrying out their research to explore novel activities of *F. benghalensis* in the field of pharmacology and pharmacognosy.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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