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REVIEW ARTICLE

# Traditional uses, medicinal properties, and phytopharmacology of *Ficus racemosa*: A review

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## Abstract

*Ficus racemosa* Linn. (Moraceae) is a popular medicinal plant in India, which has long been used in Ayurveda, the ancient system of Indian medicine, for various diseases/disorders including diabetes, liver disorders, diarrhea, inflammatory conditions, hemorrhoids, respiratory, and urinary diseases. *F. racemosa* is pharmacologically studied for various activities including antidiabetic, antipyretic, anti-inflammatory, anti-tussive, hepatoprotective, and antimicrobial activities. A wide range of phytochemical constituents have been identified and isolated from various parts of *F. racemosa*. In this review, a comprehensive account of its traditional uses, phytochemical constituents, and pharmacological effects is presented in view of the many recent findings of importance on this plant.

**Keywords:** *Ficus racemosa*; biological activity; phytopharmacology; medicinal properties; toxicity

## Introduction

Medicinal plants, since times immemorial, have been used in virtually all cultures as a source of medicine. The widespread use of herbal remedies and healthcare preparations, as those described in ancient texts such as the Vedas and the Bible, and obtained from commonly used traditional herbs and medicinal plants, has been traced to the occurrence of natural products with medicinal properties (Hoareau & DaSilva, 1999). The use of traditional medicine and medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has also been widely observed (UNESCO, 1996). Furthermore, an increasing reliance on the use of medicinal plants in industrialized societies has been traced to the extraction and development of several drugs and chemotherapeutics from these plants as well as from traditionally used rural herbal remedies (UNESCO, 1998). The World Health Organization has estimated that 80% of the world's population use botanical medicine for their primary health care needs (Akerele, 1993).

*Ficus racemosa* Linn. (Moraceae) is an evergreen, moderate to large-sized spreading, lactiferous, deciduous

tree 15–18 m high, without prominent aerial roots (Varier, 1995). *Ficus* is an exceptionally large pan-tropical genus with over 700 species (Berg, 1989) distributed widely throughout the warmer parts of Asia, Africa, America, and Australia. It is retained as a single, large genus because it is well defined by its unique reproductive system, involving syconia fig and specialized pollinator wasps (Novotny et al., 2002). *F. racemosa* is commonly known as 'gular', and all parts of this plant are regarded medicinally important in Ayurveda and it has been used extensively in the treatment of biliary disorders, jaundice, dysentery, diabetes, diarrhea and inflammatory conditions (Kirtikar & Basu, 1975; Nadkarni et al., 1976; Chopra et al., 1958).

In this review a comprehensive account of the morphology, phytochemical constituents, traditional uses, and pharmacological activities are included in view of the many recent findings of importance on this plant.

## Taxonomy of *Ficus racemosa*

Kingdom: Plantae, Planta, Planter, Plants, Vegetal; Sub Kingdom: Tracheobionta, Vascular Plants; Division: Magnoliophyta; Superdivision: Spermatophyta; Class:

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*Magnoliopsida*; Subclass: *Hamamelididae*; Order: *Urticales*; Family: *Moraceae*; Genus: *Ficus* L.

### Synonyms

*Covellia glomerata* (Roxb.) Miq., *Ficus glomerata* Roxb., *Ficus vesca* F.Muell. ex Miq., and *Ficus semicostata* F.M.Bailey (DMP, 1982).

### Common names

Gular fig, cluster fig, country fig and redwood fig (Joy et al., 2001).

### Vernacular names

English: Cluster fig, Country fig, Redwood fig; Chinese: Ju Guo Rong; Burmese: Jagyadumbar; Hindi: Gular; Urdu: Dimiri; Sanskrit: Udumbara; Kannada: Atti; Bengali: Dumur; Tamil: Atti (DMP, 1982; Kunwar & Bussmann, 2006).

### Distribution

*F. racemosa* is not epiphytic but is found throughout greater part of India in moist localities, along the banks of streams, sides of ravines and also on rocky slopes, sometimes almost gregariously. It is also found in Burma, China, Indonesia, Malaysia, and Australia (DMP, 1982). It is often cultivated round villages in India for its edible fruits (CSIR, 1952).

### Morphology

*F. racemosa* is an evergreen, moderate to large, spreading, lactiferous, deciduous tree (Figure 1), 15-18 m high, without prominent aerial roots (Varier, 1995). Young shoots are glabrous, pubescent or scaberulous, leaves are dark green colored, 7.5-15 by 3.2-6.3 cm, ovate oblong, or elliptic-lanceolate, tapering to a bluntish point at the apex, with entire margins, glabrous on both surfaces when mature, base acute or rounded, 3-nerved; lateral main nerves 4-6 pairs; petioles 1.3-3.8 cm long, glabrous; stipules 2 cm long, ovate-lanceolate, scarious, pubescent; fruit receptacles 2-5 cm in diameter, subglobose or pyriform, found in large clusters on short leafless branches arising from main trunk or large branches (Figure 2).

Figs are smooth or pubescent and rarely covered with minute soft hairs. When ripe, they are orange, dull reddish or dark crimson (Figure 3) with depressed umbilicus (edible but usually full of worms); basal bracts 3, ovate-triangular; male, female, and gall flowers together in one receptacle, the male flowers forming a layer near the walls of the receptacle, and the gall flowers a more internal layer; male flowers sessile; sepals 3-4, membranous, inflated, enveloping the 2 elongate ovate anthers; filaments connate; gall

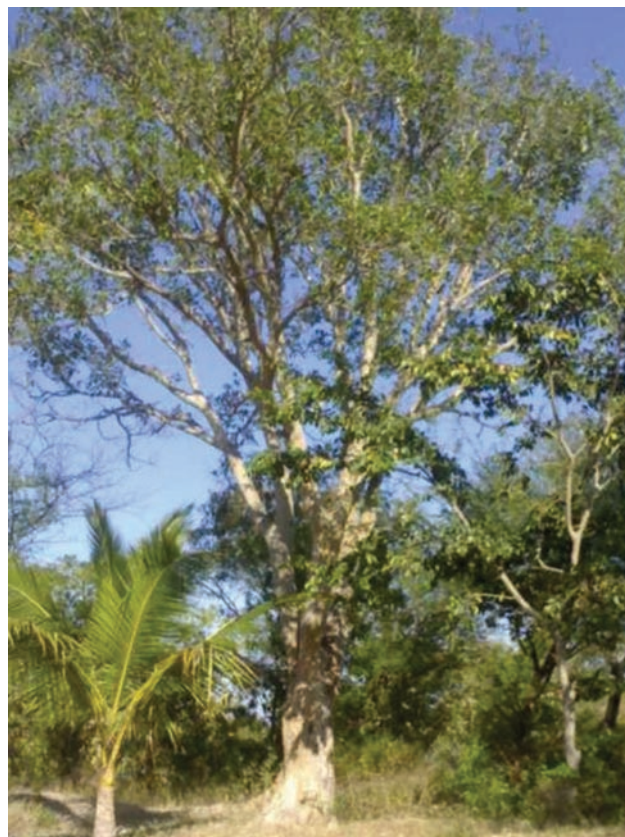


Figure 1. *Ficus racemosa* tree.



Figure 2. Unripe fruits of *Ficus racemosa*.

flowers pedicellate; perianth gamophyllous, irregularly toothed, covering only the base of the rough ovoid ovary; style lateral, elongate; stigma clavate; fertile flowers subsessile; perianth gamophyllous, with 4 or 5 long lanceolate teeth enveloping the small minutely tuberculate achene; style sub-terminal; stigma clavate (Kirtikar & Basu, 1975).

The fruits, borne in great profusion, mature generally from March to July. When fully ripe, they have a pleasant



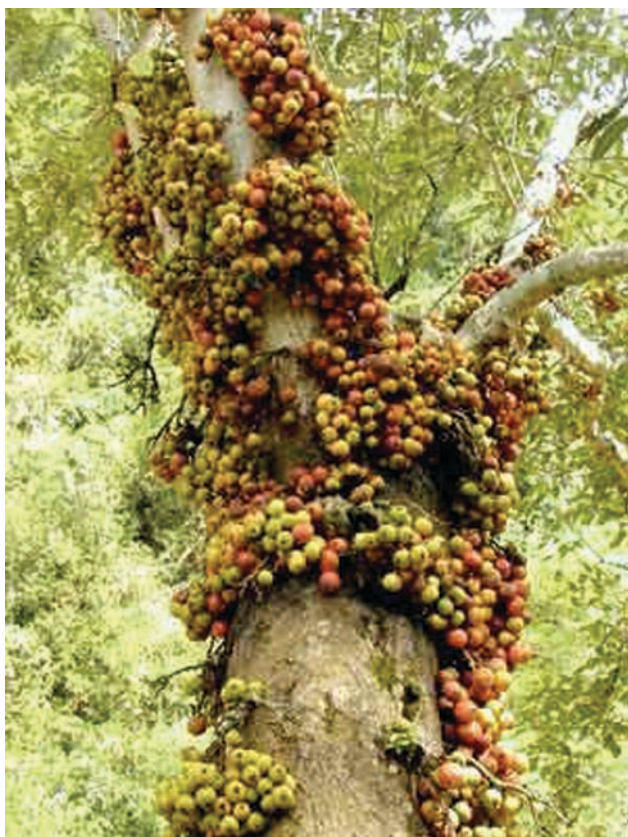


Figure 3. Ripe fruits of *Ficus racemosa*.

odor, resembling that of cider apples. Often they are full of maggots of the fertilizing wasp and unfit for eating (CSIR, 1952). The bark is astringent, rusty brown with a fairly smooth and soft surface, the thickness varies from 0.5-2 cm according to the age of the trunk or bark, surface with minute separating flakes of whitish tissue, texture homogenous leathery (Varier, 1995).

#### Traditional uses

*F. racemosa*, which has been reported to have many medicinal properties, is widely cultivated all over India (Trivedi et al., 1969). Different parts of the plant are traditionally used as fodder (CSIR, 1952), edible and ceremonial (Manandhar, 1972; DMP, 1982; Dhakal & Aizz, 1996; Chaudhary et al., 1999; Pathak, 2000; Sah et al., 2002; Manandhar & Acharya, 2003). All parts of this plant (leaves, fruits, bark, latex, and sap of the root) are medicinally important in the traditional system of medicine in India (Kirtikar & Basu, 1975).

#### Leaves

A mixture of leaves powdered with honey is used in bilious infections (Kirtikar & Basu, 1975). A decoction of leaves is used as a douche in dysmenorrhea (Nadkarni

et al., 1976), as a wash for wounds and ulcers. Leaf juice is massaged on hair to prevent splitting. Leaf latex is used for boils and blisters and measles (Siwakoti & Siwakoti, 2000).

#### Fruits

The fruit is an astringent, stomachic, carminative given in menorrhagia and hemoptysis (Chopra et al., 1958). Fruits are used as a remedy for visceral obstruction, diarrhea and constipation (Vihari, 1995). A bath made of fruit and bark is regarded as a cure for leprosy. The fruit is regarded as a good remedy for diabetes (Nadkarni et al., 1976).

#### Bark

The bark is astringent. An infusion of bark is employed as mouth wash in spongy gum condition, dysentery, menorrhagia, hemoptysis, and diabetes (Chopra et al., 1958). It is also used as a wash for wounds, highly efficacious in threatened abortions and also recommended in uropathy. A decoction of bark is given in asthma and piles (Kirtikar & Basu, 1975). The sap extracted from the trunk has been described as valuable medicine in diabetes. Paste of stem bark is used in burns, swelling, leucorrhea (Paudyal, 2000) dysentery and diarrhea (Tiwari, 2001).

#### Latex

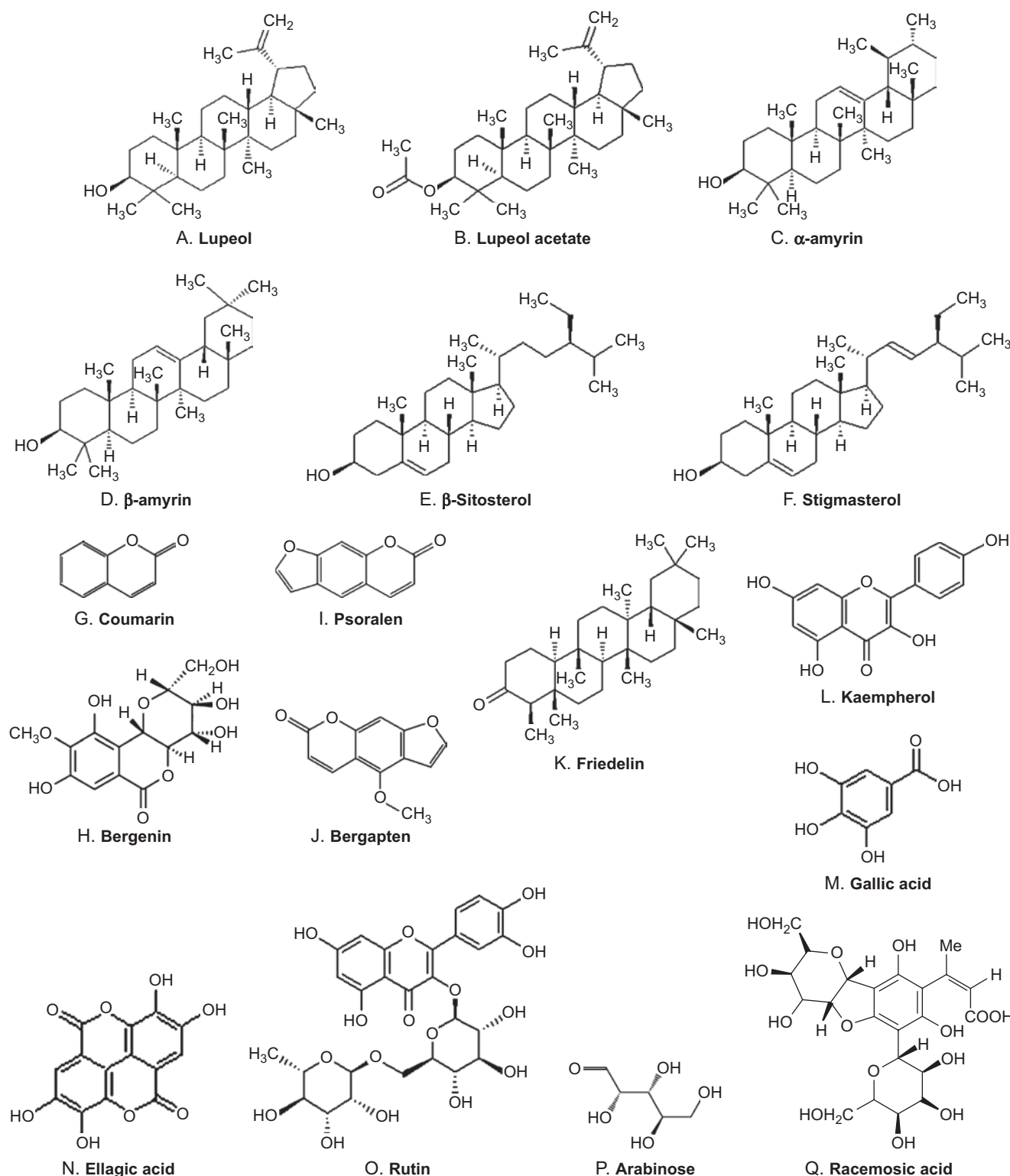
The latex is aphrodisiac and is administered in boils, diarrhea, dysentery, and hemorrhoids (Yadav, 1999). It is also used to cure stomachache (Ghimire et al., 2000), cholera and mumps (Basnet, 1998). It has been reported in the indigenous system of medicine in Sri Lanka in the treatment of skeletal fracture (Ekanayake, 1980) to control severe diarrhea, particularly in children (Bheemachari et al., 2007). Latex is used as adhesive (Dangol, 2002).

#### Sap of the root

Sap of the root is given for gonorrhea, diabetes and as a topical application in mumps and other inflammatory glandular enlargements (Chopra et al., 1958). Root sap is claimed to cure heat stroke, chronic wounds and malaria in cattle (Thapa, 2001).

#### Phytochemistry

The leaves contain triterpenoids (Mandal et al., 1999) tannins, kaempferol, rutin, arabinose, bergapten, psoralenes, flavonoids, fucosin, coumarin, phenolic glycosides (Baruah & Gohain, 1992; Deraniyagala et al., 1998) and saponins (Din et al., 2002). Fruits are reported to contain sterols, triterpenoids, flavonoids, glycosides, tannins, carbohydrates (Deshmukh et al., 2007),  $\beta$ -sitosterol, gluconol acetate, hentriacontane, tiglic acid



**Figure 4.** Structures of phytochemicals identified and isolated from various parts of *Ficus racemosa*.

of taraxasterol, lupeol acetate (Singhal & Saharia, 1980; Nguyen et al., 2001; Chandra et al., 1979; Merchant et al., 1979), gallic acid, ellagic acid (Rao et al., 2008) and  $\alpha$ -amyrin acetate (Narender et al., 2008). Stem bark

contains steroids, alkaloids, tannins (Rao et al., 2002a), gluanol acetate, leucocyanidin-3-*O*- $\beta$ -D-glucopyranoside, leucopelargonidin-3-*O*- $\beta$ -D-glucopyranoside, leucopelargonidin-3-*O*- $\alpha$ -L-rhamnopyranoside,

ceryl behenate, lupeol acetate,  $\alpha$ -amyrin acetate (Joy et al., 2001), lupeol (Balas & Agha, 1985; Singhal & Saharia, 1980; Nguyen et al., 2001), friedelin, behenate (Malairajan et al., 2006), stigmasterol (Singhal & Saharia, 1980),  $\beta$ -sitosterol,  $\beta$ -sitosterol-D-glucoside (Singhal & Saharia, 1980; Nguyen et al., 2001; Chandra et al., 1979; Balas & Agha, 1985), gluanol acetate (Rahuman et al., 2008), and quercetin (Khan & Sultana, 2005a). Bergenin, racemosic acid, (Veerapur et al., 2007; Li et al., 2004) friedelin (Balas & Agha, 1985),  $\beta$ -sitosterol,  $\beta$ -amyrin, and lupeol acetate (Rahman et al., 1994) have been isolated from the bark of *F. racemosa* (Figure 4, A-Q).

### Biological activities

#### Hypoglycemic/antihyperglycemic activity

Antidiabetic potential of various parts of *F. racemosa* has been evaluated in alloxan/streptozotocin-induced diabetic rats/rabbits. Aqueous extract equivalent to 15 g of *F. racemosa* bark powder decreased blood glucose to an extent of 13.3%; 18.8% at 18 h and 48 h fasting intervals in normoglycemic rabbits and 6%; 17% in diabetic rabbits (Shrotri & Aiman, 1960).

Aqueous and ethanol extracts of the stem bark (300 and 400 mg/kg body weight) exhibited prominent long-term antihyperglycemic effect by reducing the blood glucose to an extent of 80% in alloxan-induced diabetic rats. The hypoglycemic effect of ethanol extract was comparable with that of glibenclamide (Vasudevan et al., 2007). The extracts significantly increased the plasma insulin levels and inhibited the activity of glucose 6-phosphatase and hexokinase. Ethanol extract of *F. racemosa* bark (300 mg/kg body weight) reduced the blood glucose, serum lipids and lipoproteins to near normal range and these effects were comparable with that of the standard antidiabetic drug-glibenclamide (Sophia & Manoharan, 2007). Similarly, methanol extract of the stem bark at doses of 200 and 400 mg/kg exhibited significant hypoglycemic effect in both normal and alloxan-induced diabetic rats, comparable to that of glibenclamide (10 mg/kg), a standard antidiabetic agent (Rao et al., 2002b). In another study, petroleum ether extract of the fruits (200 mg/kg) exhibited a significant anti-hyperglycemic activity in alloxan-induced diabetic mice (Deshmukh et al., 2007) and oral doses of petroleum ether extract (250 mg/kg) significantly lowered blood sugar, serum cholesterol, serum urea and serum triglyceride levels in alloxan-induced diabetic treated rats and the hypoglycemic effects were compared with those of glibenclamide (Patil et al., 2006).  $\alpha$ -Amyrin acetate (100 mg/kg) isolated from the fruits of *F. racemosa* lowered the blood glucose by 18.4% and 17.0% at 5 and 24 h, respectively, in sucrose challenged streptozotocin-induced diabetic rat model (Narender et al., 2008).

A compound recipe of medicinal plants containing *F. racemosa* leaves as an ingredient showed a significant hypoglycemic effect and increased serum insulin levels significantly in alloxan-induced diabetic rabbits. The study indicated that the increase in serum insulin levels of diabetic rabbits was due to the regeneration of some of the pancreatic  $\beta$ -cells (Wadood et al., 2007). The compound recipe did not show acute toxicity nor resulted in any behavioral changes. Kar et al. (2003) reported oral feeding of ethanol extract of the root (500 mg/kg) caused a significant decrease in blood glucose in alloxan-induced diabetic rats. The herbal formulation D-400 containing *F. racemosa* as an ingredient showed a significant hypoglycemic activity and effectively decreased renal damage in alloxan-induced diabetic rabbits (Benny & Adithan, 2000). In an acute study petroleum ether extract of the leaves at the levels of 200 and 400 mg/kg decreased blood glucose to an extent of 29% and 35%, respectively, in streptozotocin induced diabetic rats (Mandal et al., 1997a). Similar observations are reported by Patil et al. (2009) at a dose of 300 mg/kg. The 95% ethanol extract decreased blood glucose by 50% in streptozotocin induced diabetic rats (Patil et al., 2009).

The petroleum ether extract of stem bark decreased blood glucose by 16% and 62%, fruits by 11% and 20%, and the latex by 7% and 8%, respectively, in normal and diabetic rats. The results suggested that most of the hypoglycemic principles are present in the stem bark of *F. racemosa*. Further, the stem bark extract effectively inhibited glucose 6-phosphatase and arginase *in vitro* (Rahman et al., 1994).

#### Antioxidant and radioprotective activity

Herbal radioprotectors have been gaining prime importance in radioprotective drug discovery due to lesser side effects as reviewed extensively by many authors (Arora et al., 2005; Meenal et al., 2006). The damage to DNA and membrane lipids is a critical factor in radiation-induced cellular damage and reproductive cell death. The ethanol extract of *F. racemosa* stem bark showed a significant free radical scavenging activity in a dose-dependent manner. Such free radical scavengers exert a key role in radio-protection, because radiation-induced cytotoxicity is mediated mainly through generation of free radicals in the biological system (Breen & Murphy, 1995).

Sharma and Gupta (2008) investigated the antioxidant activity of ethyl acetate extract of the root and the results indicate that the extract possesses potent antioxidant activity and is mediated through free radical scavenging, reducing power and hydrogen peroxide scavenging activity. Preliminary phytochemical analysis and  $\beta$ -carotene linoleate oxidation models indicates the presence of polyphenols (tannins, flavonoids) in the extract and the antioxidant potential of the extract



may be due to the presence of phenolic compounds. Racemosic acid isolated from the ethanol extract of *F. racemosa* bark exhibited a strong radical scavenging activity comparable to that of Trolox™, a synthetic antioxidant (Li et al., 2004). Aqueous and ethanol extract of *F. racemosa* stem bark exhibited significant antioxidant activity in alloxan-induced diabetic rats and significantly improved the antioxidant status by decreasing TBARS content and increasing GSH levels and other enzymatic antioxidant defense systems (Vasudevan et al., 2007).

Methanol and 70% acetone extracts of *F. racemosa* stem bark exhibited dose-dependent reducing power activity and the methanol extract exhibited more hydrogen donating ability. Similar dose-dependent activity was seen in DPPH• and •OH scavenging systems. Both the extracts exhibited antioxidant activity against the linoleic acid emulsion system and the potential of multiple antioxidant activity was evident as it possessed antihemolytic activity and metal ion chelating potency (Manian et al., 2008). Channabasavaraj et al. (2008) reported the methanol extract of the bark to exhibit potent antioxidant activity *in vitro*.

#### Hepatoprotective activity

The hepatoprotective activity of petroleum ether extract of *F. racemosa* leaves was evaluated in carbon tetrachloride/paracetamol-induced chronic liver damage. Oral administration of the leaf extract (400 mg/kg) exhibited a significant reduction in the levels of SGOT, SGPT, alkaline phosphatase and serum bilirubin. The activity of the extract was comparable with that of Neutrosec (a standard liver tonic). Further, 3.95% mortality was observed in the CCl<sub>4</sub> treated group and autopsy showed congested and enlarged liver, sometimes associated with intestinal bleeding and inflammation. However, no mortality was observed in extract-treated groups (Mandal et al., 1999). The extract also exhibited a significant hepatoprotective effect comparable to that of Neutrosec in paracetamol-induced hepatotoxicity (Mandal et al., 1999).

The methanol extract of the bark when given orally along with CCl<sub>4</sub> at the doses of 250 and 500 mg/kg body weight (bw) showed a significant hepatoprotection as evident by the reversal of increased serum transaminases comparable to that of silymarin histological changes (Channabasavaraj et al., 2008).

#### Chemopreventive activity

Treatment of rats orally with *F. racemosa* extract (200 and 400 mg/kg bw) resulted in significant decrease in  $\gamma$ -glutamyl transpeptidase, lipid peroxidation, xanthine oxidase, H<sub>2</sub>O<sub>2</sub> generation, blood urea nitrogen, serum creatinine, renal ODC activity, DNA synthesis (Pb 0.001) and incidence of tumors in ferric nitrilotriacetate (Fe-NTA)-induced chemotoxicity in rats. Renal glutathione content, glutathione metabolizing enzymes and

antioxidant enzymes were also restored suggesting *F. racemosa* extract to be a potent chemopreventive agent (Khan & Sultana, 2005a).

Oral treatment of rats with *F. racemosa* extract (200 and 400 mg/kg BW) resulted in a significant decrease in xanthine oxidase,  $\gamma$ -glutamyl transpeptidase activities, lipid peroxidation and H<sub>2</sub>O<sub>2</sub>. A significant recovery of renal glutathione and antioxidant enzymes was also reported. There was also reversal in the enhancement of renal ornithine decarboxylase activity, DNA synthesis, blood urea nitrogen and serum creatinine indicating *F. racemosa* extract to be a potent chemopreventive agent and suppressing potassium bromate-induced nephrotoxicity in rats (Khan & Sultana, 2005b).

#### Anti-inflammatory activity

Anti-inflammatory activity of *F. racemosa* has been evaluated in several studies. The petroleum ether extract of the leaves effectively suppressed the inflammation produced by histamine and serotonin and the anti-inflammatory activity was attributed for the anti-serotonin activity of the extract. The extract also reduced the edema, produced by dextran which is known to be mediated both by histamine and serotonin (Ghosh et al., 1963). The extract exhibited significant anti-inflammatory activity in the cotton pellet test reflecting its efficacy to reduce an increase in the number of fibroblasts and synthesis of collagen and mucopolysaccharide which are natural proliferative events of granulation tissue formation (Arrigoni-Martellie, 1977).

The ethanol extract of the bark, frozen fruits and the milky sap as such exhibited significant anti-inflammatory activity *in vitro* as reflected by the inhibition of COX-1 to an extent of 89%, 71%, and 41%, respectively, at 3.4 mg/mL concentration (Li et al., 2003). In another study, the ethanol extract of the bark showed a significant inhibition of COX-1, 5LOX and phospholipase A<sub>2</sub> (PA<sub>2</sub>). The extract effectively inhibited the biosynthesis of PGE<sub>2</sub>, PGD<sub>2</sub> in COX-1 assay and the formation of 5HETE in 5LOX assay (Li et al., 2004).

The petroleum ether extract of *F. racemosa* leaves at doses of 200-400 mg/kg bw exhibited significant anti-inflammatory activity in carrageenan-, serotonin-, histamine- and dextran-induced rat hind limb paw edema. A maximum effect was observed at 400 mg/kg dose. In chronic tests, at 400 mg/kg the effect was comparable with that of phenylbutazone, a non-steroidal anti-inflammatory agent (Mandal et al., 2000).

#### Analgesic activity

Analgesic activities of ethanol extracts of the bark and leaves were evaluated using hot-plate and tail-immersion methods. At 300 mg/kg, i.p., *F. racemosa* leaf extract increased the latency time significantly, giving about 40.1% protection; the bark extract increased the

reaction time significantly providing 35% protection. The observed analgesic effect was attributed to the presence of friedelin, behenate, bergenin, lupeol and lupeol acetate (Malairajan et al., 2006).

The decoction of *F. racemosa* leaves produced a significant decrease in the number of writhes in the acetic acid writhing test in mouse. A similar effect was seen in the hot-plate test where a significant analgesic activity was observed which continued until 3 h after the administration of the decoction in mice. A significant anti-edemic effect was exhibited by the petroleum ether extract in carrageenan-induced paw edema in mice (Forestieri et al., 1996).

#### Antibacterial/antifungal activity

A number of studies have reported the antibacterial potential of *F. racemosa* against different bacterial strains. Stem bark ethanol extract was found to be very effective against *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Staphylococcus aureus*, *Bacillus cereus*, *Alcaligenes faecalis*, and *Salmonella typhimurium* bacterial strains, indicating the scope to discover bioactive natural products that may serve as leads in the development of new pharmaceuticals in order to address unmet therapeutic needs (Nair & Chanda, 2007). In another study the same authors reported that the ethanol extract of stem bark exhibited significant antibacterial activity against *Pseudomonas aeruginosa*, *Proteus mirabilis*, and *Bacillus cereus* bacterial strains, while the aqueous extract inhibited *Streptococcus faecalis* significantly (Nair & Chanda, 2006) and the methanol extract exhibited significant antibacterial activity against *Bacillus subtilis* (Mahato & Chaudhary, 2005).

Mandal et al. (2000) evaluated various extracts of *F. racemosa* leaves for antibacterial potential against *Escherichia coli*, *Bacillus pumilus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. It was found that the petroleum ether extract was most effective against the tested organisms and the effect produced was significant and was compared with chloramphenicol, a known antibiotic, supporting the use of *F. racemosa* for treating dysentery and diarrhea in the traditional system of medicine. The 50% methylene chloride in hexane flash column fraction of the extract of the leaves of *F. racemosa* effectively inhibited the growth of *Curvularia* sp., *Colletotrichum gloeosporioides*, *Alternaria* sp., *Corynespora cassicola*, and *Fusarium* sp. (Deraniyagala et al., 1998).

#### Gastroprotective activity

Ethanol extract (50%) of the fruits showed dose-dependent inhibition of ulcer index in pylorus ligation, ethanol and cold resistant stress-induced ulcers. The extract also protected the gastric mucosa by inhibiting lipid peroxidation and superoxide dismutase, H<sup>+</sup>

K<sup>+</sup> ATPase and increased the activity of catalase (Rao et al., 2008).

The ethanol extracts of *F. racemosa* bark and leaves attenuated the gastric volume free acidity total acidity ulcer index in aspirin plus pylorus ligation-induced gastric ulcer in rats and also reduced the gastric lesion induced by HCl-ethanol mixture and showed protection against water immersion stress-induced ulcers (Malairajan et al., 2007). Anti-ulcerogenic effect of 50% ethanol extract of unripe fruits of *F. racemosa* (100, 200, and 300 mg/kg) was studied in ethanol 4 h pylorus ligation-induced gastric ulcer in rats. The extract produced significant antiulcer activity at all the doses studied and the effect at 300 mg/kg dosage was comparable with that of sucralfate (250 mg/kg) (Sangameswaran et al., 2008). Similar antiulcer effect comparable with that of sucralfate was exhibited by the methanol extract of unripe fruits of *F. racemosa* (100, 200, and 400 mg/kg) in gastric ulcer models induced by aspirin and cold restraint stress (Sangameswaran et al., 2007).

#### Antidiarrheal activity

Methanol extract of the bark has shown a significant antidiarrheal effect in castor oil-induced diarrhea and PGE<sub>2</sub>-induced enteropooling in rats. The extract also exhibited a significant reduction in gastrointestinal motility in charcoal meal test in rats (Mukherjee et al., 1998). Mandal et al. (1997b) reported similar observations by the petroleum ether extract of *F. racemosa* leaves in rats. The latex exhibited significant inhibitory activity against castor oil-induced diarrhea and enteropooling in latex-treated rats and also reduced gastrointestinal motility following charcoal meal in rats (Bheemachari et al., 2007).

#### Antifilarial activity

Alcoholic and aqueous extracts of the fruits of *F. racemosa* caused inhibition of spontaneous motility of whole worm and nerve muscle preparation of *Setaria cervi* characterized by increase in amplitude and tone of contractions. The concentrations required to inhibit the movement of the whole worm and nerve muscle preparation for alcohol extract were 250 and 50 µg/mL, respectively, while, for aqueous extract it was 350 and 150 µg/mL, respectively. Both alcohol and aqueous extracts caused death of microfilariae *in vitro*. LC<sub>50</sub> was 21 and 27 ng/mL and LC<sub>90</sub> was 35 and 42 ng/mL, respectively, for alcohol and aqueous extracts (Mishra et al., 2005).

#### Larvicidal/wormicidal activity

Rahuman et al. (2008) evaluated the larvicidal activity of hexane, ethyl acetate, petroleum ether, acetone, and methanol extracts of the leaf and bark of *F. racemosa* against the early fourth instar larvae of



*Culex quinquefasciatus*. The larval mortality was observed after 24 h exposure and all the extracts showed moderate larvicidal effects but the acetone extract of the bark showed highest larval mortality. The larvicidal activity of *F. racemosa* was attributed to the presence of gluanol acetate which was also found to be very potent against fourth instar larvae of *Aedes aegypti* L., *Anopheles stephensi* L., and *C. quinquefasciatus* Say.

The crude extracts of *Ficus racemosa* bark (petroleum ether, chloroform, ethanol and water) evaluated for anthelmintic activity using adult earthworms exhibited a dose-dependent inhibition of spontaneous motility (paralysis) and evoked responses to pin-prick. Higher doses of aqueous extract (50 mg/mL) caused irreversible paralysis indicating the wormicidal activity of the extract (Chandrashekhara et al., 2008).

#### Antipyretic activity

The methanol extract of the bark given at a dose of 200 and 300 mg/kg bw showed a significant dose-dependent reduction in body temperature in both normal and yeast-induced pyrexia in albino rats. The antipyretic effect of the extract was comparable to that of paracetamol (150 mg/kg bw) a standard antipyretic drug (Rao et al., 2002a). The decoction and petroleum ether extract of the leaves manifested a significant antipyretic effect comparable to that of indomethacin against yeast-induced pyrexia in rats (Forestieri et al., 1996).

#### Antitussive activity

The antitussive potential of the methanol extract of the bark was evaluated in sulfur dioxide gas-induced cough in mice. The extract demonstrated significant antitussive activity comparable to that of codeine phosphate (10 mg) a standard antitussive agent. Maximum activity was attained at 200 mg/kg bw at 90 min after administration of the extract (Rao et al., 2003).

#### Hypotensive activity

The leaves of *F. racemosa* extracted with various solvents and the fraction rich in glycosides exhibited significant hypotensive and vasodilator effect on anesthetized dogs and direct cardiac depressant action on isolated hearts of frog and rabbit. The extract did not affect the behavioral activity and did not show signs of acute toxicity in rats (Trivedi et al., 1969).

#### Wound healing property

The wound healing property of *F. racemosa* is mentioned in different *Ayurvedic* texts and in a research study the ointment prepared from the powder of the leaves with petroleum jelly (15% w/w) in an 8 mm full-thickness punch wound rat model showed highly significant generation of tissue DNA (1.73 mg/g), RNA (1.17 mg/g), and total protein (16.62 mg/g) during the healing process

in comparison with untreated control rats (Biswas & Mukherjee, 2003).

#### Toxicity studies

Li et al. (2004) evaluated the cytotoxic effect of ethanol extracts of *F. racemosa* bark using ATP-based luminescence assay in human skin fibroblasts (1BR3), human hepatocytes carcinoma (HEPG2) and human promyelocytic leukemia (HL-60) of cell density  $1 \times 10^4$  cells/mL. The extract showed  $IC_{50}$  values of 1.79, 0.098, and 1.69 mg/mL, respectively, which were significantly lower than that of aspirin and mercuric chloride. The extract was significantly less toxic than aspirin and mercuric chloride after 48 h of exposure of the cell lines tested.

The water/hydro-alcohol/alcohol extracts of the bark showed a  $LC_{50}$  of 850  $\mu$ g/mL in brine shrimp lethality test, rendering it non-toxic and representing its safety in its usage in traditional medicine (Krishnaraju et al., 2006). The acute toxicity of methanol extract of the stem bark of *F. racemosa* was evaluated in Albino mice and the study established that the extract is safe even at a higher dose of 3.2 g/kg (Rao et al., 2002b), while the petroleum ether extract of *F. racemosa* fruits did not produce toxicity even at a dose of 5 g/kg in mice (Deshmukh et al., 2007). Rao et al. (2008) reported that the hydro-ethanol extract (50%) of fruits is non-toxic and safe, as no mortality or change in behavioral pattern was observed in mice. The leaf extract also did not affect the behavioral activity and did not show signs of acute toxicity in rats (Trivedi et al., 1969). Forestieri et al. (1996) reported a  $LD_{50}$  value  $>10$  g/kg bw for petroleum ether and ethanol extracts of *F. racemosa* leaves, and a value of  $>5$  g/kg bw for the aqueous extract. All these observations regard various parts of *F. racemosa* (plant particularly) bark less toxic and safe for possible human consumption in order to derive its diverse health benefits.

#### Conclusions

The study of herbal medicine spans the breadth of pharmacology including the study of the history, source, physical, and chemical properties, mechanisms of action, absorption, distribution, biotransformation, excretion and therapeutic uses of "drugs". In many respects, the pharmacological investigation of herbal medicine is just beginning. This review leaves no doubt that *F. racemosa*, a versatile medicinal plant, is investigated for many biological activities. Quite a significant amount of research has already been carried out during the past few decades in exploring the phytochemistry and biological activities of different parts of *F. racemosa*. *F. racemosa* is a unique source of various types of compounds having diverse chemical structures. Very little work has been done on the biological activity

and plausible medicinal applications of these compounds and hence extensive investigation is needed to exploit their therapeutic utility to combat diseases. The aqueous extract has also been marketed, which generates enough encouragement among the scientists in exploring more information about this medicinal plant in order to exploit its commercial potential. An extensive research and development work should be undertaken on *F. racemosa* for its better economic and therapeutic utilization.

## Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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