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Review

Phytochemical composition and pharmacological prospectus of *Ficus bengalensis* Linn. (Moraceae)- A review

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Ficus bengalensis **Linn (Moraceae) is a plant that is widely distributed in India. To the Hindus it is sacred and worshipped with special prayers on Vata Sawitri day. In traditional medicines it is used for healing obstruction of urine flow, diarrhea, dysentery, conjunctivitis, scabies and diabetes. So it has been a subject of chemical, biological and pharmacological interest since a long time. Its chemical investigation shows that it contains Bengalenosides that is, glycosides or flavonoids, ketones, flavonols, pentacyclic triterpenes and triterpenoids, coumarin, sterols, tiglic acid esters, alpha-D-glucose and meso-inositol. The aqueous or alcoholic extracts of various parts of this plant were found to have various pharmacological activities for example, antidiabetic, hypocholesterolemic, hypolipidemic, anti-inflammatory, anthelmintic, antibacterial, antiallergic and anti-tumor activity. In this review, we have investigated the pharmacological activities of *F. bengalensis* Linn (Moraceae) and discussed its various chemical constituents that may be responsible for these multi-aspect activity spectrums of this plant.**

Key words: *Ficus bengalensis,* moracceae, phytochemical composition, pharmacoligical activity.

INTRODUCTION

Ficus bengalensis (*FB*) (Moraceae) is commonly known as Banyan tree or Vata or Vada tree in Ayurveda. There are more than 800 species and 2000 varieties of *Ficus* species, most of which are native to the old world tropics (Manoj et al., 2008). It is endemic to Bangladesh, India and Sri Lanka. It is also known as Bengal fig, Indian fig and East Indian fig, Indian Banyan or simply Banyan (English), also borh, nyagrodha (Sansikrat), Bat, Bargad and Bar (Hindi). The English name Banyan is given by the Britishers to this tree because under the tree Banias that is, the Hindu merchants used to assemble business. The triad Ganges, the Himalayas and the Banyan tree symbolize the images of India, for this reason it is considered as National Tree. Ficus means fig and bengalensis means belonging to or is of Bengal (Patil et al., 2009).

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Abbreviations: FBA, *Ficus bengalensis* agglutinin; **SDS–PAGE,** sodium dodecyl sulfate polyacrylamide gel electrophoresis; **α-AA,** α-amyrin acetate; **MEFB,** methanolic extract of *Ficus bengalensis;* **MPO,** myeloperoxidase; **MDA,** malondialdehyde; **SRBC,** sheep red blood cells; **ROS,** reactive oxygen species; **AODS,** antioxidant defense system; **SOD,** superoxide dismutase; **LCAT,** lecithin-cholesterol acyltransferase; **STZ,** streptozotocin.

Taxonomic classification

The plant is classified as shown in the Table 1.

Table 1. Taxonomic classification of *F. bengalensis* (Edwin and Sheeja, 2006).

Kingdom	Plantae
Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Hamamelidae
Order	Urticales
Family	Moraceae
Genus	Ficus
Species	*F. bengalensis*

Habitat

It is found throughout India from sea level to 1200 m (Narayan et al., 2006) and in Bengal.

Plant description

A very large tree upto 30 m in height with widely spreading branches bearing many aerial roots functioning as prop roots, bark greenish white, leaves simple, alternate, often in clusters at ends of branches, stipulate,10 to 20 cm long and 5 to 12.5 cm broad, broadly elliptic to ovate, entire, strongly 3 to 7 ribbed from the base; the fruit recacles are axillary, sessile, in pairs, globose, brick red when ripe, enclosing male, female and gall flowers; fruits small, crustaceous achenes, enclosed in the common fleshy receptacles (Narayan et al., 2006), shown in Figure 1.

Traditional uses

According to Ayurveda, it is astringent to bowels; useful in treatment of biliousness, ulcers, erysipelas, vomiting, vaginal complains, fever, inflammations, leprosy. According to Unani system of medicine, its latex is aphrodisiac, tonic, vulnerary, maturant, lessens inflammations; useful in piles, nose-diseases, gonorrhea, etc. The aerial root is styptic, useful in syphilis, biliousness, dysentery, inflammation of liver, etc (Varanasi, 2007). Milky juice is used for pains, rheumatism, lumbago and bruises. For the treatment of spermatorrhea, 2 drops of fresh latex in a lump of sugar are taken once daily on empty stomach early in the morning. Seeds are cooling and tonic in nature (Govil et al., 1993). Its leaf buds are astringent, leaves infusion is given in diarrhea and dysentery, poultice of hot leaves is applied on abscesses. The bark is astringent and tonic and used in diabetes and leucorrhoea, lumbago, sores, ulcers pains and bruises (Syed, 1990). Some important Ayurvedic marketed formulations are Nyagrodhaadi churnam (Bhaishajya Rutnavali), Saarivaadya Chandanaasava, Dineshavalyaadi Taila (Sahasrayoga) (Vikas and Vijay, 2010).

Phytochemical constitution

Phytochemical investigation of *F. bengalensis* led to the expolration of a wide variety of constituents which are responsible for its wide range of pharmacological activities. They include ketones, flavonoids, flavonols, sterols, oentacyclic triterpenes and triterpenoids, furocoumarin, tiglic acid ester and some other esters.

Ketones

Three ketones 20-tetratriacontene-2-one, 6-heptatriacontene-10-one, pentatriacontan-5-one were isolated from stem bark of *FB* (Vikas and Vijay, 2010).

Flavonols and flavonoids

Leaves of *F. bengalensis* contain Flavonols that are responsible for its antioxidant effects. These flavonols include quercetin-3-galactoside and rutin (Vikas and Vijay, 2010). Stem bark of *F. bengalensis* also contains bengalenosides that is, glycosides or flavonoids, 5, 7 Dimethyl ether of Leucoperalgonidin-3-0-α-L-rhamnoside and 5, 3 dimethyl ether of leucocyanidin 3-O-β-D-galactosyl cellobioside, and 5, 7, 3 trimethoxy leucodelphinidin 3-O-α-L-Rhamnoside (Vikas and Vijay, 2010). All these flavonoids consist of various sugars attached with OH groups of Leucoperalgonidin, Leucodelphinidin and Leucocyanidin.

Terpenoids

Pentacyclic triterpenes and triterpenoids for example, friedelin, 3-friedelanol, beta sitosterol**,** 20-traxasten-3-ol, Lupeol or Betulinic acid and β-amyrin are present in the leaves of *F. bengalensis* (Vikas and Vijay, 2010).

Coumarins

Coumarins (furocoumarins) have been identified from *F. bengalensis* Psoralen (also called psoralene) is the parent compound in a family of natural products known as *furocoumarins*. It is structurally related to coumarin by the addition of a fused furan ring, and may be considered as a derivative of umbelliferone. Psoralen occurs naturally in the seeds of *F. bengalensis*. It has photosensitizing activity. Bergapten (5-methoxypsoralen) is a psoralen that was also explored from *F. Bengalensis*.

Figure 1. *Ficus bengalensis* leaves and fruit.

Esters

The tiglic acid ester of ψ-traxasterol has been isolated from the heartwood of *F. bengalensis.* Recently three new esters were isolated and characterized from methanolic extract of the bark of *F. bengalensis* along with linolyl glucoside and oleiyl glucoside. These esters are Keto-n-cosanyl stearate, Hydroxypentacosanyl palmitate and Phenyl tetradecanyl oleiate (Mohammad et al., 2010).

CH_3-$(CH_2)_{16}$-CO-O-CH_2-$(CH_2)_{14}$-CO-$(CH_2)_3$-CH_3, Keto-n-cosanyl stearate, CH_3-$(CH_2)_{14}$-CO-O-CH_2-$(CH_2)_{17}$-CH-(OH)-$(CH_2)_5$-CH_3, Hydroxypentacosanyl palmitate, CH_3-$(CH_2)_7$-CH=CH-$(CH_2)_7$-CO-O-CH_2-$(CH_2)_{13}$-C_6H_5-OH, Phenyl tetradecanyl oleiate

Carbohydrates

A galactose specific lectin was isolated from the seeds of *F. bengalensis* (Moraceae) fruits and designated as *Ficus bengalensis* agglutinin (FBA). The lectin was purified by affinity repulsion chromatography on fetuin-agarose and was a monomer of molecular mass 33 kDa. Like other Moraceae family lectins, carbohydrate-binding activity of FBA was independent of any divalent cation. FBA did not bind with simple saccharides, however sugar ligands with aromatic aglycons showed pronounced binding (Biswajit et al., 2007).

Serine protease

A serine protease was purified to homogeneity from the latex of medicinal plant *F. bengalensis* by a single step procedure using anion exchange chromatography. The enzyme, named benghalensin, has a molecular mass of 47 kDa (MALDI-TOF and sodium dodecyl sulfate polyacrylamide gel electrophoresis SDS–PAGE). This enzyme has important biological roles in the plant (Anurag et al., 2009).

Other constituents

The bark of *F. bengalensis* also contain certain other constituents for example, alpha-D Glucose and meso-inositol (Vikas and Vijay, 2010).

PHARMACOLOGICAL PROSPECTUS

Hypoglycemic activity

F. bengalensis (Banyan tree) is one of the common herbs used in Tribal Belts of Midnapur (West) District of Bengal for the treatment of diabetes. A decoction of bark is to be prepared and consumed twice daily in a dose of 40 to 80

ml (Analava, 2007). So *F. bengalensis* is known to have a considerably good hypoglycemic activity. A dimethoxy derivative of leucocyanidin 3-O-beta-D-galactosyl cellobioside isolated from the bark of *F. bengalensis* Linn demonstrated antidiabetic action. Antidiabetic activity of ethanolic extract of *F. bengalensis* was performed on male albino alloxan-induced diabetic rats. Oral administration of the ethanolic extracts of the fruit, aerial root and bark of *F. bengalensis* for 21 days produced significant hypoglycemia or decrease in blood glucose as 31.73, 18.33 and 28.84%, respectively. The study reveals that the ethanolic extract of the fruits produces maximum reduction in blood glucose level as compared to the extract of aerial root or bark of *F. bengalensis.* Histopathological studies were made for both untreated and treated diabetic rats. Untreated diabetic rats showed almost complete destruction of pancreatic beta cells due to alloxan. Diabetic rats which were treated with ethanolic extract of the fruits showed almost normal cells. It seems that extract either protected the cells from the toxic effect of alloxan or the cells recovered after the initial injury (Sharad et al., 2007). In 2009, a study was conducted to reveal the antihyperglycemic activity of α-amyrin acetate (α-AA) isolated from the aerial roots of *F. bengalensis* in normal and diabetic rats and in models of type-2 diabetes that is, db/db mice. The oral administration of α-AA significantly improved the diabetic condition in streptozocin-induced diabetic rats at 50 mg/kg dose level (Singh et al., 2009).

Hypolipidemic activity

The water extract of *F. bengalensis* bark has been reported to possess hypocholesterolaemic and hypolipidaemic effects (Shukla et al., 1995). In 1995 hypolipidemic effect of water extract of the bark of *F. bengalensis* was investigated in alloxan induced diabetes mellitus in rabbits. Treatment for one month (50 mg/kg body weight/day) brought down the level of total serum cholesterol (TC) in subdiabetic and diabetic rabbits from 82±11 and 118±10.6 mg% to 42.7±3.1 mg% and 51.7±4.7 mg%, respectively. Low density lipoprotein cholesterol and very low density lipoprotein cholesterol also came down (Rimi et al., 1995).

Anthelmintic activity

The anthelmintic activity of methanolic, Chloroform and petroleum extracts of the roots of *F. bengalensis* was observed on Indian adult earthworms. Preliminary Phytochemical analysis showed the presence of carbohydrates, flavonoids, aminoacids, steroids, saponins and tannins like phytoconstituents in the extracts of *F. bengalensis*. Some of these phytoconstituents may be responsible to show a potent anthelmintic activity. From the observations made all the extracts of roots of *F. bengalensis* was found to show a potent anthelmintic activity (Manoj et al., 2008).

Anti-inflammatory activity

Ayurvedic practitioners in India are using the milky juice (latex) of stem bark of *F. bengalensis* for the treatment of rheumatism and other inflammatory diseases (Kirtikar and Basu, 2004). A study was designed to demonstrate the anti-inflammatory activity of the methanolic extract of *FB* (MEFB) and possible mechanisms of its anti-inflammatory activity. MEFB inhibited the carrageenan induced edema. It is likely that it elicits its anti-inflammatory response by inhibiting the synthesis and release of prostaglandins, proteases and lysosomal enzymes like non-steroidal anti-inflammatory drugs (Kang et al., 2008). Anti-inflammatory activity of MEFB is due to its multiple effects on mediators of inflammation, lysosomal enzymes, oxidative stress and vascular permeability. Myeloperoxidase (MPO) is enzyme present in neutrophils, monocytes and macrophages at lesser concentration. The level of MPO activity is directly proportional to neutrophils concentration in inflamed tissue. MEFB decreases MPO activity in edematous tissues. MEFB has an inhibitory effect on malondialdehyde (MDA) which is an index of lipid peroxidation and shows that anti-oxidant activity of MEFB contributes to a great extent to its anti-inflammatory activity (Vishnu et al., 2010).

Antibacterial activity

In 2007, aqueous and ethanolic extracts of *F. bengalensis* were investigated for antibacterial activity against *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Stapylococcus aureus*, *Bacillus cereus*, *Alcaligenes faecalis* and *Salmonella typhimorium*. The ethanolic extract showed considerable antibacterial activity against *Pseudomonas aeruginosa*, *Proteus mirabilis* and *Bacillus cereus*. It also showed certain antibacterial effects against *A. faecalis* and *S. typhimorium* but it was inactive against *S. aureus*. Aqueous extract of *F. bengalensis* had no antibacterial activity against any of the six bacterial strains investigated. From the results of experiment it was concluded that ethanolic extract of *F. bengalensis* has great potential as antimicrobial compound against microorganisms and it can be used for the treatment of infectious diseases caused by resistant microorganisms (Rathish and Sumitra, 2007). *Actinomyces viscosus* belongs to group of Actinomycetes. It is gram positive, aerobic, non sporing rod shaped bacteria. It is frequently encountered in high proportion of smooth tooth surface and gingiva. Various experiments were performed to check the antibacterial activity of *F. bengalensis* against

A. viscosus. These show that the extract of *F. bengalensis* bark of 0.08 mg/ml to 0.1 mg/ml have better antibacterial activity (Shandavi et al., 2010).

Immunomodulatory activity

The aqueous extract of the aerial roots of *F. bengalensis* was evaluated for its effect on both specific and non-specific immunity. This extract exhibited a significant increase in percentage phagocytosis by human neutrophils in the *in-vitro* tests. It exhibited promising immunostimulant activity at doses of 50, 100, 200 and 400 mg/kg body weight in sheep red blood cells (SRBC), induced hypersensitivity reaction and hemagglutination reaction in rats. The aqueous extract was found to stimulate the cell mediated and antibody mediated immune responses. Per oral administration of the aqueous extract for five days produced a dose related increase in early (4 h) and delayed (24 h) hypersensitivity reactions in rats. The maximum response was observed at a dose of 100 mg/kg. Increase in the dose beyond 100 mg/kg did not result in further increase in the immune response (Tabassum et al., 2008).

Antistress and antiallergic activity

Taur et al. (2007) screened various extracts of *F. bengalensis* for its antiallergic and antistress potential in asthma by milk-induced leukocytosis (antistress effect) and milk-induced eosinophilia (antiallergic effect). Aqueous, ethanolic and ethyl acetate extracts showed significant decrease in leukocytes and eosinophils while petroleum ether and chloroform extracts were inactive. This shows the application of polar constituents of *F. bengalensis* bark as antistress and antiallergic agents in asthma.

Antioxidant activity

Antioxidants protect the body against oxidative stress by neutralizing free radicals and reactive oxygen species (ROS) for example, superoxide radicals, hydroxyl radicals, hydrogen peroxide radicals, etc. Body has antioxidant defense system (AODS) that include superoxide dismutase (SOD) and catalase, etc. Sometimes prolonged exposure to infection may result in irreversible oxidative damage to the body and the body needs exogenous supply of antioxidant from some natural sources. Flavonoids, flavonols and terpenoids are favorite choices among natural antioxidants. Antioxidant activity and phenolic contents of *F. bengalensis* was observed (Ratnesh et al., 2009). In their experiment aqueous extract of fresh aerial roots of *F. bengalensis* showed good antioxidant activity due to the presence of phenolics and flavonoids. Phenolics are the phytochemicals that provide natural intake of antioxidants. Out of all phenolics, flavonoids have diphenyl propane structure with different degrees of oxidation, hydroxylation and substitution. They normally occur in plants as glycosides and are a rich source of antioxidant. They found that *F. bengalensis* showed high flavonol to total phenolics ratio and high flavonoid to total phenolics ratio but it exhibited very low antioxidant activity. It might be due to the presence of certain other factors which could impede antioxidant efficacy of flavonoids in root extract of *F. bengalensis* (Ratnesh et al., 2009). A research on the antioxidant potential of various central medicinal plants explored that the maximum antioxidant activity is exhibited by the aerial roots of *F. bengalensis*. Phytochemical assay showed the presence of flavonoids and tannins that might be responsible for the antioxidant activity of *F. bengalensis* (Savita and Huma, 2010).

Analgesic and antipyretic activity

Many attempts have been made to study various pharmacological actions of this plant especially its analgesic and antipyretic activity. Recently Jain Vika et al. made a valuable effort in this aspect. They utilized albino rats to check analgesic activity of *F. bengalensis* and antipyretic activity was studied in Brewer's Yeast-induced pyrexia in rats. To study analgesic activity the rats were kept on fasting for 24 h. Then aqueous, ethanol, chloroform and petroleum ether extracts of *F. bengalensis* and also aspirin were administered orally (100 mg/kg) 60 min prior to the commencement of the reaction time. Finally the animal models were subjected to hot plate and tail immersion analgesic activity. The ethanolic extract showed more significant analgesic activity as compared to other extracts. In case of antipyretic activity animals were fevered by injection of Brewer's Yeast suspension (10 mg/kg) subcutaneously in back below the nape of neck. All above mentioned extracts were fed to fevered rats. Ethanolic extract showed significant decrease in elevated body temperature while other extracts did not show the significant decrease in elevated body temperature. So it is concluded that ethanolic extract of *F. bengalensis* shows analgesic and antipyretic activity similar to those observed for non-steroidal analgesic drug aspirin. The phytochemical analysis showed the presence of flavonoids, alkaloids, triterpenoids and tannins that might be responsible for its activity (Vikas et al., 2010).

Antidiarrhoeal activity

Ethanol extract of four different plants of the Khatra region of the Bankura district of West Bengal, India were

evaluated for antidiarrhoeal activity against different experimental models of diarrhea in rats. The extracts of *F. bengalensis* Linn (hanging roots) showed significant inhibitory activity against castor oil induced diarrhea and PGE_2 induced enter pooling in rats. The extract also showed significant reduction in gastrointestinal motility in charcoal meal tests in rats. The results obtained show its medicinal use as antidiarrhoeal agent (Pulok et al., 1998).

Antiatherogenic activity

One month treatment of alloxan diabetic dogs with a glycoside, viz. leucopelargonin derivative (100 mg/kg/day) isolated from the bark of *F. bengalensis* decreased fasting blood sugar and glycosylated hemoglobin by 34 and 28%, respectively. Body weight was maintained in both the treated groups while the same was decreased significantly by 10% in the control group. In cholesterol diet fed rats, as the atherogenic index and the hepatic bile acid level and the faecal excretion of bile acids and neutral sterols increased, the HMGCoA reductase and lipogenic enzyme activities in liver and lipoprotein lipase activity in heart and adipose tissue and plasma Lecithin-Cholesterol Acyltransferase LCAT activity and the incorporation of labeled acetate into free and ester cholesterol in liver decreased significantly (Daniel et al., 2003).

Antidiabetic and ameliorative activity

F. bengalensis bark aqueous extract (500 mg/kg body weight/day) decreased the levels of serum electrolytes significantly ($F > 0.05$; $p < 0.001$) in streptozotocin (STZ) induced diabetic rats. Histological examination of pancreas of the STZ induced diabetic rats showed significant changes in the morphology of pancreatic cells including mild swelling and inflammation. Oral administration of *F. bengalensis* bark aqueous extract (500 mg/kg body weight/day) reduced the inflammation and swelling in pancreatic tissue and restored the levels of serum electrolytes, glycolytic enzymes and hepatic cytochrome P-450 dependent enzyme systems and decreased the formation of liver and kidney lipid peroxides at the end of 12 weeks. This suggests antidiabetic and ameliorative potential of *F. bengalensis* (Mahalingam and Krishnan, 2008).

Wound healing activity

Since ancient times various herbs and medicinal plants have been of medicinal importance for treatment of different ailments. One of these is wound healing activity. Wound healing process holds various steps which involve coagulation, inflammation, formation of granulation tissue, matrix formation, remodeling of connective tissue, collagenization and aquisation of wound strength (Suresh et al., 2002). Research on wound healing drugs is a developing area in modern biomedical sciences. Scientists who are trying to develop newer drugs from natural resources are looking toward the Ayurveda, the Indian traditional system of medicine. Several drugs of plant, mineral and animal origin are described in the Ayurveda for their wound healing properties under the term *Vranaropaka*. Most of these drugs are derived from plant origin. Some of these plants have been screened scientifically for the evaluation of their wound healing activity in different pharmacological models and patients, but the potential of most remains unexplored. In a few cases, active chemical constituents were identified. Some Ayurvedic medicinal plants, namely, *FB, Cynodon dactylon, Symplocos racemosa, Rubia cordifolia, Pterocarpus santalinus, Ficus racemosa, Glycyrrhiza glabra, Berberis aristata, Curcuma longa, Centella asiatica, Euphorbia nerifolia* and *Aloe vera*, were found to be effective in experimental models (Tuhin and Biswapati, 2003). For wound healing activity, leaf powder of *F. bengalensis* is mixed with coconut oil and applied topically on the affected places to treat the wounds. Dosage is once a day for 3 days (Ayyanar and Ignacimuthu, 2009).

Growth promoting activity

The growth promoting potential of alcohol and aqueous extracts of young prop roots of *F. bengalensis*, a medicinal plant widely used among the tribes of the Western zone of Maharashtra state, India to increase height was studied. Its growth promoting effect was evaluated in one-month-old immature female rats. Extracts were administered to young rats for 30 days. Significant ($p < 0.05$) increase in body weight was observed in alcohol and aqueous extract treated immature female rats. Animals treated with alcohol extract showed statistically significant difference ($p < 0.05$) in parameters such as mean food consumption, total body length and increase in alkaline phosphatase levels, a biochemical marker for bone formation. Significant results were not observed in other parameters such as feed efficiency, tail length, relative organ weight, bone density, tibial epiphyseal cartilage width and bone hydroxy proline levels. The results obtained establish the efficacy of the plant material as well as importance of chronic studies to justify the use of this plant in growth promotion (Nidhiya et al., 2009).

Bioactivity

The fruit extracts of various F*icus* species including *F. bengalensis* were screened for bioactivity. All the extracts

exhibited antitumor activity in the potato disc bioassay. None of the tested extracts showed any marked inhibition on the uptake of calcium into rat pituitary cells GH4C1. The results of this preliminary investigation support the traditional use of these plants in folk medicine for respiratory disorders and certain skin diseases (Mousa et al., 1994).

TOXICOLOGICAL STUDY

It has no toxicity on human consumption. Latex of borh exhibit toxicity to the growth of *Penicillium citrinium* and suppress the production of citrinin to different extents. Plant extract is 100% toxic to *Epidermophyton floccosum* and *Microsporum gypseum*. Plant has significant antibacterial activity (Varanasi, 2007).

CONCLUSION

This review article comprised of plant description, phytochemical constitution, pharmacological prospetus and toxicological study of *F. bengalensis* Linn. (Moraceae), a medicinal plant found throughout India and also in Bengal. This plant has a great medicinal value as it has been reported to have verstile phytochemical constituents including ketones, flavonols and flavonoids, terpenoids, coumarins, esters, carbohydrates, serine protease. It has pharmacological activities such as antidiabetic, hypolipidemic, anthelmintic, antibacterial, immunomodulatory, antistress and antiallergic, antioxidant, antiinflamatory, antidiarhoeal, analgesic and antipyretic, antiatherogenic, wound healing and growth promoting. Thus the plant has great medicinal potential for humans.

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