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Pharmacological potential of *Eugenia jambolana:* A review

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ABSTRACT - Many herbal remedies individually or in combination have been recommended in various medical treatises for the cure of different diseases. The therapeutic value of *Eugenia jambolana* Lam. commonly known as 'Jamun' has been recognized in different system of traditional medication for the treatment of different diseases and ailments of human beings. It contains several phytoconstituents belonging to category alkaloids, glucosides, flavonoides and volatile oil. It has been reported as digestive, astringent to the bowels, anthelmintic, sore throat, bronchitis, asthma, thirst, biliousness, dysentery, blood purifier, ulcers and diabetes. Several studies using modern techniques have authenticated its use in diabetes and its complication (nephropathy, cataract, insulin resistance), as antibacterial, analgesic, anti-inflammatory, antioxidant, as well as gastro protective agents. Most importantly, the studies have shown that it protects against the radiation-induced DNA damage and it has significantly decreased the fertilizing capacity of the male albino rats. There are few reports available on clinical uses of *Eugenia jambolana* in diabetes that have shown promising results.

KEY WORDS - *Eugenia jambolana*, Jamun, Traditional medicine, Antidiabetic.

INTRODUCTION

Traditional or indigenous drugs used by different ethnic groups of the world for the treatment of diseases has special significance of having been tested on long time scale. They are relatively safe, easily available and affordable to masses. Traditional drugs have given important lead in drug search, resulting the discovery of novel molecules, Artemisinine for the cure of multi-drug resistant malaria, Silymarin for hepatoprotection and Vincristine and Vinblastine for certain type of cancers have already been isolated from plants and sincere efforts for curing the immunity related problems, AIDS, alzheimers and diabetes are on their way.

For variety of reasons, the popularity of complimentary medicines is on increase. Traditional plant therapies coupled with dietary measures as prescribed Ayurvedic and other indigenous system of medication. In Australia and U. S., a sizable number of populations use at least one form of unconventional therapy including herbal medicine (1,2). The World Health Organization (1980) has also recommended the evaluation of the effectiveness of plants in conditions where there is lack of safe synthetic drugs (3).

Eugenia jambolana Lam. (Syn. *Syzygium cumini* Skeels or *Syzynium jambolana* Dc) belonging to the family Myrtaceae is a large evergreen tree up to 30 m high. Bark pale brown, slightly rough on old stems. Leaves opposite, simple, entire, elliptic to broadly oblong, smooth, glossy, somewhat leathery, 7.5-15 cm long, short pointed at tips. Flowers white 7.5-13 mm across in branched clusters at stem tips, calyx cuplike; 4 petals, fused into a cap; many stamens. Fruit variable in size up to 2.5 cm long, ellipsoid or oblong, crowned with truncate calyx-limb, black with pink juicy pulp. It is widely distributed through out India, Ceylon-Malaya and Australia and known as Jamun, Jam, Jambul in India. It has been valued in Ayurveda and Unani system of medication for possessing variety of therapeutic properties (4). The present review will possibly help to the bridge between traditional claims and modern therapy on *E. jambolana*.

Fig: 1 Photograph of *E. jambolana*

TRADITIONAL USES

Most of the plant parts of *E. jambolana* are used in traditional system of medicine in India. According to Ayurveda, its bark is acrid, sweet, digestive, astringent to the bowels, anthelmintic and in good for sore throat, bronchitis, asthma, thirst, biliousness, dysentery, blood impurities and to cure ulcers (4). The

fruits are acrid and sweet, cooling, dry and astringent to bowels. They increase "Vata" and remove bad smell from the mouth. As per Unani system of medicine they acts as liver tonic, enriches blood, strengthens teeth and gums and forms good lotion for removing ringworm infection of the head. The vinegar prepared from the fruit is tonic, astringent, carminative and useful in spleen diseases. The seeds are sweet, astringent to bowels and good for diabetes. The sprouts are refrigerant, carminatives & astringent to bowels (4,6).

In Unani medicine system the ash of leaves is used for strengthen the teeth and the gums. The seeds are astringent, diuretic and stops urinary discharge (4). Its bark, with or without the addition of other astringents like cardamom and cinnamon, is used as decoction in case of chronic diarrhoea and dysentery. It is also acts as a gargle in sore throat, spongy gums etc. and when externally used, bark shows good wound healing properties (5, 6).

Juice of the tender leaves of *E. jambolana* together with mango leaves and myrobalan is administered along with goat's milk and honey to cure dysentery with bloody discharge (Chakardata) where as juice of tender leaves alone or in combination with carminatives is given along with goat's milk to cure diarrhoea in children.

Powdered seeds are used as a remedy in diabetes (5) and in metrorrhagia (6). Seed powdered in combination with mango kernels were administered with curd to overcome the problem of diarrohea and dysentery, enlargement of spleen and as diuretic in scanty or suppressed urine and oil of leaves is useful in skin diseases.

Juice of black jamun and mangoes in equal parts relieves thirst and has been found very effective in diabetes. The riped fruits are considered to be the good diet in convalescence diarrohea and dysentery and syrup or vinegar prepared from them is also useful in spleen enlargement and it is effective in chronic diarrhoea (5).

PHYTOCHEMISTRY

Seeds of *E. jambolana* contain glycosides, a trace of pale yellow essential oil, fat, resin, albumin, chlorophyll (5), an alkaloid- jambosine (7), gallic acid, ellagic acid, corilagin and related tannin, 3,6-hexahydroxydiphenoylglucose and its isomer 4,6-hexahydroxydiphenoylglucose, 1-galloylglucose, 3-galloylglucose, quercetin (8) and elements such as zinc, chromium, vanadium, potassium and sodium (9). Unsaponifiable matter of seed fat contains ß-sitoterol (10). Dry seeds of *Eugenia jambolana* have been reported with 11.67% alcohol soluble extractive, 3.397% inorganic (11), 40% of water-soluble gummy fiber and 15% of water insoluble neutral detergent fibers (12).

Fruits of *E. jambolana* have been reported with raffinose, glucose, fructose (13), citric acid (14), mallic acid (15) and gallic acid. The sourness of fruits may be due to presence of gallic acid. Venkateswarla (1952) reported that the color of the fruits might be due to the presence of anthocyanins namely delphinidin-3-gentiobioside and malvidin-3-laminaribioside along with petunidin-3-gentiobioside (16,17).

Betulinic acid, friedelin, friedelan-3-α-ol and ß-sitosterol from petroleum ether extract and kaempferol and its 3-o-glycoside, ß-sitosterol-D-glucoside, sucrose, gallic acid, ellagic acid, gallotannin and ellagitannin from alcohol extract (18) and myricetine in small amount have been reported from stem bark of *E. jambolana* (19).

Gupta and Sharma isolated sitosterol, betulinic acid and crategolic (maslinic) acid and also detected n-hepatcosane, n-nonacosane, n-hentriacontane, n-octacosanol, n-triacontanol and n-dotricontanol by GLC and sugars- glucose, fructose, acids- oxalic, citric, glycolic acids and amino acids- glycine, alanine, tyrosine and leucine by co-paper chromatography in the leaves of *E.* jambolana (20). Subsequently Mahmoud et al., isolated 15 polyphenols and two acetylated flavonol glycosides identified as 3-O- (4"-O-acetyl)-alpha-L-rhamnopyranosides of mearnsetin (myricetin 4'-methyl ether) and myricetin 3-O- (4"-O-acetyl-2"-O-galloyl)–alpha-L-rhamnopyranoside from leaves of *E. jambolana* (21) and subsequently Timbola et al., (22) isolated quercetin (0.0085%), myricetin (0.023%), myricitrin (0.009%), and a flavonol glycosides myricetin 3-O-(4"-acetyl)-α-¤L-rhamnopyranosides (0.059%) from its leaves.

Leaves, stems and fruits of *E. jambolana* have been reported with essential oil respectively yields of 0.11, 0.20 and 0.03 (%v/w) and the GC-Msanalysis of these oils (Table 1), revealed that except bornyl acetate the common components of essential oil are mono- or sesqui- terpenes (23).

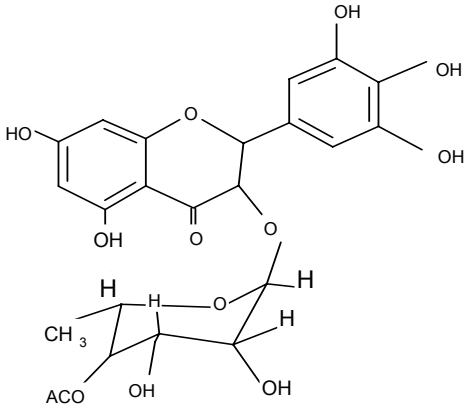
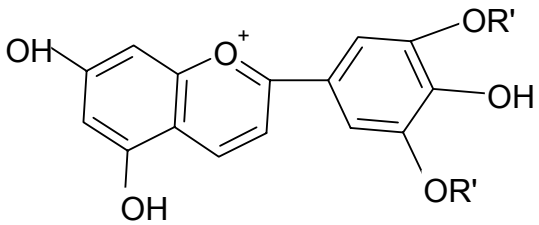
Flowers of *E. jambolana* contain oleanolic acid, two other triterpenoids ellagic acids and flavanols isoquercetin, quercetin, kampferol and myricetin are present in small amounts (19) where as myricetin-3-L-

arabinoside, dihydromyricetin and quercetin galactosides have also been isolated (24).

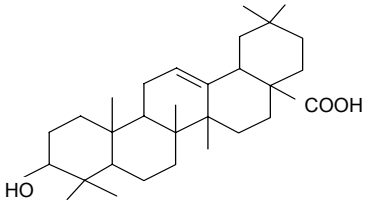
Table: 1 Chemical profile of essential oil from leaves, stems, and fruits of Eugenia jambolana (Craveiro 1983).

S.NO.	COMPOUND	PERCENTAGES		
		LEAVES	STEMS	FRUITS
1	α-Pinene	30.10	18.56	30.89
2	Camphene	-	1.31	1.00
3	β-Pinene	20.50	12.61	10.81
4	Myrcene	-	4.28	3.82
5	Limonene	8.50	6.48	4.50
6	*cis*-Ocimene	9.00	14.83	18.50
7	*trans*-Ocimene	9.50	12.24	12.10
8	γ-Terpinene	-	0.65	-
9	Terpinolene	-	0.96	-
10	Bornyl acetate	2.20	1.46	0.32
11	α -Copaene	-	2.15	-
12	β-caryophyllene	2.50	-	0.40
13	α -Humulene	2.80	6.51	-
14	γ-Cardinene	-	0.64	-
15	δ-Cardinene	-	1.46	2.30
	Total% accounted for	85.10	84.14	84.64

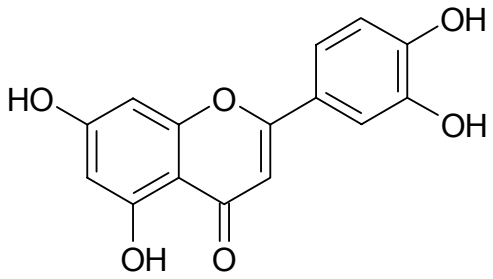
Table 2: Structure of isolated phytoconstituents of *E. jambolana*

Phytoconstituents	Structure
Myricetin 3-O-(4”-acetyl)-α-L-rhamnopyranosides	
Delphinidin-3-gentiobiside R= Gentiobioside, R’= H **Malvidine-3-laminariboside** R= Laminaribose, R’= CH_3	

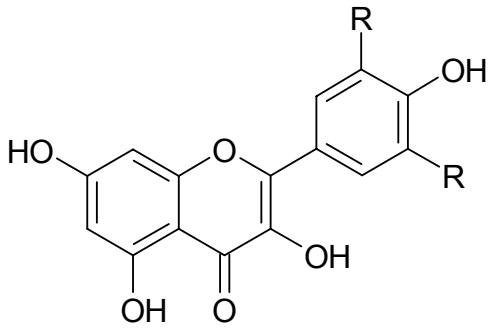
Oleanolic acid



Quercetin



Kaempferol R= H
Myricetin R= OH



PHARMACOLOGY

Although *E. jambolana* has been prescribed in various complications including diabetes, diarrohea and dysentery etc. in folklore and traditional system of medication but scientific proof of its efficacy are still lacking.

Antidiabetic activities

Although earlier reports stated that administration of powdered seeds of *E. jambolana* do not produce appreciable difference in blood sugar levels in rabbits but according to Brahmchari et al., its ethanolic extract shows hypoglycaemic activities in albino rabbits (25). Latter French scientists Sigogneau-Jagodzin-ski et al., proved that constituents isolated from ethanolic extract had hypoglycemic action on alloxan induced diabetic rats (26). Ratsimamanga et al., has reported ethanolic extract of bark of jamun tree to decrease blood glucose level by 21% after one hour in hyperglycaemic rabbits in a dose corresponding to 10g/ kg dry bark (27). According to Bansal et al., observed that oral feeding of seeds at 170, 240 and 510 mg/rat for 15 days caused maximum reduction in blood glucose of normal fasted rats at 240 mg/rat doses as comparison to chlorpropamide treatment. In addition there was a 2.4-6.8 fold and 9.2 fold increase in cathepsin B activity pertaining to proteolytic conversion of proinsulin to insulin by seed extracts of *E. jambolana* and chlorpropamide respectively in rats (28). From a preliminary study Mahapatra et al., reported hypoglycemic effect from seeds (29). Muna et al., investigating the hypoglycemic activity in normal and streptozotocin-induced diabetic rats, and results were compared to those obtained using the sulfonylurea, glibenclamide and reported significant decrease in blood glucose level by oral administration of *E. jambolana* seeds (30). Achrekar et al., reported that oral administration of pulp extract of fruits of *S. cumini* to normoglycaemic and streptozotocin induced diabetic rats exhibited hypoglycemic activity in 30 min which was possibly mediated by insulin secretion. In addition the extract inhibited insulinase activity in the liver and kidney. Indira and Mohan Ram (1992) reported hypoglycemia and reduced glucosuria on oral administration of alcoholic extracts of dried seeds of *E.* jambolana (31). Teixeira et al., reported decoction of dry leaves of *S. cumini* exhibiting hypoglycemic effect (32). Later they also observed no anti-hyperglycemic action of the leaves (in the form of tea) of *Eugenia jambolana* collected in South Brazil at 16–32 g leaves

per liter of water, to normal and diabetic rats for 14-95 days (33). Prince et al., reported prominent hypoglycemic (>glibenclamide) and antioxidant activity at the dose of 5.0 gm/kg for 6 days of aqueous extract of *E. jambolana* seeds however the low dose of 2.5 gm/kg had no significant effect (34). Kar et al., reported inorganic constituents of *E. jambolana* possessing more pronounced action of glucose tolerance factor compared to their corresponding organic components extracted from 95% ethanol (11). In subsequent study Teixeira et al., found no anti-hyperglycemic action when aqueous extract of leaves (0.25–1.0 g/100g b.wt.), was given to normal rats for 14 days and to diabetic rats for 4 days, and when non-diabetic young volunteers ingested a decoction prepared from 2 g dry leaves in 250mL of water (35).

According to Grover et al., daily administration of lyophilized powder of *E. jambolana* seeds (200 mg/kg) showed maximum reduction of blood glucose level to 73.51, 55.62 and 48.81% as compared to their basal value in mild (21 days), moderate (120 days) and severe (60 days) in diabetic condition in rats. In addition the treatment also partially restored altered hepatic and skeletal muscle glycogen content and hepatic glucokinase, hexokinase, glucose-6-phosphate and phospho-fructokinase levels (36).

Pepato et al., observed no significant difference in biochemical and physiological parameter when decoction of *E. jambolana* leaves (15% w/v) was given to streptozotocin induced diabetic rats as a substitute for water (37). Vats et al., has reported that treatment with aqueous extracts of *E. jambolana* at 400 mg per day for 15 days substantially prevented hyperglycemia and hyperinsulinemia induced by high fructose diet in rats (38). Pandey et al., observed that the hypoglycemic effect of *S. cumini (E. jambolana)* seeds is due to water-soluble gummy fiber and not because of water insoluble neutral detergent fiber and other constituents of the seeds (12). Kar et al., observed blood glucose lowering effect with in 1 week dosing of 250mg/kg/day of the ethanolic extracts of *E. jambolana* in alloxan induced diabetic rats (39). Sharma and co-worker investigated that hypoglycemic and hypolipidemic effect of ethanolic extracts (100mg/kg, P.O.) of seeds in alloxan induced sub diabetic, mild diabetic and severe diabetic rabbits showed significant fall in the fasting blood glucose level on 15 days administration. They also observed 32.85 and 26.95% increase in insulin level in mild and severe respectively and fall in total serum cholesterol /HDL ratio (40).

Prince et al., have reported a significant reduction in blood glucose and urine sugar and lipids in serum and tissues in alloxan diabetic rats by the administration of alcoholic extracts (100mg/kg) of *E. jambolana*. The extract also increased total haemoglobin level (41). Daisy et al., notified significant decrease ($P<0.05$) in serum glucose and cholesterol levels on oral administration of aqueous extracts of seeds and bark of *E. jambolana* to alloxan diabetic rats for 60 days and the total RBC, T- lymphocytes were also significantly increased in treated animals (42). In a comparative study Jasmine et al., noticed greater hypoglycemic effect due to aqueous extracts of *E. jambolana* seeds compared to *Phyllanthus niruri* leaves (43).

Bose et al., proved the clinical effectiveness of the *E. jambolana* seeds in diabetes (44). Karnick et al., reported a polyherbal preparation containing *E. jambolana* to be clinically effective in the treatment of diabetes (45). Kohli et al., has carried out clinical trial of *E. jambolana* seed powder in NIDDM (46).

Effect on diabetic complication

French scientist Chirvan-Nia et al., have reported regression of cataract and hyperglycemia in diabetic rats having received an extract of *E. jambolana* (47). As per Grover et al., extracts of *E. jambolana* significantly ($P<0.05$) prevented renal hypertrophy as compared to diabetic controls (48). Rathi et al., has reported lyophilized aqueous extract of *E. jambolana* seeds preventing the development of cataract in alloxan induced diabetic rats (49). According to Prince et al., oral administration of an aqueous *E. jambolana* seed extract (5 g/kg) for 6 weeks caused a significant decrease in lipids, thiobarbituric acid reactive substances and an increase in catalase and superoxide dismutase in the brain of alloxan induced diabetic rats. Further the oral administration of an alcoholic seed extract (100 mg/kg) for 6 weeks brought back all the parameters to near normal. According to them the effect of both these extracts was better compared to glibenclamide (600 µg/kg) in reducing tissue damage in diabetic rat brain (50).

After giving lyophilized fruit-pulp extract of Brazilian *Eugenia jambolana* (50 mg/kg) for 41 days to streptozotocine diabetic rats, found no observable difference in body weight, food or water intake, urine volume, glycaemia, urinary urea and glucose, hepatic glycogen, or on serum levels of total cholesterol, HDL cholesterol or triglycerides (51).

Grover et al., Oral administration of aqueous extracts of *E. jambolana* for 50 days caused a significant increase in gastric transit percentage compared to streptozotocin induced diabetic control and significant decrease in serum sugar level (21% reduction) without any euglycaemic state. They also reported insignificant prevention in the rise in basal tail flick latency by daily administration of aqueous extracts of *E. jambolana* in comparison to diabetic controls (52).

Mechanism of action

The antidiabetic action of *E. jambolana* is not fully understood. It exerts a dual effect namely a combination of mechanism of action of sulfonylurea and biguanids (36) where as per Archekar et al., and Ravi et al., *E. jambolana* may bring about its hypoglycemic action through stimulation of surviving β cells of islets of langerhans to release more insulin (31,53). However according to some other studies it increases G-6-P content in liver indicating an overall increase in glucose influx thus it is having an over all effect in increasing glucose utilization (36) and as per Bansal et al., it may be acting as hypoglycemic agent by increased the insulin content through increasing activity of cathepsin B (28).

Anti oxidants

Ravi et al., has observed that oral administration of ethanolic extracts of *Eugenia jambolana* seed kernel to streptozotocin induced diabetic rats significantly decreased the levels of glycosylated hemoglobin, increased the body weight and hemoglobin, restored the activities of superoxide dismutase, catalase, glutathione peroxidase to the normal level. They also found an increase in glutathione content and increased levels of lipid peroxidation and hydroperoxides in liver and kidney. The same group in the plasma and pancreas observed later similar results along with the capacity to bring level to near normal of vitamin C concomitant to vitamin E and ceruloplasmin in plasma (53,54).

Anti-bacterial activity

Shafi et al., reported good antibacterial properties from essential oil of *E. jambolana* leaves (55). Shaikh et al., have reported antibacterial activity of ethanolic extracts of *E. jambolana* against gram positive and gram-negative organisms (56). Bhuiyan et al., has determined antibacterial activity of methanol and ethyl-acetate extracts of the seeds of *E. jambolana* at a concentration of 200 µg/disc against five gram positive bacteria (*Bacillus creus, B.subtilis, B. megaterium, Streptococcus β-haemolyticus, Staphylococcus aureus*) and nine gram-negative bacteria (*Shigella dysenteriae, Sh. shiga, Sh. boydii, Sh. flexneriae, Sh. sonnei, E.coli, S.typhi B, S. typhi B-56* and *Klebsicella species*) by disc diffusion method where the MIC for methanol extract was 64, 128 and 64µg/ml against *Bacillus creus, E. coli* and *Sh. flexneria* respectively where as those for ethyl acetate extract MIC were 256, 256 and 64 µg/ml against *Bacillus creus, E. coli* and *Sh. flexneria* respectively (57).

Anti-inflammatory activity

According to Muruganandan, ethanolic extract of *E. jambolana* bark extract has a potent anti-inflammatory action against different phases of inflammation without any side effect on gastric mucosa (58,59). They further stated that ethanolic extracts of *E. jambolana* exhibiting inhibitory role on inflammatory response to histamine, 5-HT and PGE_2 (60). Chaudhuri et al., reported chloroform fractions of its seeds significantly inhibit carrageenan, kaolin and other mediator-induced odeama. They also observed significant antipyretic action of the extracts against yeast-induced pyrexia (61).

Antifertility activity

Rajasekaran et al., has revealed antifertility effect of oleanolic acid isolated from the flowers of *E. jambolana* significantly decreased the fertilizing capacity of the male albino rats without any significant change in body or reproductive organ weights. It causes significant reduction in conversion of spermatocytes to spermatides and arrest of spermatogenesis at the early stages of meiosis leading to decrease in sperm count without any abnormality to spermatogenic cells, leyding interstitial cells and sertoli cells (62).

Gastroprotective effects

Mukherjee et al., has reported that ethanolic extract of the bark of *E. jambolana* at dose of 400 mg/kg p.o. reduced diarrohea by inhibiting gastrointestinal motility ($P<0.001$) and PGE_2 – induced enteropolling ($P<0.001$) in castor oil induced rats (63). The work carried out by Ramirez et al., suggests that tannins extracted from *E. jambolana* bark have gastroprotective and anti-ulcerogenic effects (64).

Other uses

Krikorian et al., found anorexigenic power of *Eugenia jambolana* was approximately equal to that of amphetamine (65). According to Ahmed et al., seed extracts of *E. jambolana* produce alteration in the

general behavior of test animal such as reduction in locomotion, decrease in aggressiveness and increase in phenobarbitone induced sleeping time in dose dependent fashion in a stress reducing study. They also found significant analgesic effect against acetic acid induced writhing movement and reduction in body temperature and also reduces plasma cortisone level, which was elevated due to stress (66).

Jagetia et al., have reported radiation-induced DNA damage protection by the leaf extract of *E. jambolana*. Later they reported that this extract provide protection against the gastrointestinal death by increasing the survival by 66.66% compared to 12% survival in the irradiated control group. Similarly 30-mg/kg b.wt. of extract provided protection against the radiation-induced bone marrow death in mice (67,68).

CONCLUSION

From the time immemorial, plants have been widely used as curative agents for variety of ailments. Concentrated fruit or seed extract can be found in various herbal preparations that are in market today. *E. jambolana* preparations are widely available and employed by practitioner of natural health for treatment of diabetes and related complications, antioxidant, anti-inflammatory, and antifertility agents. *Eugenia jambolana* plant serves varies purposes in diabetic patients such as lowering blood glucose level, delaying diabetic complications such as neuropathy and cataract etc. Most of the studies have been conducted using crude preparation of *Eugenia jambolana* without mention of their chemical profile. Although the studies on *Eugenia jambolana* have proved its efficacy in several complications including the management of diabetes, the detailed research work on isolation of bioactives through clinical trials followed by standardization is seriously required on this potential plant of Ayurveda. Although many studies have claimed it for the treatment of the diabetes but in the Ayurveda it is mentioned for several ailments like diarrohea and dysentery. However most pharmacological work was carried out with seeds but the pharmacological potential of the other parts of the plant are required to explore.

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