Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Biomedicine

journal homepage:www.elsevier.com/locate/apjtb

Document heading doi:10.1016/S2221-1691(12)60221-4

Ethnobotanical, phytochemical and pharmacological review of *Mimusops elengi* Linn.

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ARTICLE INFO

Article history:
Received 23 January 2012
Received in revised form 13 February 2012
Accepted 5 April 2012
Available online 28 September 2012

Keywords:
Mimusops elengi
Pharmacology
Ethnomedicine

ABSTRACT

Mimusops elengi is Indian native plant and is used for a long time in the history of the medicine. Plant was well studied in majority of the world because of its high potential medicinal value. Traditionally all different part of this plant, namely leaf, root, fruit, seed, bark and flower are used to cure various kinds of disorders. Information compiled here will be useful to improve the present investigation of several health care research regarding the *Mimusops elengi*.

1. Introduction

Mimusops elengi Linn. (*M. elengi*) is a large glabrous evergreen trees 12-15 m high, with a compact leafy head and short erect trunk, bark smooth, scaly, and gray, Leaves 6.3-10 by 3.2-5 cm, elliptic shortly acuminate, glabrous, base acute or rounded, petioles 1.3-2.5 cm long, flower white, fragrant, nearly 2.5 cm across solitary, buds ovoid, acute; pedicels 6.20 mm long. Calyx 1 cm long, stamens 8, opposite to the inner circle of lobes. Ovary appressedly silky-pubescent, fruit berry about 2.5 cm long, ovoid, yellow when ripe, seed solitary, ovoid, compressed, brown, shining[1].

Taxonomy and nomenclature (common names) is as following:

Kingdom: Plantae, Order: Ericales, Family: Sapotaceae, Genus: Mimusops, Species: *M. elengi* L., Binomial name: *Mimusops elengi* (L). The plant is also known as varieties of name as mention bellow:

Sanskrit: Anangaka, Bakula, Chirapushpa, Dhanvi, Gudhpushpa, Kantha, Karuka, Kesha, Madhupushpa, Mukula, Padyamoda, Sharadika, Sindhugandha, Simhakeshaa, Sthirmukhgandha, Surabhi, T ailanga, Varalahdha, Visharada

Gujarati: Babhuli, Bolsari, Varsoli, Vovoli

Hindi: Bakul, Bolsari, Maulsarau, Maulser, Maulsari

Marathi: Bakhor, Bakula, Barsoli, Ovalli, Owli, Vavoli, Wovali, Wowli

Malayalam: Bakulam, Elengi, Ilanni, Iranni, Makuram

Tamil: Alagu, Ilangi, Kesaram, Kosaram, Magil, Magilam, Vagulam

Punjabi: Maulsari, Maulsiri

Bengali: Bakal, Bakul, Bohl, Bukal

English: Bullet wood, Indian Medlar

Nepalese: Bakulapuspa

Sinhalese: Munemal

German: Affengesict

French: karanicum

Unani: Moolsari

Burmese: Kaya

Malaysian: Enengi

It is distributed throughout South India and Andaman Islands in evergreen forests and grown as avenue tree[1].

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2. General properties

The bark is acrid and sweet; cooling, cardiotonic, alexipharmic, stomachic, anthelmintic, astringent; cures biliousness and diseases of the gum and teeth[1,2]. The flowers are sweet, acrid, oleagenous; cooling, astringent to the bowels; good for the teeth, causes flatulence. They are used as expectorant; cures biliousness, liver complaints, diseases of the nose, headache, and their smoke is good in asthma[3]. The seeds fix loose teeth; as an errhine cures nasal congestion and headache[4]. The root is sweet and sour; aphrodisiac, diuretic, astringent to the bowels; good for gonorrhoea; as a gargle, strengthens the gums[1]. The fruits are sweet and sour, aphrodisiac, diuretic, astringent to the bowels, good in gonorrhoea. The pulp of the ripe fruits is sweetish and astringent and has been successfully used in curing chronic dysentery[1,5]. The leaves are well known for analgesic and antipyretic[3, 6].

3. *M. elengi* in literature

M. elengi is considered as one of the best trees. This tree is very famous for its shade, fragrant flowers and above all its elegant looks. So the plantation of more *M. elengi* is recommended. In Ayurveda, *M. elengi* is known for its strengthening property for teeth[4]. But Charak and Sushruta both had never mentioned the use of *M. elengi* for its mode of action on teeth. Charak categorized it in 'Aasavayoni phalvarg' and he recommended it as anthelmintic. Where as Sushruta placed it in 'Kashaya' category and he recommended the use of its fruits. But good effect of *M. elengi* on teeth was disclosed by 'vaidyas', after Charak and Sushruta. Chewing of the root bark strengthens the teeth and improves oral health. It has also been mentioned that the chewing of a twig of '*M. elengi*' as 'Danta pavana' (one which cleans and strengthens the teeth)[7].

For the loose teeth, 'kawath' of the bark including pepper, honey and ghee if used as a gargle reduces the pain and strengthens the teeth. For fixing up the teeth the seed powder is being rubbed on the teeth. Decoction of a root bark along with the milk taken in the morning for three days could strengthen the teeth of even an old person. Chewing of bark for long time period strengthens the teeth like anything. The bark of Bakula is one of the ingredients in the preparation of Mahakhadiradivati indicated for stomatitis, halitosis, appetizer, anorexia, spongy gums and on pharyngeal affections. *M. elengi* is also used in several such teeth strengthening formulations. The bark of 'Maulsiri' is an important ingredient for the ayurvedic formulations used as a toothpowder[8].

4. Chemical composition

M. elengi is well documented for several medicinal properties like antinociceptive, diuretic effects, gastroprotective, antibacterial, antifungal, anticariogenic, free radical scavenging, antihyperglycemic etc. And due to this since several decades it is being focused for its chemical composition. Chopara and Kapoor reported in preliminary chemical investigation about the presence of saponins in *M. elengi*. The ethanolic extract of the leaves yielded quercitol (1.7%), hentriacontane, β-carotene and glucose. D-mannitol, β-sitosterol, β-sitosterol-β-D-glucoside, and quercetin were recovered from leaves[3,7,8].

Bark of *M. elengi* contains tannin, some caoutchouc, wax, coloring matter, starch and ash forming inorganic salts[4]. Saponin was isolated from the ethanolic extract of the bark, which on hydrolysis yielded β-amyrin and bassic acid. Hexane soluble fraction of the alcoholic extract yielded taraxerone, taraxerol, α-spinasterol, sodium ursolate and betulinic acid, where as hexane insoluble fraction yielded β-D-glucoside of β-sitosterol and the aqueous extract, gave quercitol. Other pentacyclic triterpenoids betulic acid (2-167), lupeol (4-167), taraxerol (3-167) and ursolic acid (3-167). Fatty acid ester of α-spinasterol (3-167) was also isolate from bark[8]. The petroleum ether extracts of stem bark yielded α-spinasterol and taraxerol, the same was also isolated from wood portion of *M. elengi* along with meso-inositol. The ethanolic extract of heart wood of *M. elengi* gave lupeol and α-spinasterol whereas the aqueous, alcoholic and hexane-soluble fractions yielded hederagenin and β-d-glucoside of β-sitosterol[8]. Ethanolic extraction of roots gave lupeol acetate, taraxerol, α-spinasterol, β-D-glucoside of β-sitosterol and hederagenin. A new types of steroids stigmast-9 (11)-en-3-Ol, 5-α: 3-O, was also reported in roots of *M. elengi*[9].

Fresh flowers of *M. elengi* on extraction with acetone yielded D-mannitol where as extraction with ethanol yielded β-sitosterol and β-sitosterol-β-D-glucoside. Flowers also yielded quercitol, ursolicacid and a triterpene alcohol which was later, identified as lupeol[8]. Ethanolic extract of *M. elengi* seeds yielded quercitol, dihydroquercetin, and quercetin, β-D-glucoside of β-sitosterol and α-spinasterol[10]. The fatty oil comprised capric, lauric, myristic, palmitic (16.71%), stearic(17.23%), arachidic, oleic(53.48%) and linoleic (16.71%) acids, the unsaponifiable matter from the seed fat consisted of β and γ-sitosterol[8]. Glucose is reported to be present in mesocarp, testa and kernel. Quercetin, quercetol types of flavonoids are present in testa, spinasterol, type of steroid are present in kernel and taxifolin type of flavonoid are present in testa[10].

M. elengi reportedly contain calcium (212 mg) and phosphorus (30 mg) per 100g. Further phytochemical screening has shown that, the alkaloids are absent in the bark[4]. They are also absent in seeds[4,8,11]. Though alkaloids

are present in flowers, but pyrrolizidine type of alkaloid is absent in flowers[12].

5. Ethno-medicinal information on *M. elengi*

The unripe fruits, the ripe fruits and flowers along with other astringents are used to prepare a lotion for the sores and wounds. A snuff made from the dried and powdered flowers is given in a disease called 'Ahwah', common in Bengal. The symptoms of this disease are strong fever, headache, and pain in the neck, shoulders and other parts of the body. The powdered flowers induce a copious defluxion from the nose and relieve the pain in the head. Water distilled from the flowers is in use amongst the natives of Southern India, both as a stimulant medicine and as a perfume. The bruised seeds are applied locally within the anus of child in case of constipation. The bark has astringent tonic properties. It is much esteemed by the Javanese, and is stated to have proved useful in fevers, and as a general tonic. The leaf is one of anti-venome remedies of Sushruta. In practice about half a teaspoonful of the expressed juice of the fresh leaves is poured into the nostrils in stupor and coma. However, Mhaskar & Kai's report convey that the leaf is not an anti dote to snake- venom. A. K. Menon examined the oil yield out of kernels for its physical and chemical characters[1,13-17].

The bark is used in certain districts of Bengal, either by itself or in combination with that of *Terminalia tomentosa*, for dyeing shades of brown. The bark is scarcely, in the slightest degree, astringent; it only contains the small amount of brownish-red coloring matter. With cotton a light grey color was obtained, and with silk various shades of reddish-drab, drab and fawn were obtained. The bark is also employed as a tan in various parts of the country. Bark of *M. elengi* yield dyes used for the coloring material under CSIR research, further chemical investigation said the dyes properties is because of falvonoids moieties present in their molecule[18,19]. Further examinations revealed that bark contain 4% of tannic acid and to yield pale reddish, slightly turbid decoction is used. The tanning material obtained is found of least commercial value compared to others.

This tree is chiefly cultivated for its ornamental appearance, and its fragrant flowers. The tree produces small fragrant flowers in abundance during the hot season. They fall in showers and are succeeded by small, oval berries, which are yellowish ripe and have a small quantity of sweetish pulp, sometimes eaten by the poorer natives. The flowers are valued for making garlands, are sometimes used for stuffing pillows and the attar distilled from them is esteemed as a perfume. The flower contains volatile oil from which sweet-scented water is distilled. From the seeds a fixed oil is obtained by expression, which is used for culinary purposes for burning and for medicine. A particular opinion about this plant conveys that the green fruit is astringent. The bruised seeds are used in constipation of children, but are highly irritant. The seed, reduced to paste and mixed with old ghee, is used as a suppository in cases of constipation of children. Frequent instances had been observed where it has been employed in this way and have found hard scybellae passed within 15 minutes after the introduction of the suppository into the rectum. Decoction of the bark is an excellent astringent gargle. In Orrisa plant is used as ethanomedicine diarrhoea disease[20]. *M. elengi* cultivate for its valuable wood used in railway slipper, its carbohydrate content (35.5%), and protein content (1.8%) of fruits would be use as source of food[21], plants are recommended to reforestation in degraded area and so for its production seed germination study was also done[22, 23], seed and its function are well studied for its protein content[24]. Hydrocarbon fraction obtained from *M. elengi* produce 16.40 kJ/mol energy, and so it could be the new source of hydrocarbon energy[25]. Various types of solvent extract from leaves extract is dropped into the ears of human adult to cure suppuration and earache and given orally to cure internal pains in humans. Hot aqueous extract of *M. elengi* roots is given orally to human adult as an anti- pyretic. Hot aqueous extract of dry bark is used as an astringent and applied externally too. This extract is also given orally to cure diseases of gums and teeth, biliousness as an anthelmintic, stomachic and cardiotonic[26-29].

A hot aqueous extract of dried flower is given orally to human adult to cure oleaginous blood diseases and this extract also acts as an astringent for the bowels, same extract is also given orally to human as diuretic and it also acts as an anti pyretic. Fresh methanolic extract of *M. elengi* flower shows inhibitory effect at 1:9 dilution ratio on zoosporangium of *Sclerospora graminicola* a pathogen cause downy mildew in pearl millet [*Pennisetum glaucum* (L) R. Br., hybrid HB3][30]. Ripe fruits are given orally to a pregnant woman to promote a delivery. Sometimes they are used as an abortifacient[8,31,32]. Hot aqueous extract of dried fruits of *M. elengi* is considered good for the teeth, while hot water extract of seeds is used to fix loose teeth. Such aqueous extract given orally to adult female to cure menorrhagia[8].

6. Biological & Pharmacological activities of *M. elengi*

M. elengi contains variety of active phytoconstituents and thus possess various kinds of biological and pharmacological activities. It possess activities like antibacterial[8,33], antihemorrhoidal[8], antifungal[3,33], anticariogenic[3,34], free radical scavenging[35-37] antihyperglycemic[3,38], antineoplastic[3], gastroprotective[39,40], antinociceptive & diuretic effects[3], antiviral[41, 42], cognitive enhancing activity[43] and cytotoxic activities[8, 44].

The leaf extract showed *in vitro* antibacterial activity against *Bacillus anthracis*, *Bacillus mycoides*, *Bacillus pumilus*, *Bacillus subtilis*, *Salmonella paratyphii*, *Staphylococcus albus*, *Vibrae chlorae*, and and *Xanthomonas malvacearum*, the inhibition was significant against *Xanthomonas campestris* and *Bacillus anthracis*. The bark extract showed *in vitro* antimicrobial activity against *Staphylococcus aureus*, *Streptococcus mutans*, *Streptococcus salivarius*, *Streptococcus sanguis*, *Lactobacillus acidophilus* and *Candida albicans*[33]. While aqueous and solvent based extract of aerial part of *M. elengi* like leaves, bark, stem, fruit pulp, fruit rind, seed cotyledon, seed testa, and flower were screened at 20 mg/mL concentration for antibacterial activity by agar diffusion methods against *Enterobacter aerogens* (ATCC13048), *Pseudomonas aeruginosa* (ATCC25668), *Staphylococcus aureus* (ATCC9144), *Micrococcus luteus* (ATCC4698), *Klebsiella pneumoniae* (ATCC15380), *Bacillus subtilis* (ATCC6051) and *Bacillus cereus*, *Escherichia coli*, *Salmonella paratyphi*-A, *Salmonella typhi*-B (clinically isolated)[8]. The Bark was identified as potential antimicrobial possessing part among all tested aerial part. *In vitro* developed callus from nodal portion also possessing similar phytochemical & biological activities and can be used as substitutes of the bark[45]. Essential oil from leaves at the concentration of undiluted/disc, anti-fungal activity was against *Keratinonyces ajelloi*, *Microsporum gyseum*, *Trichophyton equinum*, *Trichophyton mentagrophytes*, *Trichophyton terrestris*, *Trichophyton rubrum* on the agar plates. Leaves aqueous as well as methanolic-aqueous (1:1) and methanolic extracts at the dose, where IC50> 1 000 mμ/mL showed no plaque formation suppressant activity against *Streptococcus mutans*. Ethanolic-aqueous (1:1) extract of dried aerial parts of *M. elengi* when given intraperitoneally at the dose of 17.0 mg/kg showed diuretic activity within rats. Whatever dose administered was 1/4 of the LD_{50}. In same case quantitative toxicity assessment was proved positive; dose maintained was LD_{50} 68.1 mg/kg[8].

The effect of *M. elengi* bark extract was studied against experimental gastric ulcers. The 50% alcoholic extract of *M. elengi* and its different fractions namely ethyl acetate, *n*-butanol, methanol, and aqueous were studied in ethanol-induced, pylorus-ligated and water-immersion plus stress-induced gastric ulcer models in mice. Ranitidine HCl (80 mg/kg) was used as a reference standard. In ethanol-induced gastric ulcer model, pantoprazole (20 mg/kg) was also used as a reference standard. Ethyl acetate extract of bark tested in mice up to the dose of 5 000 mg/kg did not produce any sign of toxicity. While 50% alcoholic extract of bark at the doses of 50, 100, 300 and 500 mg/kg and its different fractions (100 mg/kg) showed reduction in gastric ulceration ($P< 0.05$). Ethyl acetate extract at the doses of 10, 50 and 100 mg/kg showed dose-dependent inhibition of gastric lesions against ethanol-induced gastric damage. In 19 h pylorus-ligated animals, Ethyl acetate extract at 50 and 100 mg/kg doses showed significant reduction in ulcer index ($P<0.05$). Significant reduction was also observed in total acidity, volume of gastric acid secretion, total acid output and pepsin activity ($P<0.05$) when compared with the control group. Ethyl acetate extract showed increase in the mucosal glycoproteins that was evident from significant rise in total carbohydrates to protein ratio (TC:PR ratio) ($P< 0.05$), which is an indication of mucin activity. Ethyl acetate extract also showed protection against water-immersion plus stress-induced gastric lesions that was evident from dose-dependent decrease in ulcer index ($P< 0.05$), score for intensity ($P< 0.05$) and total lesion area ($P< 0.05$) when compared with the control group[40]. Aqueous extract of dry bark at the variable concentration showed anti-nematocidal property against Meloidogyne incognita, results were equivocal. Bark extract of *M. elengi* showed moderate inhibitory activity against HIV type 1 protease[29] and non-significant activity against Herpes simplex virus type 1[30]. Methanolic extract of *M. elengi* bark has analgesic and neuropharmacological activity on mice[28].

Methanolic extract of *M. elengi* roots showed mitogenic activity against lymphocyte cell culture at the dose of 10.0 μg/mL. Ethanolic-aqueous (1:1) extract of fungus infected roots of *M. elengi*, at the dose of 0.01 g/mL administered through ileum showed anti-histamine effect in guinea pig. Variable doses through gastric intubation showed no anti-pyretic activity in rabbits, where pyrexia was induced by yeast, where as variable intravenous doses showed any hypotensive activity, but ileum dose of 0.01 g/mL showed parasympatholytic activity in guinea pig. Dose of 32.0 g/kg by gastric intubation showed no toxicity effect in general; here the dose is expressed as a dry weight of plant.

Hot aqueous extract of flowers, at the intravenous dose of 1.0 mL/kg to dogs showed diuretic activity. Ethanolic-aqueous (1:1) extract at variable doses through ileum does not shown anti-histamine and unspecified type of anti-spasmodic activity in guinea pig, and variable doses through gastric intubation did not show anti-pyretic activity in rabbits, here pyrexia was induced by yeast. Hot aqueous extract at variable intravenous doses showed bradycardia activity within dogs. Different concentrations viz. 10%, 30%, 50% produced hypotension and bradycardia. Aqueous extract administered in the heart vent strip at the concentration of 1.0 mL showed cardiac depressant activity in rats. Intravenous dose of 1.0 mL/kg showed negative chronotropic effect and hypotensive effect in dogs. 10%, 30%, 50% w/v of extracts was used[8]. Ethanolic-aqueous (1:1) extract through gastric intubation at the dose of 10.0 gm/kg in mouse showed no general toxic effect. Aqueous extract when given to both sexes of rat through gastric intubation showed weak hypokalemic activity. Extract (6% w/v) was administered for the periods of 3, 6, 9, 12 and 15 days.

Decoction of *M. elengi* fruits at the concentration of

10.0 mg/mL showed weak nematocidal activity against Pheritima posthuma. Ethanolic (90%) extract showed hypotensive effects in dogs and diuretic, anti- inflammatory, hypoglycemic, anti-pyretic, anti-coagulant activities nor any effect on CNS and isolated tissues were not observed. LD_{50} of the extract was 500 mg/kg i.p. in albino rats. Aqueous, methanolic and ethanolic extract of fruits, fruit pulp and fruit rind were failed to show any antibacterial effect[8]. But phenolic extracts of fruit at different ripening stages were well documented for their antioxidant capacities[36]. Infect all parts of *M. elengi* showed good antityrosinase, DPPH scavenging and reducing power activities in methanol[37].

Saponin fractions have been reported to have spermicidal activity at a dilution of 0.06% in human semen. It was devoid of any CVS activity in dogs (at a dose of 0.5 mg/kg intravenous) and did not haemolyse human blood cell at 10 μg/mL concentration. The saponin had no anti-inflammatory activity against carrageenin induced rat paw edema. The LD_{50} of the saponins was 40 mg/kg intraperitoneal in mice. The saponins had spasmolytic action on isolated guinea pig ileum preparation against acetylcholine histamine and barium chloride. It was most active against histamine[46].

The methanolic extract of *M. elengi* on administration (i.v.) at a dose range of 2-16 mg/kg, produced about a 7%-38% fall in mean arterial blood pressure, in a dose-dependent manner. The effect was independent of andrenergic, muscarinic and histaminergic receptors. The hypotension was also unchanged after autonomic ganglion or angiotension converting enzyme blockade. Administration of calcium channel blockers, however, including nifedipine (0.9 mg/kg) and verapanil (3.9 mg/kg), caused corresponding reductions of 81% and 64% in extract-induced hypotension. These data implies *M. elengi* might possess calcium-blocking activity that would explain its hypotensive effect. The triterpene, mimusopic acid from seed, possessing the novel migrated oleanane skeleton, mimusopane, exhibits anti-HIV reverse transcriptase activity and modification of this novel compound may lead to more potent bioactive substances. Moreover, the saponins present also demonstrated to be antifungal against some human pathogens[47]. A α-glucosidase delay digestion of complex carbohydrate by acting as competitive inhibitors of the intestinal enzyme α-glucosidase that hydrolyzes oligosaccarides into monosaccarides. Due to these α-glucosidase inhibitors used to reduce the postprandial glycemic excursions and decrease postprandial hypoglycaemia. Two α-glucosidase inhibitors from the methanolic extracts of *M. elengi* was isolated namely 3β-Hydroxy-12-ursen-28-oic acid, and 3β-(4-hydroxy cinnamoyl)-12-ursen-28-oic acid[48]. Traditionally seeds of *M. elengi* is being used for curing piles, headache, constipation and such traditional claim are well supported by modern research[8, 49].

Conflict of interest statement

We declare that we have no conflict of interest.

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