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(Review Article)

Mimusops elengi Linn. (Bakul) - A Potential Medicinal Plant: A Review

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ABSTRACT

Medicinal plants are the valuable and cheap source of unique phytochemicals which are frequently used in the development of drugs against various diseases. A large fraction of the world population, especially in the developing and underdeveloped countries still depends mainly on the traditional system of medicine. The use of plants and plant products in medicines is getting popularized because the herbal medicines are cheap, easily available and have natural origin with higher safety margins and lesser or no side effects. Mimusops elengi (Linn.) is an evergreen tree of the family Sapotaceae. It is most frequently known as "Bakul" which is cultivated as an ornamental tree largely in gardens. Conventionally, different parts of the plant are used in various ways to cure a number of human aliments. Several therapeutic uses such as cardiotonic, alexipharmic, stomachic, anthelmintic and astringent have been ascribed to the bark of the plant. The bark and fruit of this plant are used in the treatment of diarrhea and dysentery, and a decoction of the bark is used as a gargle. The present review is an attempt to enrich our knowledge about various pharmacological properties of this plant and to draw attention for further research so as work on untouched pharmacological properties.

Key Words: Herbal; Sapotaceae; Diuretic; Phytochemicals; Antibacterial.

INTRODUCTION

Plants are considered as chemical factories which biosynthesize a variety of chemical compounds such as alkaloids, glycosides, saponins, resins, lactones and oils which act on human body in different ways. The biological properties of the medicinal plants are due to presence of specific phytochemicals synthesized in different parts. These phytochemicals can be valuable in maintenance of health in humans and other animals. The promising results from researches on various properties of the medicinal plants have forced scientists to search for plant derived drugs for treatment of different diseases. Therefore, there has been growing interest among scientists to isolate and study the pharmacological properties of the phytochemicals. Herbal medicines are employed to cure a wide variety of health related problems ranging from treatment of common colds to treatment of cancer.

Mimusops elengi Linn. (*M. elengi*) is an evergreen ornamental tree of the family *Sapotaceae* with pleasant fragrant flowers. It carries a variety of names such as Bakul (Hindi and Bengali), Spanish cherry, West Indian Medlar or Bullet wood tree (English), Bakula (Sanskrit) *etc*. in different languages. *M. elengi* is regarded as one of the best medicinal plants since each and every part of it is used in various ways to cure a variety of human diseases. The bark is used as a tonic, and in gargles to cure odontopathy, inflammation and bleeding of gums. It is also useful in urethrorrhoea, cystorrhoea, diarrhoea and dysentery. The bark and seed coat are used for strengthening the gum and are utilized along with tannin rich substances like catechu (*Acacia catechu*), pomegranate (*Punica granatum*) bark *etc.* in various herbal tooth powders, such as "Vajradanti". Further, it is one of the constituents in the preparation of "Mahakhadiradivati" prescribed for stomatitis, halitosis, appetizer, anorexia, spongy gums and pharyngeal problems. The bark is also useful in painful high fever [1, 2]. The bark of *M. elengi* produces a commercial dye. The chemical constituents of the color components responsible for dyeing have been identified. The dyeing behavior of these color components on wool has also been evaluated. The color components isolated from the bark mainly contain flavonoid moiety [3]. The leaves have been considered as an antidote for snakebite. The flowers and unripe fruits are used as an ointment for treating wounds and ulcers. The powder from dried flowers is a brain tonic and relieves from cephalalgia. The flowers are used as expectorant, to cure problems of liver, nose, and are smoked in asthma. Further, the flowers are used to make garlands and for stuffing pillows [1, 2]. The fruits are aphrodisiac, diuretic, astringent to the bowels and good in gonorrhoea. The pulp of the ripe fruits has been successfully used to cure chronic dysentery. The immature fruits are chewed to protect loose teeth. The ripe fruits are given orally to pregnant women to facilitate delivery. The hot aqueous extract of fruits is given orally to human as diuretic which also acts as antipyretic. The ripe fruits rich in carbohydrates are good source of food [2]. The seeds of *M.*

elengi are powdered and applied locally with ghee within the anus of children to cure constipation. The hot water extract of dried seeds is used to fix loose teeth. The seeds produce oil which is used in medicines for burning. The young twing of *M. elengi* like that of Neem tree is used as tooth brush for cleaning teeth, while the valuable wood is used in railway slipper. The roots are aphrodisiac, diuretic, astringent to the bowels and good in gonorrhea The hot aqueous extract of root as a gargle strengthens the gums and teeth, and can be given orally as antipyretic [1]. The important ayurvedic preparation of *Mimusops* is '*Bakuladya Taila*' which is applied on gum and teeth for strengthening, whereas in Unani system of medicines, the bark is used for the genitourinary diseases in males [1, 2, 4].

DISTRIBUTION

It is cultivated mainly in North and Peninsular India, and in Andaman Islands [4].

TAXONOMIC POSITION

The taxonomic nomenclature of *M. elengi* is as follows [4]:

Kingdom : Plantae,
Order : Ericales,
Family : Sapotaceae,
Genus : *Mimusops*,
Species : *elengi* Linn.

Figure 1: *Mimusops elengi* Linn. (Bakul)

BOTANICAL DESCRIPTION

M. elengi is an ornamental tree with abundant strong aromatic flowers. It is an evergreen large tree with a compact leaf crown and a short erect trunk. The bark is dark grey fissured. The leaves are oblong, glabrous and leathery with wavy margins. The flowers are white, fragrant, axillary, solitary or fascicled. The fruits are ovoid or ellipsoid berries (Figure 1). The seeds are ovoid, compressed, greyish brown and shiny. The other important species belonging to the genus *Mimusops* are *M. hexandra* Roxb. and *M. kauki* Linn. *syn*. *Manilkara kauki* Dub. [1, 2, 4].

PHYTOCHEMICAL PROPERTIES

A large variety of phytochemicals have been isolated and characterized from different parts of *M. elengi*. Phytochemical analysis of *M. elengi* has established the presence of tanins, alkaloids, saponins, cardiac glycosides, steroids, flavonoids and reducing sugar. The ethanolic extract of leaves showed presence of quercetin, quercitol, hentriacontane, β-carotene and glucose. The aerial parts together with the roots and seeds contain taraxerone, taraxerol and lupeol. The fruits, seeds and stems, in addition, gave quercetin, dihydroquercetin, myricetin, glycosides, hederagenin, betulinic acid and ursolic acid together with salts. The ethanolic extract of bark contained a saponin which on hydrolysis produced β-amyrin and brassic acid. The seed oil was comprised of capric, lauric, myristic, palmitic, stearic, arachidic, oleic and linoleic acids [1, 2, 5, 6]. A pentacyclic triterpene along with other known triterpenoids and gallic acid esters from the ethanolic extract of the stem bark, while two new triterpenes from the methanolic extract of *M. elengi* have been isolated and characterized[7,8,9]. Two novel triterpenoid saponins, mimusopin 1 and 2 were isolated from the seeds of *M elengi* and their structures were elucidated [10].

PHARMACOLOGICAL PROPERTIES

Medicinally all parts of *M. elengi* are used to cure various human ailments. However, the bark has been studied extensively for its pharmacological properties. *M. elengi* exhibits various biological and pharmacological activities such as antiviral, antibacterial, antifungal, anthelmintic, anticariogenic, antihyperlipidemic, antihyperglycemic, diuretic effects, free radical scavenging, antioxidant, cognitive enhancing, cytotoxic activities *etc*. due to presence of a variety of active phytochemicals.

Antiviral Activity

The crude aqueous and methanol extracts of *M. elengi* inhibited HIV type 1 protease (PR) by more than 70 % at a concentration of 0.2 mg/ml as determined by HPLC [11].

Antibacterial Activity

There are several studies reporting antibacterial potential of extracts prepared from different parts of *M. elengi*. Two antibacterial compounds *viz.* 2,3-dihyro-3,3'4'5,7-pentahydroxyflavone and 3,3',4',5,7-pentahydroxyflavone from the seeds of *M. elengi* showed strong inhibitory activity against Gram-positive and Gram-negative bacteria [12]. Dried and powdered bark of *M. elengi* was extracted with various solvents for evaluation of antibacterial activity against Gram-positive and Gram-negative bacteria and other microorganisms isolated from tooth-tartar of dental patients. Among all the extracts tested, chloroform extract exhibited major antibacterial activity at 200 mg against all the microorganisms present in tooth-tartar of dental patients [13]. Further in a study, aqueous and ethanol extracts from ten medicinal plants including *M. elengi*, were screened for antibacterial activity against bacterial strains *viz. Pseudomonas aeruginosa, Proteus mirabilis, Staphylococcus aureus, Bacillus cereus, Alcaligenes faecalis* and *Salmonella typhimurium* using both agar disc diffusion and agar well diffusion methods. The ethanol extracts were found to be more potent than aqueous extracts of all the medicinal plants [14]. The antibacterial activity of petroleum ether, ethyl acetate and methanol extracts from bark, fruits and leaves of *M. elengi* was tested against some pathogenic bacteria. Fruit extracts were found less potent against most of the tested bacteria compared to those prepared from bark and leaves of *M. elengi*. Further, leaf extracts displayed good activity against *Bacillus subtilis* [15]. The ethanolic bark extract of *M. elengi* when tested for its antimicrobial activity against the bacterial isolates *Staphylococcus aureus*,

Pseudomonas aeruginosa and E. coli, showed inhibitory activity against three *Staphylococcus* isolates including *S. aureus* with MIC 128 mg/l [16].

Two native plants *viz. Tephrosia purpurea* (Linn.) Pers. (Fabaceae) and *M. elengi* were tested against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *E. coli* and one clinical isolate of *Candida* spp. with water extracts of leaves, pods and roots using the 'disc diffusion bioassay'. In addition, ethanolic extracts of the bark of *M. elengi* was tested for its antimicrobial activity against the above bacterial isolates. The ethanolic leaf extracts and all the water extracts showed no activity against any of the isolates. The bark extract of *M. elengi* showed activity against three *Staphylococcus* isolates including *S. aureus*. The MIC of ethanolic root extracts of *M. elengi* was found to be 128 mg/l [17]. The extracts prepared from bark, fruit and seed of *M. elengi* were evaluated for antibacterial activity using spectrophotomertic method against Gram-positive and Gram-negative strains *viz. Nocardia asteroids, Micrococcus luteus, Bacillus subtilis, Bacillus licheniformis, Proteus mirabilis* and *Salmonella typhimurium.* The fruit and seed extracts were found inactive, while stem bark extracts showed antibacterial activity against all bacterial strains. The ethyl acetate extract exhibited the highest % age inhibition (84.5 % age, MIC = 0.6 mg/ml) against *B. subtilis*, while the aqueous methanol (2:8) extract showed significant results with 74.9 % age inhibition (MIC = 0.9 mg/ml) against *N. asteroids* compared to standard antibacterial drugs streptomycin and ampicillin [18]. In a study, petroleum ether, acetone, methanol and water extracts of six medicinal plants *viz. Terminalia chebula, Mimusops elengi, Achyranthes aspera, Acacia catechu, A. arabica* and *Glycyrrhiza glabra extracts* were tested for their antibacterial activity against five dental infection microorganisms such as *Staphylococcus aureus, Streptococcus mutans, S. salivarius, S. sanguis, Lactobacillus acidophilus* and *Candida albicans* by well diffusion method. All the extracts of plants showed significant activity against all pathogens. Phytochemical investigation of above the plants showed presence of several constituents which might have exerted synergistic antimicrobial effect [19]. In another study, the acetone bark extract of *M. elengi* was screened for antimicrobial activity against salivary micro flora collected from children of 6-12 years of age by 'paper disc diffusion' method. The results confirmed that the acetone extract of *M. elengi* at 450 µg/disc inhibited growth of most of the tested salivary micro flora compared to chlorhexidine, a known chemical antimicrobial agent [20]. *In vitro* evaluation of antibacterial activity of aqueous, petroleum ether, toluene, chloroform, methanol and ethanol extracts from leaves of *M. elengi* was investigated against five pathogenic bacteria *viz., Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi , Vibrio cholera* and *Streptococcus pneumonia* at concentrations of 10,20,30,40 and 50 µl. Among the five pathogens tested, *S. pneumonia* and *E.coli* showed a maximum inhibition of 26.9 mm and 24.4 mm with aqueous extract at 50 µl compared to standard antibiotics Gentamicin, Tetracycline and Streptomycin. The methanol and ethanol extracts at 10 to 50 µl showed a maximum inhibition against all the pathogens [5]. However, further in a study, aqueous and acetone bark extracts of *M. elengi* and *Juglans regia* (Walnut) were evaluated and compared for antibacterial activity against salivary microflora collected from children of 6-12 years of age with moderate caries (DMFT = 3-4) using paper disc diffusion method. The acetone extract of *J. regia* showed highest zones of inhibition indicating its use as a potent antibacterial agent. Comparatively, the aqueous and acetone extracts of *M. elengi* did not show any significant zones of inhibition [21].

Antifungal Activity

Different extracts (petroleum ether, ethyl acetate and methanol) from bark, fruits and leaves of *M. elengi* were tested for antifungal activities against some pathogenic fungi. Fruit extracts were less potent against most of the tested organisms compared to those prepared from bark and leaves of *M. elengi* and were inactive against the fungus *Trichoderma viride*. However, leaf extracts displayed good activity against *Trichoderma viride* [15]. The effect of aqueous extracts of leaf and bark of *M. elengi* on the radial growth and sclerotial development (number and size) of the polyphagous fungus *Sclerotinia sclerotiorum* (Lib.) de Bary affecting 400 crop species was investigated. The unsterilized aqueous bark extract showed significantly higher inhibition of radial growth and number and size of sclerotia compared to the sterilized and unsterilized aqueous leaf extract. Further, unsterilized aqueous bark extract at 30 % concentration showed highest sensitivity reducing radial growth by 56.54 %, sclerotia number by 65.15 % and sclerotial size by 68.90-73.11 % [22]. Hexane, ethyl acetate, ethanol and methanol extracts of *M. elengi* and other medicinal plants were tested against the dental caries causing bacteria and a fungus *Candida albicans* isolated from caries infected patients. However, *M. elengi* extracts did not show any antifungal activity against *C. albicans* [23].

Anthelmintic Activity

The anthelmintic potential of crude methanolic extract and it's fractions from the leaves of *M. elengi* was studied in adult earthworms *Pheretima posthuma*. The methanolic extract and ethyl acetate fraction of the leaves caused paralysis and death of the worms at high doses compared to Albendazole as standard and distilled water as control [24]. In a similar study *in viro* anthelmintic activity of *M. elengi* using methanolic bark extract (25, 50 and 100 mg/ml) was reported against earthworms (*Pheretima posthuma*) [25]. Dhamija *et al*., (2011) reported anthelmintic activity of ethanolic and aqueous extracts of *M. elengi* against adult earthworm *Eisenia foetida* (redworm) at 4 mg/ml or more [26].

Anticarciogenic Activity

The effects of oral administration of 50 % alcoholic extract of *M. elengi* and its different fractions namely ethyl acetate, n-butanol, methanol and aqueous were studied against ethanol-induced gastric damage and it was observed that ethyl acetate fraction possessed anti-ulcer activity against experimental gastric ulcers [27]. Further in a study, the effect of alcoholic and petroleum ether extracts of bark (200 mg/kg body weight) of *M. elengi* was evaluated in rats. The alcoholic extract showed significant antiulcer activity compare to petroleum ether extracts of bark [28].

Antihyperlipidemic Activity

In an experiment, hyperlipidemia in Hyperlipidemic group (HG), Fenofibrate group (FG) and *M. elengi*-treated groups (100, 300, 600 mg/kg body weight, *p.o*.) was induced by

single *i.p.* injection of Triton WR-1339 at 200 mg/kg except normal control (NC). The groups treated with *M. elengi* showed significant reduction in levels of triglyceride and total cholesterol as compared to HG after 7 and 24 h of induction. Even after 48 h the groups treated with *M. elengi* at 300 and 600 mg/kg showed significant decrease in level of triglyceride and decrease in level of total cholesterol compared to HG. Moreover HDL level was significantly elevated in the groups treated at 300 and 600 mg/kg after 7 and 24 h, however, it was significantly elevated only in group treated at 600 mg/kg after 48 h of the treatment. It was concluded that *M. elengi* had antihyperlipidemic effect owing to its ability to reduce the levels of total cholesterol, triglyceride and increasing the level of HDL[29]. The methanolic extracts (100 mg/kg body weight) of flower and leaves of *M. elengi* when administered orally to normal and alloxan-induced diabetic rats, both the extracts showed marked decrease in blood glucose level in normotensive rats within 2 h after oral administration. In diabetic rats, the extracts given for 7 days decreased triglycerides levels compared to the diabetic control group[30].

Anti-inflammatory, Antipyretic and Analgesic Activities

The ethanolic extract (200 mg/kg body weight, *p.o*) of bark of *M. elengi* significantly inhibited the carrageenan-induced paw edema at 3rd and 4th h and in cotton pellet model. It reduced the transudative weight and little extent of granuloma weight. In analgesic models, the extract decreased the acetic acid-induced writhing and reduced the rectal temperature in Brewer's yeast induced pyrexia. However, there was no increase the latency time in the hot plate test. The results showed that ethanolic extract of bark of *M. elengi* has anti-inflammatory, analgesic and antipyretic activities [31]. Further in a study, *M. elengi* leaf extract in acetic acid induced writhing, produced 45.61 % and 63.85 % writhing inhibition at 250 and 500 mg/kg body weight respectively. In hot plate test, the extract exerted significant prolongation in the response of latency time to the heat stimulus showing analgesic activity [32]. In a similar study, antioxidant and *in vitro* anti-inflammatory effects of alcoholic leaf extract of *M. elengi* were demonstrated using different parameters[33]. The antipyretic and analgesic activities of methanolic extract of leaves of *M. elengi* were investigated in yeast induced pyrexia in rats and tail immersion model after oral administration of the extract at 100 and 200 mg/kg body weight. The extract produced significant antipyretic effect in a dose dependent manner and an appreciable antipyretic effect was noticed at 200 mg/kg. A dose dependent analgesic activity was observed and significant effect was observed at 200 mg/kg [34]. The methanolic bark extract (100, 200 and 400mg/kg body weight) of *M. elengi* was investigated for analgesic and neuropharmacological activities in mice. In tail immersion test, the extract produced an increase of latent time to flick tail compared to control in a dose dependent manner. In acetic acid-induced writhing test, the extract at 400 mg/kg showed a maximum of 65.48 % inhibition of writhing compared to the control. In CNS depressant activity tests, the extract significantly decreased motor activity and exploratory behavior of mice in hole cross and open field tests respectively. The results suggested that the extract possesses analgesic and CNS depressant activity [35]. The pretreatment with ethanolic bark extract (200 and 400mg/kg body weight, *p.o*) and isolated compound β-amyrincaprylate (5mg/kg body weight) of *M. elengi* exhibited significant anti-inflammatory activity in acute and chronic models [36].

Antioxidant and Free Radical Scavenging Activities

The methanol extract of the leaves of *M. elengi* in a study showed significant activities in all antioxidant assays (1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay, reducing power and total antioxidant capacity) compared to ascorbic acid in a dose dependent manner. In DPPH scavenging assay, the IC_{50} value of the extract was found to be 43.26 µg/ml compared to ascorbic acid (58.92 µg/ml). Total antioxidant activity was also found to increase in a dose dependent manner [37]. The antioxidant capacities of the phenolic compounds extracted from immature green, mature green and orange ripe fruits of *M. elengi* were investigated in a study. The antioxidant capacity of the crude extract from immature fruit (GAE = 318.5 ± 12.3 mg/g extract) was higher than that of either the mature (GAE = 234.1 ± 9.2 mg/g extract) or the ripe fruit (GAE = 111.9 ± 4.9 mg/g extract). High performance liquid chromatographic analysis confirmed that all phenolic fractions contained gallic acid as a constituent. *M. elengi* fruits appeared to be a good source of natural antioxidant [38]. Ashok *et al*. (2010) studied *in-vivo* antioxidant and antiurolithiatic activities of petroleum ether, chloroform, and alcohol extracts of bark of *M. elengi* and reported that the alcohol extract had more potent antioxidant activity than petroleum ether and chloroform extracts [39]. The methanolic bark extract of *M. elengi* in another study offered significant *in vitro* reducing power capacity and radical scavenging activity[40]. Rao *et al*., (2011) demonstrated that the chloroform extract of bark of *M. elengi* contained high level of total phenolic compounds and showed strong antioxidant activity by inhibiting DPPH, hydroxyl radical, nitric oxide and ABTS radical scavenging activities when compared with standard ascorbic acid. Further, there was a linear relationship between the antioxidant activity and phenolic content, indicating that phenolic compounds could be major contributors to antioxidant activity [41]. The protective role of oral administration of leaf extract (100mg/kg body weight for 30days) of *M. elengi* on lipid peroxidation and activities of both enzymatic (Superoxide dismutase, Catalase, Glutathione peroxidase and Glutathione–S-transferase) and non-enzymatic (reduced glutathione, vitamin C and vitamin E) antioxidants in plasma and tissues was studied in adult male albino rats of the Wistar strain. The extract treatment resulted in significant reduction in lipid peroxidation with increased activities of both enzymatic and non-enzymatic antioxidants when compared to diabetic rats [42]. Karmakar *et al*. (2011) also reported the antioxidant activity of leaf extract in DPPH free radical scavenging and Nitric oxide scavenging tests [32].

Antihyperglycemic and Antidiabetic Activities

The methanolic bark extract (400 mg/kg body weight, *p.o.*) of *M. elengi* in acute study in alloxan-induced diabetes, exhibited significant antihyperglycemic effect with onset at 2nd h, peak activity at 6th h. The antihyperglycemic effect of extract was persistent up to 24th h after drug administration. There was reduction in elevated glucose levels in glucose-loaded non-diabetic animals. Further the extract demonstrated significant reduction in elevated glucose levels 2 h before glucose administration and 6 h after glucose load in oral glucose tolerance test in diabetic

animals. Thus the extract demonstrated antihyperglycemic activity in diabetic as well as non diabetic glucose loaded mice [40]. The methanolic extracts (100 mg/kg body weight, *p.o.*) of flower and leaves of *M. elengi* were given to normoglycaemic and alloxan-induced diabetic rats. Both the extracts showed marked decrease in blood glucose level in normotensive rats within 2 h after oral administration. A significant decrease in elevated blood glucose level was observed in glucose loaded animals. The extracts significantly decreased blood glucose level from 221.83 ± 3.73, 210.50 ± 2.51 to 157.00 ± 9.89, 173.33 ± 11.21 mg/dl respectively after 7 days treatment in alloxan-induced diabetic rats [30].

Antityrosinase Activity

Narayanaswamy *et al*. (2011) carried out a study to identify new ingredients from *M. elengi* for their antityrosinase and antioxidant activities to determine the anti-aging and skin whitening potential. The various parts (bark, fruit, flower and leaves) of *M. elengi* were studied for their skin whitening and antioxidant potential in various solvents. The skin whitening ability of plant extracts was examined through tyrosinase inhibition assay. The antioxidant potential of the herb was investigated by 2, 2-diphenyl 1-picryl hydrazyl radical (DPPH) scavenging and ferric reducing power assay. Among the parts studied, the methanolic extract of *M.elengi* flowers showed the highest inhibition of tyrosinase with an IC_{50} value of 401 µg followed by methanolic extract of leaves. The methanolic extract of flowers (96.57 %) and fruits (97.15 %) possessed the highest and almost similar inhibition of DPPH radical when compared to other parts studied. The ferric reducing ability of methanolic extract of *M.elengi* leaves was maximum compared to all other parts[43].

Anti-atherosclerotic Activity

Satishchandra and Sumithra (2011) studied the combined effect of *M. elengi* and *Moringa oleifera* in high fat diet induced aetheroma in rats under six groups *viz.* normal diet, high fat diet, high fat diet with T_1 (*M. elengi*), high fat diet with T_2 (*Moringa oleifra*), combined drug (T_1 + T_2) with high fat diet and standard drug (Atrovastain) with high fat diet [44].

Anticonvulsant Activity

In a study with methanolic, aqueous, and n- butanolic extracts (50, 100 and 200 mg/kg body weight) of bark of *M. elengi* in Maximal electroshock (MES) induced convulsions in rats and Isoniazid (INH) induced convulsions in Swiss mice, it was concluded that methanolic extract of *M. elengi* showed maximum protection against MES and INH induced convulsions [45].

Anti-anxiety Activity

The anti-anxiety activity of methanolic (50,100 and 200 mg/kg body weight), aqueous (100 and 200 mg/kg body weight) and n-butanol (200 mg/kg body weight) extracts of bark of *M. elengi* was studied in Swiss albino mice and it was found that methanolic extract at 200 mg/kg had more significant anxiolytic activity as compared to aqueous and n-butanol extracts [46].

Cytotoxic Activity

The cytotoxic effects of *M. elengi* was investigated using different concentrations (2.5, 5, 10 mg/ml) of standard cytotoxic drug cyclophosphamide and ethanolic extract of bark on meristimatic cells of root tips of *Allium cepa*. After 48 h and 96 h of treatment, the photomicrographs showed chromosomal abnormalities, stickiness, *etc*. and there was a significant decrease in percent mitotic index and root length of *A. cepa* with respective time and increasing concentration [47]. The cytotoxic activity of the leaf extract of *M. elengi* was assessed by brine shrimp lethality bioassay as an indicator of toxicity in which LC_{50} was 80 µg/ml and LC_{90} was 320 µg/ml for the sample [32]. Nasrin *et al*. (2010) also studied cytotoxic activity of methanolic bark extract by brine shrimp lethality bioassay. The extract exhibited good cytotoxic activity with LC_{50} value of 40 µg/ml whereas LC_{50} of vincristine sulphate was 0.078 µg/ml [25].

Wound Healing Activity

A methanolic extract from bark of *M. elengi* was examined for wound healing activity in the form of ointment in three types of wound models on mice: the excision, the incision and dead space wound model. The extract ointments showed considerable response in all the wound models compared to standard drug Betadine ointment in terms of wound contracting ability, wound closure time, tensile strength and dry granuloma weight. Histological analysis was also consistent with the proposal that *M. elengi* bark extract exhibits significant wound healing [48].

Diuretic Activity

The diuretic and electrolyte excretion activities of petroleum ether, chloroform and alcoholic extracts (200 mg/kg body weight, *p.o.*) of bark of *M. elengi* were investigated. The highest diuretic and electrolyte excretion activities were presented by the alcoholic extract[49]. Further in another study, the ethyl acetate, ethanol and aqueous extracts (250 mg/kg body weight, *p.o.*) of *M. elengi* were evaluated for diuretic activity. The aqueous extract showed a significant diuretic activity compared to other extracts [50].

Hypotensive Activity

The methanolic extract (at a dose range of 2-16 mg/kg body weight, *i.v.*) of *M. elengi* caused hypotensive activity in anaesthetized rats and produced about a 7-38 % fall in mean arterial blood pressure in a dose-dependent manner. The effect was independent of adrenergic, muscarinic and histaminergic receptors. The hypotension was also unchanged after autonomic ganglion or angiotensin-converting-enzyme blockade. Administration of calcium channel blockers, however, including nifedipine (0.9 mg/kg) and verapamil (3.9 mg/kg), caused corresponding reductions of 81 and 64 % in extract-induced hypotension [51].

Cognitive Enhancing Activity

The 70 % ethanolic extract (200 mg/kg body weight) of flowers of *M. elengi* was shown for congestive enhancing activity using Elevated plus Maze and Passive Avoidance Task methods [52]. In a study, the ethanol extract of *M. elengi* (100 and 200 mg/kg body weight, *p.o.*) was administered orally for 8 successive days to both young and aged mice and Elevated plus maze and Passive avoidance paradigm were employed to assess short term and long term memory respectively. *M. elengi* (100 and 200 mg/kg body weight,

p.o.) significantly attenuated amnesic deficits induced by diazepam (1 mg/kg body weight, *i.p.*), scopolamine (0.4 mg/kg body weight, *i.p.*) and natural aging. Further, *M. elengi* decreased transfer latencies and increased step down latencies significantly in the aged mice. It also reversed amnesia induced by diazepam and scopolamine in young mice. *M. elengi* also decreased whole brain acetyl cholinesterase activity significantly [53].

Immunostimulatory Activity

The immunostimulatory activity of methanolic extract (10, 20, 40 mg/kg body weight) of bark of *M. elengi* in mice was studied by Carbon Clearance Test (CCT), Haemagglutination Antibody Titre (HA) and Delayed Typre Hypersensitivity using Sheep R.B.C. as antigen. Distilled water served as a control in all the tests and Vitamin E 150 mg/kg was used as standard. The *M. elengi* extract showed a dose dependent increased immunostimulatory response [54].

Larvicidal Activity

The hexane (HEX) and ethyl acetate (EA) extracts of bark of *M. elengi* was shown to have promising larvicidal activity against IV instar larvae of *A. aegypti* and *C. quinquefasciatus* and its benefits in developing cost-effective and environment friendly new type of larvicide for mosquito control [55].

Spermicidal Activity

There are reports on spermicidal potential of saponins isolated from seeds of *M. elengi* [56]. The results of preliminary studies carried out in our laboratory have confirmed the spermicidal activity of the plant and further work is in progress (unpublished data).

CONCLUSION

In spite of our great dependence on modern medicines and tremendous advances in synthetic drugs, a large portion of the world population still likes drugs of plants origin. *M. elengi* (Bakul) is one of the most important medicinal plants used in preparations of Ayurveda because of having a number of medicinal properties. It is the source of a variety of biologically active phytoconstituents which are responsible for antimicrobial, antioxidant, antihyperglycemic, anticancer and protective effects on various vital organs such as nerves, heart, kidney and liver. Although crude extracts from various parts of *M. elengi* have medicinal applications from time immemorial, modern drugs can be developed after extensive investigation of its bioactivity, mechanism of action, pharmacotherapeutics, and toxicity after proper standardization and clinical trials.

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