Review Article

Phyllanthus maderaspatensis Linn. – A Comprehensive Review on Pharmacognosy, Ethnobotany, Phytochemistry and Pharmacology

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ABSTRACT

Phyllanthus maderaspatensis Linn. (family – Phyllanthaceae), commonly known as Madras leaf-flower, is a herbaceous medicinal plant, widespread in the tropical and subtropical regions of the old world. It is widely used to treat liver disorders, headache, constipation, diarrhoea, edematous, dysentery, fever, ulcer, burn, scabies and other diseases in Ayurveda and Unani. This review particularly deals with the pharmacognosy, ethnobotany, phytochemistry, pharmacology and other aspects of *Phyllanthus maderaspatensis* L.

Keywords: Phyllanthus maderaspatensis L., Phyllanthaceae, Pharmacognosy, Ethnobotany, Phytochemistry, Pharmacology.

INTRODUCTION

Medicinal plants play a key role in the human health care from time immemorial. About 80% of the world population rely on the use of traditional medicine which is predominantly based on plant drugs.[1] The genus *Phyllanthus* L. (family - Phyllanthaceae) has more than 800 species, distributed in tropical and subtropical regions of the world, 53 species are found in India and 23 species are reported to be endemic.[2-3] Several species of *Phyllanthus* have been extensively used in traditional system of medicines in India, Brazil, China and Southeast Asian countries.[4-5] In India, *Phyllanthus* species have been traditionally used for treating disturbances in kidney and urinary bladder, intestinal infections, liver disorders and diabetes etc.[6-10]

Phyllanthus maderaspatensis L. is one of the important medicinal herbs in *Phyllanthus*, widely distributed in India, used to treat liver disorders and other diseases by traditional healers.[11] The plant is known to contain several pharmacologically important biomolecules whose efficacy is well established by several biochemical and pharmacological studies. This review provides comprehensive details of plant habit, distribution, pharmacognosy, ethnobotanical uses, phytochemical constituents, pharmacological actions and micro-propagation of *P. maderaspatensis* L.

Classification:

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Malpighiales
Family:	Phyllanthaceae
Genus:	*Phyllanthus*
Species:	*Phyllanthus maderaspatensis* L.

Botanical description (Figure – 1):

Figure 1: *Phyllanthus maderaspatensis* Linn.

Herb, monoecious, glabrous, up to 80 cm; stem usually woody at base; branching mostly basal, erect or ascending. *Leaves* – Spiral, petiole very short, lamina linear to obovate, 0.7-2 × 0.3-0.7 cm, glaucous below, subacute, obtuse or rounded at the apex, tapered to the base, lateral veins obscure; stipules peltate, lanceolate. *Male flowers* – above; *Female flowers* – below; *Tepals* 6, obovate, margin scarious. *Stamen* 3; filaments connate; anther (sub)sessile, dehiscence vertical. *Styles* horizontally spreading. *Disc* glands 6, oblong in both flowers. *Capsule* 3-valved, globose, 4 mm across, 3-lobed; seed triquetrous, vertically muriculate.

Distribution: Widespread in the tropical and subtropical regions of the old world. India, Indonesia, Pakistan, Sri Lanka, Africa, SW Asia, Australia.

Vernacular names:

English: Madras leaf-flower

Sanskrit: Bhumyamalaki

Hindi: Bazarmani, Hazarmani, Kanocha, Khejario Khad, Ranavali

Marathi: Bhooyi yavali, Kachora

Urdu: Kanocha, Tukhm kanocha

Kannada: Adanelli, Kiru nelli, Madras nelli, Male nelli, Nelanelli

Tamil: Mela nelli, Neela cadamboo, Nilakkatampai, Nilanelli, Talakini, Katampai

Telugu: Nalasereki, Nalla-usirika, Nela usirika, Nelausiri

Pharmacognostic studies:

Khatoon et al., Sharma & Sheela and Alekya et al., have given detailed account on the pharmacognosy of *P. maderaspatensis*.[12-14]

Organoleptic characters of dried plant powder:

Light green colour, indistinct odour, slightly bitter taste, slightly smooth in texture.

Macroscopic characters:

Root: Woody taproot with numerous secondary rootlets, light brown coloured with yellow colour fracture.

Stem: Glabrous, woody at base, 30 to 90 cm long, erect, branches terete below, striate and flattened, particularly at nodes towards apex.

Microscopic characters:

Stem: Outline of stem is somewhat pentagonal in shape. Epidermis is single layered with compactly arranged cells. Hypodermis is made up of single layered but contains 2-4 layered sclerenchyma cells. Cortex is made up of 3 – 5 layers of simple parenchymatous cells. Xylem is separated by uniseriate medullary rays. Phloem is well developed situated above the xylem with sieve elements and fibres. Parenchymatous pith cells are compactly arranged in pith region. Pith cells are filled with oil globules, simple and compound starch grains and sphenoid crystals of calcium oxalate.

Root: Outline of root is irregularly circular with shallow ridges. Epidermis is filled with lignified cork cells with some cells filled with brown content. Below epidermis is composed of tangentially elongated 2-3 layers of lignified cork cells, some of the cells filled with brown content. Cortex region is found to be moderately loosely arranged and made up of 4 - 7 layers of simple parenchymatous cells. Medullary rays are uniseriate and started from central region and extended up to inner layers of the pericyclic region.

Leaf: Leaf margins are more or less crenate and the size of the teeth varies, at some places these are large and comparatively more curved. Epidermal cells angular and stomata are anisocytic type and present on both the surfaces.

Ethnobotanical uses:

The whole plant is traditionally used in India against headache, constipation, diarrhea, edematous, dysentery, fever, ulcer, burn, jaundice, bacterial infections and also taken as a popular dietary supplement in the southern part of India, because of its antihepatotoxic, hepatoprotective and choleretic activities.[4-5] It is widely used in Ayurveda and Unani systems of medicine in the powder form of dried plant material mixed with milk to treat jaundice.[15-17] It is also effective for treatment of diabetes and gall bladder disorders.[7, 18] The leaves are expectorant, diaphoretic and useful in strangury and sweats. The infusion of leaf is given for headache relief and the seeds are carminative, laxative, diuretic and useful in bronchitis, earache, griping, ophthalmia and ascites.[19-21]

In Unani system of medicine, *P. maderaspatensis* popularly known as Kanocha and has various actions and clinical indications such as carminative, concotic, emollient, stomachic tonic, intestinal tonic, cardiac tonic, demulcent, absorbent, liver tonic, laxative, diaphoretic, diuretic, emmenagogue, astringent, dysentery, diarrhoea, expectorant, deobstruent, flatulent, analgesic/anodyne, headache, colitis, bronchitis, ascites, otalgia and ophthalmits.[22]

Phytochemical constituents:

The whole plant of *P. maderaspatensis* contains secondary metabolites such as tannins, reducing sugars, proteins and saponins.[12, 23] Seed contains linoleic acid, linolenic acid, myristic acid, oleic acid, palmitic acid, stearic acid and maderin reported in aerial part.[24] Jain et al., have characterized 11 compounds from *P. maderaspatensis* on the basis of comparative spectral data and mass fragmentation pattern. The isolated compounds were n-tetracosane, taraxeryl acetate, ester of β-sitosterol, taraxerol, hexacosane, 32-methyl-1-tritriacontanol, heptacosanol-14, 11-hydroxyhexacosan-3-one, tetracos-20(en)-l,18-diol, β-sitosterol and oleana-11:13(18)-diene-

3beta,24-diol.[25] Bagul et al., have reported gallic acid and ellagic acid, two widely occurring phenolic compounds from the whole plant of *P. maderaspatensis* by HPTLC method. They have reported 0.064% w/w of gallic acid and 0.096% w/w of ellagic acid.[26] Rajasekhar et al., reported the presence of alkaloids, carbohydrates, steroids, phenolics, flavonoids, gums and mucilages in hexane extract; alkaloids, carbohydrates, steroids, phenolics, gums and mucilages in chloroform extract; carbohydrates, steroids, phenolics, proteins, flavonoids, lignins, gums and mucilages in ethanol extract and carbohydrates, steroids, phenolics, proteins, flavonoids, gums and mucilages in aqueous extract.[27] Phytochemical analysis of shoot extract contains alkaloids, anthocyanins, anthocyanidins, anthracene glycosides, coumarins, flavonoids, flavones, flavonols, phenols, dihydrochalcones, catacholic compound, iridoids and the root extract was found to have similar compounds, except anthocyanins, anthocyanidins and anthracene glycosides. The richness of secondary metabolites in shoot and root were reported as 66.6% and 57.1% respectively.[28]

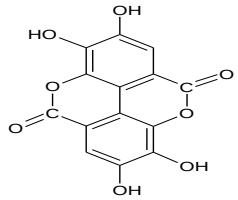
Chang et al., made phytochemical investigation on *P. maderaspatensis* by liquid chromatography-solid phase extraction-nuclear magnetic resonance (LC-SPE-NMR). Twelve compounds were characterized and identified from n-butanol and chloroform soluble fractions. Two flavonoids, rutin and quercitrin-3-O-rhamnoside, one phenolic compound, gallic acid methyl ester 4-O-dimer were isolated from n-butanol soluble subfractions and nine cinnamoyl sucrose acetates were identified from chloroform soluble subfractions.[29] A flavonoid glycoside: Quercetin-3-O-β-D-glucopyranosyl(1-4)α-rhamno pyranoside was isolated from ethyl acetate extract of the whole plant using silica gel column chromatographic separation and the isolated compound was found to possess the antioxidant properties.[30]

Hydro-alcoholic extract of *P. maderaspatensis* was found to contain rutin (0.34%), catechin (2.62%), gallic acid (0.93%), ellagic acid (0.17%), quercetin (0.01%) and kaempferol (0.06%). The hydro-alcoholic extract on repeated column chromatography has yielded corilagin, an ellagitannin, reported for anti-inflammatory and hepatoprotective activity.[31]

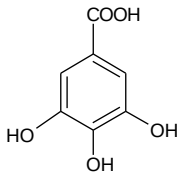
Akhtar et al., made physicochemical examination on seeds of *P. maderaspatensis* and found the amount of total ash, water soluble ash and acid insoluble ash as 5.66 (%), 0.83(%) and 2.16 (%) respectively. The percentage of loss of weight on drying, moisture content, crude fibre content, alcohol and water soluble extractives were found to be 6.72, 4.11, 28.43, 14.07 and 8.28 respectively. The percentage of extractive values by successive extraction with different solvents was found to be 12.46 in petroleum ether, 11.27 in diethyl ether, 3.06 in chloroform, 1.23 in alcohol and 17.34 in distilled water.[32] The HPLC analysis of *P. maderaspatensis* revealed the presence of phenolic acid and flavonoid quantified as ellagic acid and rutin respectively. The maximum content of ellagic acid in the whole plant was found to be 0.181% and the minimum was 0.013%. In the whole plant, minimum rutin content was found to be 0.040% and the maximum was 0.448%.[33]

Lignans, representing a class of bioactive molecules in a large number of medicinal plants, are considered as an interesting source for lead structures toward new drugs and of interest as drugs in the area of cancer chemotherapy. Their chemistry and biological activity as well as therapeutic potential have been reviewed by many workers.[34] Srivastava et al., reported phyllanthin (0.008 - 0.011%) and hypophyllanthin (0.011 - 0.013%) in leaves of *P. maderaspatensis.*[35] Quantification of six bioactive lignans, namely heliobuphthalmin lactone, virgatusin, phyllanthin, hypophyllanthin, nirtetralin, and niranthin in *P. maderaspatensis* by the HPLC-PDA-MS method was reported by Shanker et al.[36] However, Khatoon et al., and Sharma et al., have reported *P. maderaspatensis* did not contain phyllanthin and hypophyllanthin.[12, 37]

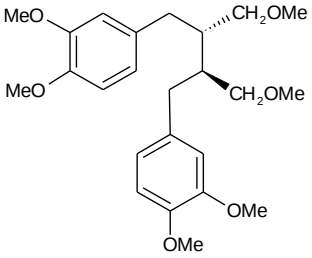
P. maderaspatensis has been proved to be a very good catalyst for the initiation of Ag nanoparticles that can be rapidly produced within a short span of 24 h and with a particle size as small as 59 nm.[38] Kokila et al., have synthesized silver nanoparticles (AgNPs) using the aqueous extract of *P. maderaspatensis* root. The morphology and size of the AgNPs were determined by SEM, HR-TEM, and X-ray diffraction analysis which showed the average particle size ranging from 3–14 nm. Their result indicates that the phytoconstituents present in the *P. maderaspatensis* root extract were mostly accountable for the reduction of Ag+ ions.[39]



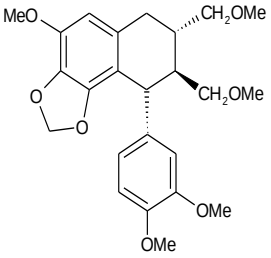
Ellagic acid



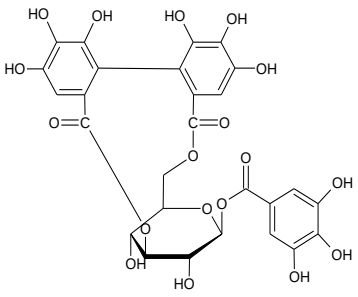
Gallic acid



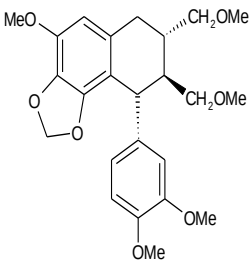
Phyllanthin



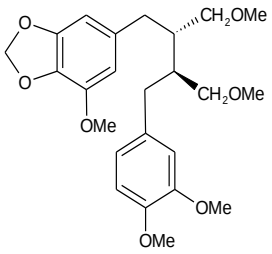
Hypophyllanthin



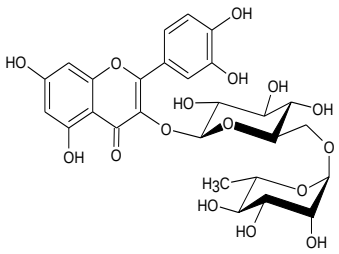
Corilagin



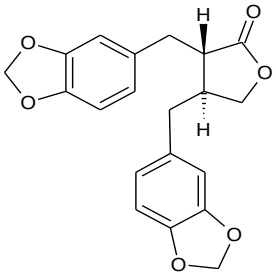
Nirtetralin



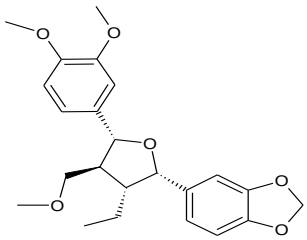
Niranthin



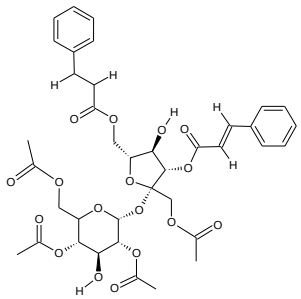
Rutin



Heliobuphthalmin lactone



Virgatusin



Niruriside

Pharmacological actions:

Studies have exhibited that *P. maderaspatensis* have anti-bacterial, anti-microbial, anti- cataleptic and also other medicinal potentials such as deobstruent, stomachic, astringent, febrifugal, diuretic and antiseptic.[40] In India, the whole plant is popularly used against kidney and urinary tract infections, digestive disorders, hepatitis and diabetes.[41] Ashok kumar and Ramasamy observed that the leaf extracts (in different solvents) of *P. maderaspatensis* with their phytoconstituents may act as source of antibiotics.[42]

Antispasmodic and antitumour activity:

Dhar et al., reported the 50% ethanolic extract of the drug showed antispasmodic activity in guinea pig ileum and antitumour activity in rats.[43]

Antihistaminic activity:

Leaves of *P. maderaspatensis* are used in the treatment of asthma traditionally. Antihistaminic principles are useful in the treatment of asthma; hence Nirmal et al., screened the antihistaminic activity of various extracts using clonidine-induced catalepsy and haloperidol-induced catalepsy in Swiss albino mice. Their results showed that the aqueous extract having significant antihistaminic activity. Thus, the polar constituents from leaves extract may be responsible for the antihistaminic activity and may have potential role in the treatment of asthma.[44]

Antiinflammatory activity:

Wagle et al., evaluated the antinociceptive and anti-inflammatory activity of phytosterol present in chloroform extract of *P. maderaspatensis* through carrageenan-induced hind paw oedema and hot plate method in male wistar rats. Their study demonstrated the potential anti-inflammatory and analgesic effect of *P. maderaspatensis*, which supports the claims by the traditional medicine practitioners.[45]

Hepatoprotective activity:

Asha and Pushpangadan (1998) reported antihepatotoxic activity *P. maderaspatensis* in paracetamol and CCl_4-induced liver damages in rats and choleritic activity in normal rats.[46] However, the drug did not show any activity against hepatitis B virus in ducks.[47-48] Krishnakumar et al., evaluated the effectiveness of *P. maderaspatensis* against liver fibrosis in Wistar rats. Hepatic fibrosis was experimentally induced in male rats and the animals were post treated with *P. maderaspatensis* hexane extract. The treatment normalized serum parameters, reduced lipid peroxidation and maintained the normal level of reduced glutathione pool. Histopathology of the liver confirmed its recovery from hepatic fibrosis and they concluded that *P. maderaspatensis* hexane extract is a very promising antifibrotic agent. They have also found that hexane extract suppresses the fibrotic gene expression, as evidenced by the inhibition of alpha-smooth muscle actin-the marker-expression, along with functional restoration.[19, 49]

Asha et al., reported antihepatotoxic and chloretic activities of *P. maderaspatensis* (whole plant extracts). Hexane extract was the most effective which showed activity at a dose as low as 1.5 mg/kg. Water and ethyl acetate extracts showed moderate activity as compared to hexane extract. They also reported hexane extract showed significant hepatoprotection on carbon tetrachloride and thioacetamide induced liver damage in rats.[11, 50] Sharma et al., reported the dose-dependent hepatoprotective activity of *P. maderaspatensis* against t-BH induced cytotoxicity in HepG2 cells and concluded that phyllanthin and hypophyllanthin may not be exclusively responsible for the hepatoprotective activity as these compounds were not found in the plant.[37] Leelaprakash et al., evaluated the protective effect of the aqueous extract of *P. maderaspatensis* on Cd-induced oxidative stress and hepatotoxicity in male Wistar rats. Their study provided the evidence supporting the usefulness of *P. maderaspatensis* to protect Cd-induced toxic effects through its reactive oxygen species scavenging and anti-oxidative properties.[51] The hepatoprotective activity of alcohol and aqueous extracts of *P. maderaspatensis* against paracetamol induced liver disorder in rats were also reported.[27]

Ilyas et al., made a comparative evaluation of standardized alcoholic, hydroalcoholic and aqueous extracts of *P. maderaspatensis* against galactosamine-induced

hepatopathy in albino rats. They reported that the hydroalcoholic extract has potent activity against hepatotoxicity and considered kaempferol, quercetin, catechin, rutin, and ellagic acid may be responsible.[52] Hussain et al., have made a detailed review on the hepatoprotective effects of various medicinal plants. They have reported that *Phyllanthus maderaspatensis*, containing β-sitosterol, is sufficiently active against liver diseases.[53]

Hypocholesterolemic activity:

Kalpani et al., screened the hypocholesterolemic activity of crude methanolic extract of *P. maderaspatensis* using male Wistar albino rats fed with high cholesterol diet. Methanolic extract significantly reduced total cholesterol, LDL-cholesterol and triglyceride levels, exhibiting hypocholesterolemic activity.[54]

Dissanayaka et al., assessed the diet induced hypocholesterolemic activity of crude methanolic extracts of *P. maderaspatensis* on Wistar rats. Hypercholesterolemia was induced in rats by feeding a mixture of egg yolk (20 ml), butter (50 g) and cow ghee (20 ml). Equal amounts of the mixture (~2 ml) were given to all the rats, except the negative control group, once a day orally throughout the experiment. The rats with blood cholesterol levels greater than 120 mg/dl were considered as hypercholesterolemic and were chosen for the study. In 14 days, total cholesterol and triglyceride were reduced to 75.28 mg/dl and 89.16 mg/dl respectively, when compared to the control groups. Their results indicated the capability of the crude methanolic extract in reducing the total cholesterol and triglyceride.[40]

Hypoglycemic activity:

Rajeswari and Shabana Begum assessed the hypolipidemic and hypoglycemic potentials in the ethanolic extracts of *P. maderaspatensis* leaves on streptozotocin (STZ) induced diabetes rats. They reported that ethanolic extract has antidiabetogenic potentials and advantageous outcomes on diabetic hyperlipidemia.[55]

Antioxidant activity:

The antioxidant activity of methanol extract of *P. maderaspatensis* was evaluated by Kumaran and Karunakaran using various antioxidant assays, including total antioxidant, free radical scavenging, superoxide anion radical scavenging, hydrogen peroxide scavenging, nitric oxide scavenging, reducing power and metal ion chelating activities. The results from various free radical scavenging systems reveal that the plant has significant antioxidant activity.[56] Sampath Kumar et al., clearly demonstrated that the ethanolic fractions of *P. maderaspatensis* has significant antioxidant property when assessed by DPPH, ABTS, Superoxide radical scavenging and reducing power assays.[57]

Immunomodulatory activity:

Ilyas et al., evaluated the immunomodulatory activity of *P. maderaspatensis* in LPS-stimulated mouse macrophage RAW264.7 cells. They reported that rutin, gallic acid, kaempferol, catechin and ellagic acid showed a significant immunosuppressive effect owing to the inhibition of Nitric Oxide production compared with the LPS-stimulated RAW 264.7 cells group, and the most significant immunostimulatory effect was produced by ellagic acid and quercetin, when compared with the control group.[41]

Antimicrobial activity:

Antibacterial activity of the methanol extract of *P. maderaspatensis* was evaluated by Komuraiah et al.[58] The minimum inhibition concentration (MIC) and minimum bactericidal concentration (MBC) were observed for *Bacillus stearothermophilus, B. subtilis, Staphylococcus aureus, Micrococcus leuteus, Salmonella typhi, Enterobacter aerogens, Proteus mirabilis* and *Proteus vulgaris*. They found that methanolic extract showed lowest MIC (30 µg/ml) as well as MBC (40 µg/ml) only against *Proteus mirabilis* among the tested bacteria.

Leelaprakash and Dass studied the antimicrobial activity of aqueous extracts of *P. maderaspatensis* against a wide variety of pathogenic bacteria such as *Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Salmonella typhimurium* and their efficacies were compared by the disc diffusion method. At the concentration of 100 mg/ml *P. maderaspatensis* showed maximum activity (25 mm) against *Staphylococcus aureus*. Other organisms showed moderate activity. The MIC of the aqueous extracts on *B. subtilis, S. aureus, E. coli, P. aeruginosa, K. pneumoniae* and *S. typhimurium* were at 75 mg/ml, 25 mg/ml, 25 mg/ml, 75 mg/ml, 50 mg/ml and 25 mg/ml, while the MBC were at 75 mg/ml, 50 mg/ml, 25 mg/ml, 75 mg/ml, 50 mg/ml and 25 mg/ml respectively. The observed antibacterial effects were may be due to the presence of saponins, carbohydrate, proteins, and tannins identified in the extracts.[23]

Karthikeyan et al., determined the antibacterial activity of *P. maderaspatensis* leaves extract against clinical isolates of some bacteria using well diffusion method. The extracts showed inhibitory activity against clinical isolates of gram negative bacteria such as *Salmonella typhi, Shigella dysentriae, Klebsiella pneumonia, Pseudomonas aeruginosa* and *Escherichia coli* and gram positive bacteria such as *Bacillus subtilis* and *Staphylococcus aureus*. The results showed that the acetone extracts were more potent than the other extracts. The acetone extract showed best activity against *K. pneumonia* with a MIC of 10 mg/ml.[59]

Swarupa Rani and Venkata Raju subjected methanol, ethyl acetate and water extracts of *P. maderaspatensis* shoot to antimicrobial screening against five different human pathogenic microorganisms viz. *Staphylococcus aureus, Klebsiella pneumonia, Pseudomonas aeruginosa,*

Salmonella typhimurium and *Candida albicans*. Among the 3 extracts, methanol extract exhibited maximum antimicrobial activity with maximum zone of inhibition as 16 mm.[28] Kokila et al., studied the antibacterial activity of biologically synthesized AgNPs from *P. maderaspatensis* against the bacterial pathogens like, *S. aureus, B. subtilis*, and *E. coli*. The zone of inhibition was higher in the case of *B. subtilis* (17 mm) and *S. aureus* (14 mm) followed by *E. coli* (16 mm), when compared to Gentamycin as a standard. The inhibition of bacterial growth reported in this study was dependent on the concentration and number of AgNPs in the medium.[39]

The aqueous, alcoholic and hydroalcoholic extracts of *P. maderaspatensis* seeds were screened by Akhtar et al., for their antibacterial actions against both gram-positive (*Streptococcus mutans, S. pyogenes, Staphylococcus aureus, S. epidermidis, Corynebacterium xerosis* and *Bacillus cereus*) and gram-negative (*Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa* and *Proteus vulgaris*) bacterial strains, compared with the standard drug Ciprofloxacin 5 µg/disk for gram-positive bacterial strains and Gentamicin 10 µg/disk for gram-negative bacterial strains, using zone of inhibition, minimum inhibitory concentration and minimum bactericidal concentration. Alcoholic and hydroalcoholic extract showed significant antibacterial activity than the aqueous extract.[60]

Chemoprotective activity:

The effect of ethanol extract of *P. maderaspatensis* was studied by Bommu et al., for its chemoprotective property on adriamycin-induced toxicity and oxidative stress in mice. The treatment of mice with different doses of extract for 7 days before the administration of a single i.p. dose of adriamycin (15 mg/kg) exhibited significant protection in a dose-dependent manner. The results clearly indicated that the plant has a protective effect against adriamycin-induced toxicity.[61]

The protective effect of aqueous extract of *P. maderaspatensis* on Cd-induced oxidative stress and hepatotoxicity was evaluated in male Wistar rats. Rats were administrated with the plant extract at 500 mg/kg followed by an acute toxic dose of Cd (200µg/kg) for 10 days. At the end of the study there was a reduction in enzyme markers, proving the protective effect of the plant.[51]

The chemoprotective effect of *P. maderaspatensis* on cisplatin-induced nephron and genotoxicity in male Swiss albino mice was studied. The treatment of mice with different doses of extract for 7 days before the administration of a single i.p. dose of cisplatin (5mg/kg) exhibited significant chemoprotective activity. A single dose of cisplatin significantly elevated the levels of blood urea nitrogen, serum creatinine, and the kidney to body weight ratio, but pre-treatment with the plant extract for 7 days significantly attenuated the cisplatin-induced nephrotoxicity. Ethanol extract thus has a marked free radical scavenging effect indicating its antioxidative property. The results suggested that the ethanol extract has a protective effect against cisplatin-induced nephro and genotoxicity through its antioxidant property.[62]

Cytotoxic activity:

The in vitro cytotoxic potential of *P. maderaspatensis* against Ehrlich Ascites Carcinoma cells was assessed using Trypan blue method. The results depicted that the methanol extract possess good cytotoxic potentials at a higher concentration (93.62% of inhibition observed in 1000 µg/ml).[63] Kokila et al., evaluated the cytotoxicity of the AgNPs from *P. maderaspatensis* against MCF-7 breast cancer cell line in vitro at various concentrations (50-250 µg/mL). The tested samples exhibited a considerable cytotoxicity against the MCF-7 cell line. The result showed that MCF-7 cells proliferation was potentially inhibited by AgNPs with an IC_{50} value of 67.23 µg/mL of the concentration. Camptothecin was used as a control. It was found that the percentage of cytotoxicity increases with the increase in concentration of AgNPs.[39]

Cytotoxic effect of nirtetralin, niranthin, and phyllanthin on two human leukemia cell lines, K-562 and Lucena-1, suggested a potential action of *Phyllanthus* lignans as multidrug resistance (MDR) reversing agents.[64]

Allelopathic activity:

Swarupa Rani had reported the allelopathic potential of aqueous extracts of *P. maderaspatensis* on Jowar. The allelopathic influence revealed that the gradation inactivity like leaf + inflorescence > stem > root extracts were found to more potent to Jowar. Higher concentrations significantly inhibited the biomass of seedlings and the inhibitory effect was found to be concentration dependent.[65]

Micropropagation:

An efficient micropropagation system was developed by Raja et al., for *Phyllanthus maderaspatensis* L. They reported for the first time the successful recovery of fertile plants of *P. maderaspatensis* from shoot tip and nodal explants. Explants were cultured on MS medium supplemented with different concentrations of 6-Benzylaminopurine (BAP), Kinetin (KIN) and Thidiazuron (TDZ) with 15 % Coconut water. Maximum number of shoots (86.88 %) was observed from shoot tip on MS medium supplemented with BAP (3.0 mg/l), 15 % coconut water, 30 g/L sucrose and 8 g/L agar. In vitro regenerated shoots were cultured on rooting medium containing half strength MS basal medium supplemented with different concentration of Indole-3-butyric acid, Indole-3-acetic acid and Naphthalene acetic acid. Maximum frequency (93.2 %) of roots induction was observed on medium containing IBA (1.0 mg/l). The fully regenerated plants were transferred to paper cup containing mixture of sterile soil and manure 2:1 ratio. Eighty eight percentages of the plantlets were successfully acclimatized and established in soil.[66]

CONCLUSION

This review has presented comprehensive details about the plant regarding its botanical characteristics, folklore uses, pharmacognosy, phytochemistry, pharmacology and other scientific studies of *Phyllanthus maderaspatensis*. It has been noted that there are some areas not much explored like antidiabetic, safety, side effects and toxicity associated with the plant. Thus, side effects and toxicity remain an area of potential future study. There is still a need to conduct further robust double-blind randomized controlled clinical trial about *P. maderaspatensis*.

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