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A phyto pharmacological review on a versatile medicinal plant: *Pongamia pinnata* (L.) pierre

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Abstract

Medicinal plants are important in the traditional medicine and as well as in modern pharmaceutical drugs. *Pongamia pinnata* exhibits many pharmacological attributes. In traditional system of medicine various plant parts like leaves, stems, seeds and even whole parts are used for treatment. Traditionally the leaves, seeds and entire plant are used in the treatment of many diseases. Its uses includes Anti-ulcer, Anti-diarrhoeal, Anti-plasmodial, Anti-inflammatory, Anti-viral, Anti-bacterial, Anti-lice. This review encompasses the available literature on *Pongamia pinnata* with respect to its pharmacognostic characters, physicochemical parameters, synopsis of pharmacological activities and traditional uses. This attempt provides a direction towards further research.

Keywords: *Pongamia pinnata*, physicochemical parameters, pharmacological activities

Introduction

Pongamia pinnata Linn Pierre (Fabaceae) is a fast growing medium sized tree commonly called as kanuga in Telugu. This plant is native in tropical and temperature regions of Asia. All parts of the plant have been used as a crude drug for the treatment of tumours, piles, skin diseases, itches, abscess, wounds, ulcers, cleaning teeth, dermatopathi, vaginopathi, painful rheumatic joints [1]. Besides the meal can be used as animal fodder or composted, green manure, timber and fish poison. It has also been recognised to possess applications in the field of environment and agricultural management.

The seed powder of the plant is given as expectorant in the treatment of bronchitis. An infusion of *Pongamia* leaves is used to relieve rheumatism. In the treatment of dyspepsia the *Pongamia* seed oil is given as stomachic and cholagogue. By the process of trans-esterification the seed oil of *Pongamia pinnata* can be converted to biodiesel. The activities such as anti-diarrhoeal, anti-plasmodium, anti-inflammatory, anti-ulcer, wound healing properties were reported [2]. The literature survey on an elite medicinal plant *P. pinnata* showed that it is a potential medicinal plant.

Synonyms

Pongamia pinnata linn pierre is also known by various synonyms such as

- *Millettia pinnata* (L.) Panigrahi
- *Pongamia glabra* vent
- *Derris indica* (Lam)

Taxonomical classification

Kingdom : Plantae
Order : Fabales
Family : Fabaceae
Genus : *Pongamia* (Millettia)
Species : *Pinnata*
Binomial name : *Pongamia pinnata* Linn pierre

Vernacular names [3]

Different vernacular names of *P. pinnata* have been reported as follows

Languages	Common names
Telugu	Kanuga
Tamil	Punagai, dalkaramacha, pongam, punku
Hindi	Karanj, pongam oil tree, papar, kanji
Bengali	Karach
Sanskrit	Naktamala
Kannada	Honge, hulagilu
Urdu	Karanj
Malayam	Pungu, ungu, unu, avittal
Oriya	Koranjo

Origin and geographical distribution

It was naturally distributed in Asia, now this is found in Australia, Florida, Hawaii, India, Malaysia, Oceania, Philippines and Seychelles^[4]. It was commonly grown in coastal forests over India and near the streams and rivers.

Ecology

The best growth is found in well drained sandy loams with assured moisture. It does not grow well on dry sands even though it tolerates salinitic conditions, alkalinity and water locked soils. It will also grow on heavy swelling clay soils. These species have P^H higher than 7.5 they become nutrient deficient.

Propagation

In-situ germination is preferred for this seeds and time limit is within 1-5 weeks of sowing. Planting to the field should occur at the beginning of the next rainy season, when the seedlings are about 60 cms in height. As young plants tolerate shade-well a spacing of 7.5x15cms is recommended. Natural reproduction is profuse by seed and commonly by root suckers. Spontaneous seedlings and root suckers may cause critical weed problems.

Temperature

This plant is ready to grow in the temperature of maximum 27-38°C to minimum of 1-16°C. The withstanding temperature of this plant is slightly below 0°C (32°F) and up to about 50°C.

Morphological characteristics

Millettia pinnata is a legume plant that grows to about 15-25 metres in height with large canopy. It has straight or curved trunk and its diameter is about 50-80 cms.

Leaves

They are soft shiny reddish-purple when young and mature to a glossy. They are deep green as the season progresses with prominent veins underneath. Imparipinnate leaves of the tree alternate and are short stalked, rounded or cuneate at the base, ovate or oblong along the length.

Flowers

Flowers are generally with small clusters of white, purple and pink flowers blossoming throughout the year. The raceme like inflorescence bears 2 to 4 flowers which are strongly fragrant and grow to be 15 -18 mm long. Flowering generally starts after 3-4 year.

Calyx

These are bell shaped and truncate

Corolla

It is rounded ovate shape with basal auricles with a central spot of green colour.

Seeds

Seeds are about 1.5-2.5 centimetres long with a brittle, oily coat and are unpalatable to herbivores. Brown seed pods appear immediately after flowering and mature in 10-11 months. The pods are thick-walled, smooth, somewhat flattened and elliptical, but slightly curved with a short, curved point. Pod production commences when seedlings are 5-7 years old. The pods generally do not open naturally, and must decay before the seeds can germinate

Stem

Stem is light green in colour with some irritating odour. It is herbaceous and slightly hard to break. It has smooth texture on its surface.

Root

The plant has a long, thick taproot and widely spreading lateral roots. The spread of roots on this species, about 9 metres in 18 years, is greater than most other species; moreover it produces root suckers profusely. Because of these characteristics, pongamia is unsuitable for agroforestry and has the potential to become a weed if not managed carefully

Medicinal value of different parts of the plant

Plant Part	Medicinal Value
Flower	Used to treat bleeding hemorrhoids, or piles
Fruit	Aid treatment of abdominal tumors, female genital tract infections, ulcers, and hemorrhoids
Seed	Extracts can be used to heal scar tissue tumors, treat high blood pressure, and treat anemia Powder reduces fever and helps in treating bronchitis and whooping cough
Oil (extracted from seed)	Used as an astringent and to kill parasitic worms Helpful in treating whooping cough, piles, liver pain, chronic fever, ulcers, and leprosy Relieves sore joints and muscles and arthritis Used to treat eczema and other skin irritations when mixed with zinc oxide
Leaf	Whole leaves used as a digestive and laxative and to treat inflammation and wounds Leaf juice aids in treatment of leprosy, gonorrhea, diarrhea, flatulence, coughs, and colds Leaf infusions and extracts alleviate rheumatism and itches, respectively
Stem	Extracts used to lower or relieve fever and to sedate the central nervous system
Bark	Relieves coughs and colds, reduces spleen inflammation, and mental disorder Useful for treatment of bleeding piles
Root	Used as a toothbrush for oral hygiene, used for killing parasitic worms, and used to treat vaginal and skin diseases Juice used to clean ulcers and to close open sores Mixed with coconut milk and lime water, juice can treat gonorrhea

Phytochemistry

Pongamia pinnata seeds contain six compounds (two sterols, three sterol derivatives and one disaccharide) together with

the eighty fatty acids (three saturated & five unsaturated). Their structures were elucidated with the help of physicochemical methods and spectroscopic techniques.

Karangin, pongagalabrone and pongapin, pinnatin and kanjone have been isolated from seeds. The leaves and stem of the plant consists of flavones and chalcone derivatives such as Pongone, Galbone, Pongalbol, Pongallone A and B⁵.

The isolation and characterization of five flavonoids pongamones A-E was done from stems of *Pongamia pinnata*. Their structures were elucidated on the basis of spectroscopic analysis and by comparing their spectroscopy data with related compounds reported in the literature. Around 18 flavonoid compounds including 9 new ones, pongames III-XI from root bark of *P. pinnata*. The structures were determined to be (2S)-3',4'-dimethoxy-6'',6''-dimethylpyrano[2'',3'':7,8]-flavanone (III), (2S)-6,3',4'-trimethoxy-6' ',6' ' - dimethylpyrano [2'',3''7,8]- β avanone (IV), (2S)-7-methoxy-6-O-γ,γ-dimethylallyl-3',4'-methylenedioxyβ avanone (V), 2'-hydroxy-3,4,5'-trimethoxy-6'',6''-dimethylpyrano[2''3'':4'3'] chalcone (VI), 2',4'-dimethoxy-3,4-methylene dioxy dihydrochalcone (VII), 2',5',β-trimethoxy-3,4-methylenedioxy-6'',6''-dimethylpyrano[2'',3'':4',3'] d i h y d r o c h a l c o n e (V I I I), 2 , β - d i m e t h o x y - 3 , 4 - methylenedioxy-furano[2'',3'':4',3']-dihydrochalcone (IX), β-hydroxy-2',4',6'-trimethoxy-3,4-methylenedioxychalcone (X) and 3-methoxy-furano-[2'',3'':7,6] flavone (XI), respectively, by means of spectral analysis and synthesis ^[6].

The fruits of *Pongamia pinnata* possess three new furnoflavanoid glucosides, pongamosides A-C and a new flavanol glucoside, pongamoside D. The structures of these compounds were established on the basis of spectroscopic studies. This is the first time that furanoflavone glucosides have been found naturally occurring compounds ^[7].

Pharmacological activities

(i) Antioxidant activity

The protective role of *Pongamia pinnata* leaf extract was studied on oxidative stress during ammonium chloride-induced hyperammonemia by measuring the extent of oxidative damage as well as antioxidant status ^[8]. Ethanolic extract of *Pongamia pinnata* (PPEt) leaves was administered orally (300 mg/kg body weight) and the effects of PPEt on the levels of thiobarbituric acid reactive substances (TBARS), hydroperoxides (HP), conjugated diene (CD), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and reduced glutathione (GSH) were studied in liver and kidney of ammonium chloride-induced hyperammonemic rats. On treatment with PPEt, a significant reduction in the levels of TBARS, HP, and CD and a significant increase in the levels of SOD, CAT, GPx, and GSH in liver and kidney of ammonium chloride-induced hyperammonemic rats were observed, which clearly shows the antioxidant property of PPEt. These findings show the protective role of PPEt against lipid peroxidation and suggest that PPEt possesses antioxidant potential that may be used for therapeutic purposes. The antioxidant property may be due to the presence of flavonoids and polyphenol in the extract ^[9].

Antioxidant property have been observed that effect of *Pongamia* leaf extract on circulatory lipid peroxidation, antioxidant status was evaluated in ammonium chloride – induced hyperammonium rats enhanced lipid peroxidation in the circulatory ammonium chloride –treated rats was accounted by a significant decrease in the levels of vitamin-C, vitamin-E reduced glutathione peroxidase, superoxide dismutacatalase. It showed that PPEt modulates by reversing the oxidant – anti oxidant imbalance during chloride-induced hyperammonemia and this could be due to its

antihyperammonemia effect by means of detoxifying excess ammonia, urea and creatinine and antioxidant property ^[10].

(ii) Antimicrobial activity

The plant materials leaf, bark and seeds were extracted successively with petroleum ether and ethyl acetate. The extracts tested for antimicrobial activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans* by disc diffusion method. Both the extracts of leaf, bark and seeds showed a good zone of inhibition. Both the extracts showed maximum zone inhibition against *Bacillus subtilis* while *E. coli* and *C. albicans* were unaffected by any of the extracts except petroleum extract of bark ^[11].

Various extracts of the plant exhibited antibacterial activity against a broad spectrum of gram negative and gram positive bacteria, such as *Proteus vulgaris*, *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Enterobacter aerogenes*, *Bacillus subtilis*, *Salmonella typhimurium*, *Escherichia coli*, *Propionibacterium acne*, *Yersinia enterocolicai*, *Listeria monocytogens*, *Shigella flexneri* and *Vibrio cholera* ^[12-18]. The plant possesses numerous phytoconstituents such as flavones, flavans, chalcone, triterpenes and aromatic carboxylic acids. These compounds seem to be responsible for antibacterial activity of various extracts of parts of *Pongamia pinnata*.

The seed oil exhibited significant antifungal activity against tested fungi. The maximum inhibition against *Aspergillus niger* followed *Aspergillus terreus* and *Candida albicans*. The pure oil (100%) showed maximum inhibition and a minimum inhibition by 40-45% of extracted oil against all tested fungi ^[19]. The first antifungal compound isolated from plant is Triperpene 118. It showed strong antifungal activity against yeast and low activity against molds and no activity against *Penicillium notatum* ^[20].

The antimicrobial efficacy of ethanolic extract of stems of *Pongamia pinnata* (PPEE) was carried by agar well diffusion method at concentrations of 250µg, 500 µg, 750 µg and 1000 µg against selective Gram positive pathogens such as *Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus megaterium*, *Enterococcus faecalis*, Gram negative *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus vulgaris* and fungi *Aspergillus niger*. The PPEE possess appreciable levels of tannin and flavonoid contents, 39.7±2.6 mg of GAE/gm and 41.2±1.7 mg of rutin/gm of extract respectively. The plant extract was exhibited maximum activity against *Bacillus subtilis* followed by *Escherichia coli* and then against *Bacillus megaterium*. The plant also exhibited significant activity against *Aspergillus niger*. The MIC lies between 31.2 to 62.5 mg/ml ^[21].

The antimicrobial efficacy of stems of *Pongamia pinnata* against dental caries pathogens like *Streptococcus mutans*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Lactobacillus acidophilus*, *Pseudomonas aeruginosa* and *Candida albicans* was performed²². The diameters of zone of inhibition range from 15.33±0.57 to 28.0±1.0 mm at different concentrations. The antimicrobial activity was compared with the standards tetracycline and fluconazole. The crude ethanolic stem extract exhibited maximum activity against *S. aureus* (26.0±1.0 mm) and moderate activity against *E. faecalis* (25.66±1.15 mm) and minimum activity against *P. aeruginosa* (21.66±1.52 mm).The plant also effectively inhibited *C. albicans* (28.0±1.0 mm). The results of the current study demonstrate the antimicrobial activity of stems of *Pongamia pinnata* to prevent dental caries. MIC was

performed by agar dilution method and the range was found to be 31.2 mg/ml to 62.5 mg/ml.

(iii) Antiviral activity

The crude aqueous seed extract showed antiviral activity. It completely inhibited growth of herpes simplex virus type-1 (HSV-1) and (HSV-2) at the concentration of 1 and 20 mg/ml (w/v) respectively and showed complete absence of cytopathic effect [23]. The crude dried leaves extract showed no activity against rota virus. *Pongamia pinnata* seed extract²⁴ showed the safety effect in acute and chronic toxicological studies conducted in swiss albino rats.

The antiviral activity of bis (2-methylheptyl) phthalate isolated from *Pongamia pinnata* leaves against White Spot Syndrome Virus (WSSV) of *Penaeus monodon* Fabricius was evaluated. The oral administration of ethanolic extract and purified compound bis (2-methylheptyl) phthalate has increased the survival of WSSV infected *Penaeus monodon*. The shrimp were fed with the pelletized feed impregnated with ethanolic extract of the leaves of *Pongamia pinnata* prior and after WSSV infection at 200 and 300 mcg/g of body weight of shrimp/day. The survival rate for the WSSV-infected shrimp that were fed with 200 and 300 mcg extract/g were 40% and 80%, respectively [25].

(iv) Antidiarrhoeal Activity

This activity was determined by evaluating antimicrobial effect of crude decoction of dried leaves of *Pongamia pinnata*. It also evaluated for its effect on production and action of Enterococcus (cholera toxin, Escherichia coli labile toxin, stable toxin) and adherence of enteropathogenic *E.coli* and invasion of enteroinvasive *E.coli* and *Shigella flex* epithelial cells. This study concludes that decoction of *Pongamia pinnata* had selective anti-diarrhoeal action with against cholera and enteroinvasive bacterial causing bloody diarrhoeal episode [26].

(v) Antiprotozoal activity

The plant was reported for its anti-plasmodial activity against *Plasmodium falciparum* [27]. The bark and leaf extract with low IC₅₀ values of 9-43 mcg/ml has been shown to be potential as anti-malaria by possessing anti-plasmodial activity. This activity might be due to the presence of lupeol (120), which blocked the invasion of *Plasmodium falciparum* merozoites into erythrocytes at IC₅₀ 1.5 mcg/ml. It also reported the inhibition of growth of *Trypanosoma cruzi* and *Leishmania* with an IC₉₀ at the dose of 100 mcg/ml [28]. Crude decoction of dried leaves had no activity against trophozoites.

(vi) Anti-Inflammatory activity

It has been reported that the 70% ethanolic leaf extract of *P. pinnata* possess potent anti-inflammatory activity against different phases (acute, sub-acute and chronic) of inflammation without side effect on gastric mucosa. It also showed significant anti pyretic action of the extract against brewer's yeast-induced pyrexia [29].

(vii) Anti-Ulcer activity

The methanolic extract of roots of *P. pinnata* reported for significant protection against mucosal damage induced by aspirin and has a tendency to decrease acetic-acid induced ulcer after 10-days treatment. The extract showed ulcer protective effect with cessation of mucosal defensive factors like mucin secretion, life span of mucosal cells, mucosal cell

glycoproteins, cell proliferation and prevention of lipid peroxidation [30].

The methanolic extract of seeds was evaluated for the ulcer protective and healing effect in rats. When administered orally, the extract showed dose-dependent (12.5-50mg/kg for 5 days) ulcer protective effect against gastric ulcer induced by 2h cold resistant stress. Optimal effective dose of PPSM (25mg/kg) showed anti-ulcerogenic activity against acute gastric ulcers (GU) induced by pylorous ligation and aspirin and duodenal ulcer induced by cysteamine but not against ethanol-induced GU [31].

viii) Anti-hyperglycemic & anti-lipid peroxidative activity

It has been reported that oral administration of ethanolic extract of *P.pinnata* flower shows significant anti-hyperglycemic and anti-lipid peroxidative effect and enhancement in antioxidant defense system in alloxan-induced diabetic [32] rats. Oral administration of the ethanolic extract of the flower (300mg/kg bw) showed significant anti-hyperglycemic activity which considerably reduce the blood glucose concentration in a similar extent to that of the reference drug glibenclamide (600microgram/kg bw) in alloxan -induced diabetic rats. The results suggested that the treatment of *Pongamia pinnata* extract could be used as a safe alternative anti-hyperglycaemic drug for diabetic patients [33].

Conclusion

In traditional system of Ayurvedic medicine *Pongamia pinnata* has been widely used as curative agents for variety of ailments. In the traditional systems of medicines, such as Ayurveda and Unani, the plant is used for anti-inflammatory, anti-plasmodial, anti-nociceptive, anti-hyperglycaemic, anti-lipidperoxidative, anti-diarrhoeal, anti-ulcer, anti-hyperammonic, anti-oxidant and antibacterial.

The extensive literature survey revealed that *Pongamia Pinnata* L. is an important versatile medicinal plant with diverse pharmacological spectrum. The plant shows the presence of many chemical constituents which are responsible for varied pharmacological and medicinal properties. However, evaluation needs to be carried out on *Pongamia Pinnata* L. in order to explore the concealed areas and their practical clinical applications, which can be used for the welfare of the mankind.

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