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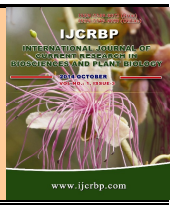

Review Article

Ethnopharmacology, Phytochemistry and Pharmacological Evaluation of *Pongamia pinnata* (L.) Pierre

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A b s t r a c t

Pongamia pinnata (L.) Pierre belonging to the family Fabaceae is a medium sized evergreen tree popularly known as Karanja in Hindi, Indian beech in English. It is widely distributed in India, Bangladesh, China and Australia. *P. pinnata* has been recognized in different system of traditional medicines for the treatment of different disease and aliments of human beings. It contains several phytoconstituents such as alkaloids, tannins, steroids, glycosides, demethoxy-kanugin, glabrin, kanugin, karangin, flavonoids and fixed oils. Extract of the plant posse's significant anti-diarrhoeal, anti-fungul, anti-plasmodial, anti-ulcerogenic, anti-inflammatory, anti-nonciceptive, anti-hyperglycaemics, anti-lipoxidative, anti-hyperammonic, antioxidant and analgesic activities. Roots are used for cleaning gums, teeth and ulcers. Bark is used internally for bleeding piles. Different parts of this plant are traditionally claimed to be used for the treatment of bronchitis, whooping cough, rheumatism, diarrhea, dyspepsia, flatulence, gonorrhea and leprosy to list a few. Its oil is a source of biodiesel-an alternative source of energy, renewable, safe and non-pollutant. Therefore, the present review paper was aimed to compile up-to-date and comprehensive information of *P. pinnata* with special reference to its phytochemistry, various scientifically documented pharmacological activities, ethnopharmacology and traditional medicinal uses along with its potential use as source of biodiesel.

K e y w o r d s

Ethnopharmacology

Karanj

Medicinal plant

Phytochemistry

Pongamia pinnata

Introduction

Pongamia pinnata (L.) Pierre is a medium sized glabrous tree popularly known as Karanja in Hindi, Indian Beech in English and Pongam in Tamil (Krishnamurthi, 1969). Most of the Tamil Nadu physicians of Indian system of traditional medicine Ayurveda and Siddha use *P. pinnata* to treat various kinds of diseases including diabetes mellitus (Punitha and Manoharan, 2006). It is a medicinal plant native to Western Ghats and chiefly found in tidal forests of India (Krishnamurthi, 1969).

P. pinnata also called as *Derris indica*, is a monotypic genus and grows abundantly along the coasts and riverbanks in Myanmar. The tree is known for its multipurpose benefits and as a potential source of biodiesel (Naik et al., 2008). The seeds are reported to contain on average about 28–34% oil with high percentage of polyunsaturated fatty acids (Sarma et al., 2005). Historically, *Pongamia* has been used as folk medicinal plant, particularly in Ayurveda and Siddha systems of Indian medicine (Meera et al., 2003). All parts of the plant have been used as a crude drug for the treatment of tumours, piles, skin diseases, itches, abscess, painful rheumatic joints wounds, ulcers, diarrhea etc (Shoba and Thomas, 2001). Besides, it is well known for its application as animal fodder, green manure, timber and fish poison. It has also been recognized to possess applications in agriculture and environmental management, with insecticidal and nematicidal activity. More recently, the effectiveness of *P. pinnata* as a source of biomedicines has been reported (Brijesh et al., 2006), specifically as antimicrobial and therapeutic agents.

Botanical description

According to Allen and Allen (1981), *P. pinnata* is a fast-growing tree which reaches 40 feet in height and spread, forming a broad, spreading canopy casting moderate shade. All the botanical descriptive characters of this plant are listed in Table 1 and its vernacular names and synonyms are provided in Table 2.

Table 1. Botanical descriptive characters of *Pongamia pinnata* (L.) Pierre.

Plant type	Medium-sized, evergreen, perennial and deciduous tree. Height: 35 to 40 feet Growth rate: Fast Texture: Medium Chromosome number: 22
Growing requirements	Light requirement: tree grows in full sun. Soil tolerances: clay; loam; sandy; slightly alkaline; acidic; well-drained. Drought tolerance: high Aerosol salt tolerance: moderate Winter interest: no special winter
Root	Taproot is thick and long, lateral roots are numerous and well developed.
Leaf	Alternate, odd pinnately compound, 2 to 4 inches, evergreen, hairless.
Flower	Lavender, pink; white, 2- 4 together, short-stalked, pea shaped, 15-18mm long.
Pods	3-6cm long and 2-3cm wide, smooth, brown, thick-walled, hard, indehiscent, 1-2 seeded.
Seed	Compressed ovoid or elliptical, been-like, 10-15cm long, dark brown, oily.
Bark	Thin gray to grayish brown and yellow on the inside.

Table 2. Vernacular names and synonyms of *Pongamia pinnata* (L.) Pierre.

Languages	Vernacular Names
Hindi, Marathi and Guajarati	Karanj, Karanja
Sanskrit	Ghrtakarauja, Karanjaka, Naktahva, Naktamala
English	Indian beech
Telgu	Pungu, Gaanuga
Tamil	Ponga, Pongam
Malayalam	Pungu, Punnu
Oriya	Koranjo
Punjabi	Sukhehein, Karanj, Paphri
Assam	Karchuw
Bengali	Dahara karanja, Karanja, Natakaranja
Kannada	Honge, Hulagilu
Synonyms	*Derris indica* (Lam.) Bennett *Millettia novo-guineensis* Kane. & Hat. *Pongamia glabra* Vent. *Pongamia pinnata* Merr

Geographical distribution and ecology

P. pinnata is native to Bangladesh, India, Myanmar, Nepal and Thailand; exotic to Australia, China, Egypt, Fiji, Indonesia, Japan, Malaysia, Mauritius, New Zealand, Pakistan, Philippines, Seychelles, Solomon Islands, Sri Lanka, Sudan, United States of America (Orwa et al., 2009).

Ecology

Native to humid and subtropical environments *P. pinnata* thrives in areas having an annual rainfall ranging from 500 to 2500 mm. in its natural habitat, the maximum temperature ranges from 27 to 38°C and the minimum 1 to 16°C. Mature trees can withstand water logging and slight frost. This species grows to elevations of 1200 m, but in the Himalayan foothills, it is not found above 600 m (GOI, 1983).

P. pinnata can grow on most soil types ranging from stony to sandy to clayey, including Verticals. It does not do well on dry sands. It is highly tolerant of salinity. It is common along waterways or seashores, with its roots in fresh or salt water. Highest growth rates are observed on well drained soils with assured moisture. Natural reproduction is profuse by seed and common by root suckers.

Ethnopharmacology

Root

- Juice of roots with coconut milk and lime water used for treatment of gonorrhea (Joshi, 2006 and Manandhar, 2002).
- Used for cleaning gums, teeth and ulcers (Bhattacharjee, 2001).
- Roots are bitter anti-helmintic and used in vaginal and skin diseases (Gills et al., 1998).
- Juice of the root is used for cleansing foul ulcers and closing fistulous sores (Gon, 2007).

Stem

- Aqueous extracts of stem bark exhibit significant CNS sedative and antipyretic activity (Philip and Sharma, 1997).

Leaf

- Juice of leaves is used for cold, cough, diarrhea, dyspepsia, flatulence, gonorrhea, leprosy (Ambasta et al., 1992; Bhattacharjee, 2001).
- Leaves are antihelminthitic, digestive and laxative used for inflammations, piles and wounds.
- As an infusion to relieve rheumatism.
- As an extract to treat itches and herpes.

Fruit

- Fruits used for abdominal tumors (Hartwell, 1967-1971).
- Useful in ailments of female genital tract, leprosy, tumour, piles, ulcers and upward moving of the wind in the abdomen (Rastogi and Mehrotra, 1960-1969).

Seed

- Used in hypertension, skin ailments and rheumatic arthritis (Ballal, 2005; Tanaka et al., 1992; Carcache et al., 2003).
- Seed powder valued as a febrifuge, tonic and in bronchitis and whooping cough (CSIR, 1948-1998).
- Useful in inflammations, pectoral diseases, chronic fevers, hemorrhoids and anemia (Warrier et al., 1995).

Oil

- Oil is styptic, anthelmintic, and good in leprosy, piles, ulcers, chronic fever and in liver pain (Warrier et al., 1995).
- Useful in rheumatism arthritis scabies (Prasad and Reshmi, 2003) whooping cough (CSIR, 1948-98).
- Mixture of oil and zinc oxide used for eczema.

Bark

- For bleeding piles, for beriberi, reduce swelling of the spleen (Kirtikar and Basu, 1984).
- Useful in mental disorder, cough and cold (Manandhar, 2002).

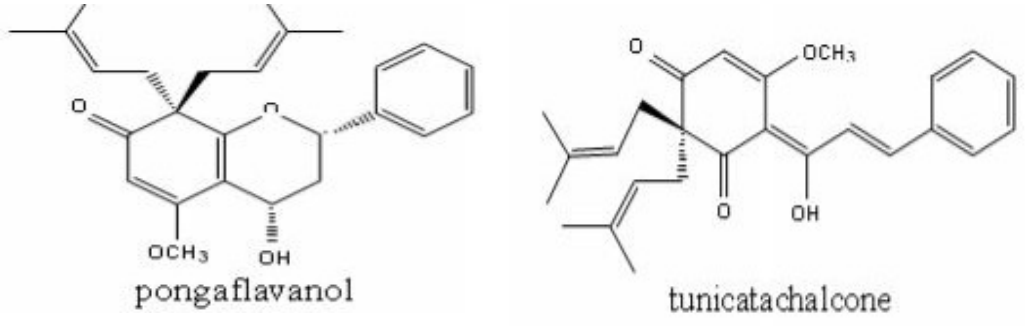
Flower

- Useful to quench dipsia in diabetes (Joshi, 2006; Bhattacharjee, 2001 and Brijesh et al., 2006), for alleviating vata and kapha (Manandhar, 2002) and for bleeding piles (Baral and Kurmi, 2006).

Phytochemistry

Phytochemical investigation of *P. pinnata* indicated the presence of abundant prenylated flavonoids such as furanoflavones, furanoflavonols, chromeno flavones, furanochalcones and pyranochalcones (Tanaka et al., 1992; Carcache et al., 2003; Yadav et al., 2004; Yin et al., 2005). Yin et al. (2006) isolated two phenylated flavonoid derivatives with a modified ring a, pongaflavanol (1) and tunicatachalcone (2) from stem bark of *P. pinnata*. Pongaflavanol was a new compound and its structure was elucidated on the basis of spectroscopic data interpretation. Pongaflavone represented the first example of a naturally occurring prenylated flavan-4-ol with a modified ring A, while compound 2, tunicatachalcone was isolated for the first time from *P. pinnata* (Yin et al., 2006). The structures of these compounds are shown in Fig. 1 (Yin et al., 2006).

Fig. 1: Structures of pongaflavone and tunicatachalcone isolated from *Pongamia pinnata* (L.) Pierre.



Yadav et al. (2004) isolated four new furanoflavonoids, pongapinnol A–D, and a new coumestan, pongacoumestan along with thirteen known compounds from the fruits of *P. pinnata*. They elucidated the structures of isolated compounds on the basis of spectroscopic data interpretation (Yadav et al., 2004). Isolation and characterization of five structurally unusual flavonoids pongamones A–E, along with 16 known flavonoid metabolites were carried out by Li et al. (2006) from the stem of *P. pinnata*. Their structures were determined on the basis of spectroscopic analyses and by comparison of their spectroscopic data with those of related compounds reported in the literature (Li et al., 2006).

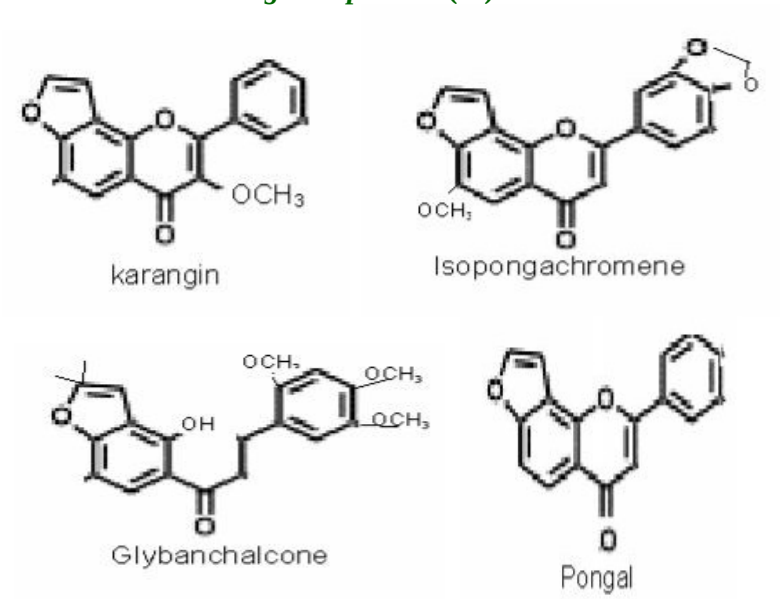
Karanja seed oil contains karanjin, a bioactive molecule with important biological attributes (Vismaya et al., 2010), and developed a facile method for efficient recovery of karanjin. They subjected the seed oil to liquid–liquid extraction with methanol. The extract was further purified by chromatography on alumina followed by crystallization to afford karanjin, whose purity was ascertained by HPLC. They obtained the recovery of karanjin as 20% with >95% purity. The structure of the compound was elucidated by MS and NMR spectral analysis (Vismayaa et al., 2010).

Six compounds (two sterols, three sterol derivatives and one disaccharide) together with eight fatty acids (three saturated and five unsaturated) have been isolated from the seeds of *Pongamia pinnata* (Linn.) Pierre. Their structures were elucidated with the help of physicochemical methods and spectroscopic techniques. The metabolites, beta-sitosteryl acetate and galactoside, stigma sterol, its galactoside and sucrose are being reported for the first time from this plant.

The saturated and unsaturated fatty acids (two monoenoic, one dienoic and two trienoic) were present in exactly the same amount. Oleic acid occurred in highest amount (44.24%), stearic (29.64%) and palmitic (18.58%) acids were the next in quantity. Hiragonic and octadecatrienoic acids were present in trace amounts (0.88%). Karangin, pongamol, pongagalabrone and pongapin, pinnatin and kanjone have been isolated and characterized from seeds. Immature seeds contain a flavone derivative 'pongol'. The other flavonoid isolated from the seeds includes 'Glybanchalcone, isopongachromene'. The leaves and stem of the plant consist of several flavone and chalcone derivatives such as Pongone, Galbone, Pongalabol, pongagallone A and B (Shameel et al., 1996). The

structures of karangin, isopongachromene, glybanchalcone and pongal are shown in Fig. 2.

Fig. 2: Structures of phytoconstituents isolated from the seeds of *Pongamia pinnata* (L.) Pierre.



Pharmacological evaluation

Anti-plasmodial activity

P. pinnata shows anti-plasmodial activity against *Plasmodium falciparum* (Simonsen et al., 2001).

Anti-inflammatory activity

Anti-inflammatory activity against different phases (acute, sub acute and chronic) of inflammation was reported by the 70% ethanolic extract of *Pongamia pinnata* (Linn.) Pierre leaf (Srinivasan et al., 2001). Anti-pyretic action was also significantly observed by the same extraction against Brewer's yeast-induced pyrexia.

Anti-diarrhoeal activity

The anti-microbial effect of crude leaf extract of *P. pinnata* evaluates its effect on production and action of enterotoxins. Its extraction has no anti-bacterial, anti-giardial, and anti-rotaviral activities but reduce the production of cholera toxin and bacterial invasion to epithelial cells. This indicates that the extraction of *P. pinnata* has selective anti-diarrhoeal action with efficacy against cholera (Brijesh et al., 2006).

Anti-ulcer Activity

The aqueous extract of *P. pinnata* root induced a significant decrease in volume of gastric juice, acid output and peptic activity without any effect on mucin activity in acetylsalicylic acid (ASA)-ulcerated rats. Moreover, it decreased the ulcer index significantly. Ulcer protective effect of methanolic extract of *P. pinnata* roots was attributed to the augmentation of mucosal defensive factors like mucin secretion, life span of mucosal cells, mucosal cell glycoproteins, cell proliferation and prevention of lipid peroxidation rather than on the offensive acid-pepsin secretion. A qualitative change in hexose and fructose contents of carbohydrates was also found, however mucin activity remained unchanged (Akhtar et al., 1996; Prabha et al., 2003).

Antihyperglycemic and antilipidperoxidative effects

Punitha and Manohar (2006) evaluated antihyperglycemic and antilipidperoxidative effects of ethanolic extract of *P. pinnata* flowers in alloxan induced diabetic rats. They noticed hyperglycemia, elevated lipid peroxidation [thiobarbituric acid reactive substances (TBARS)] and disturbed non-enzymatic [Vitamin E, Vitamin C and glutathione] and enzymatic antioxidants status in alloxan induced diabetic rats. They reported the significant antihyperglycemic and antilipidperoxidative effects

of oral administration of ethanolic extract of *P. pinnata* flowers (300 mg/kg bw) along with enhancement in antioxidants defense system in alloxan induced diabetic rats.

However, no significant characteristic changes were noticed in blood glucose level as well as in lipid peroxidation and antioxidant status in normal rats treated with the extract. Also, the extract considerably reduced the blood glucose concentration in a similar extent to that of the reference drug glibenclamide (600 mg/kg bw) in alloxan induced diabetic rats suggesting the use of *P. pinnata* as a safe alternative antihyperglycemic drug for diabetic patients (Punitha and Manohar, 2006). The antihyperglycemic effect of ethanolic extract of *P. pinnata* flowers was attributed to the presence of several bioactive antidiabetic principles and their synergistic properties.

Antihyperammonemic effect

Essa et al. (2005) evaluated the protective influence of leaf extract of *P. pinnata* on blood ammonia and urea levels in ammonium chloride induced hyperammonemia. A relationship between oxidative stress and hyperammonemia has been well established and evidences point to the fact that ammonium (acetate / chloride) salts induce hyperammonemia partly via oxidative stress (Dakshayani et al., 2002).

In the study conducted by Dakshayani et al. (2002), the levels of blood ammonia, circulatory urea, uric acid, non-protein nitrogen and creatinine increased significantly in rats treated with ammonium chloride and decreased significantly in rats treated with *P. pinnata* leaf extract and ammonium chloride. There were no significant changes in the body weights of the experimental animals when compared to controls. The antihyperammonemic effect of extract was attributed to its nephroprotective effect by means of detoxifying excess urea and creatinine, its free radical scavenging property and its antioxidant property (Essa et al., 2005).

Furthermore, flavanoids are potent antioxidants and are known to modulate the activities of various enzyme systems due to their interaction with various biomolecules (Dakshayani et al., 2002). The plant is known to contain a number of bioflavonoids like kaempferol, quercetin, karanjin, kanjone, pongaglabrone, gammatin, pongaglabol, kanugin, etc. (Satyavati et al., 1987).

Antifungal and antibacterial activity

Evaluation of antifungal and antibacterial activity of different concentration of oil obtained from *P. pinnata* against *Aspergillus niger*, *A. fumigatus*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* was carried out by Wagh et al. (2007) employing Minimum Inhibitory Concentration (MIC) determination and dry-weight method. Chemical analysis of oil performed by gas chromatography (GC) and gas chromatography / mass spectrometry (GC-MS) showed the presence of fatty acid. They suggested the use of fatty oil of this plant for developing plant derived antimicrobial drugs (Wagh et al., 2007).

Antiviral activity

White Spot Syndrome Virus (WSSV) is an extremely virulent, contagious, causative agent of the White spot syndrome of shrimp and causes high mortality and affects most of the commercially important cultured marine crustacean species globally. Rameshthangam and Ramasamy 2007) evaluated the antiviral activity of bis (2-methylheptyl) phthalate isolated from *P. pinnata* leaves against WSSV of *Penaeus monodon* Fabricius. Oral administration of ethanolic extract and purified compound from the leaves of *P. pinnata* has increased the survival of WSSV infected *P. monodon*. They fed the pelletized feed impregnated with ethanolic extract of the leaves of *P. pinnata* to shrimp prior and after WSSV infection at 200 and 300 mc/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 (Rameshthangam and Ramasamy, 2007).

Antifilarial potential

Uddin et al. (2007) investigated the antifilarial potential of the fruits and leaves extracts of *P. pinnata* on cattle filarial parasite. In their investigation, the aqueous and alcohol extracts of fruits and the alcohol extract of leaves caused an inhibition of spontaneous movements of the whole worm and the nerve-muscle preparation of *Setaria cervi*. The concentration required to inhibit the

movements of the whole worm preparation was 250µg/mL for aqueous, 120µg/mL for alcohol extract of fruits and 270µg/mL for alcohol extracts of the leaves. The concentrations of *P. pinnata* extracts required to produce an equivalent effect on the nerve-muscle preparation were 25µg/mL, 5µg/mL and 20µg/mL, respectively suggesting a cuticular permeability barrier (Uddin et al., 2007).

Anti-lice Activity

Growing patterns of pediculocidal drug resistance towards head louse laid the foundation for research in exploring novel anti-lice (Mumcuoglu, 1999; Yang et al., 2004) agents from medicinal plants. In the study, various extracts of *P. pinnata* leaves tested against the head louse *Pediculus humanus* Capitis (Shirwaikar et al., 2004). A filter paper diffusion method was conducted for determining the potential pediculocidal and ovicidal activity of chloroform, petroleum ether, methanol and water extracts of *P. pinnata* leaves. The findings revealed that petroleum ether extracts possess excellent anti-lice activity with values ranging between 50.3% and 100% where as chloroform and methanol extracts showed moderate pediculocidal effects.

Nootropic activity

In the investigation carried out by Singh et al. (1996) various extracts derived from the seeds of *P. pinnata* decreased pentobarbitone sleeping time in rats. The probable mechanism of this action was attributed to the stimulation of the hepatic microsomal enzyme system (Singh et al., 1996). Furthermore, Singh et al. (1997) evaluated the similar properties for the *P. pinnata* roots. In their study the petroleum ether extract (PEE) of the roots enhanced pentobarbitone sleeping time, probably due to CNS depression.

The PEE of the seed of *P. pinnata* was further tested for nootropic activity in an experimental model of Alzheimer's disease (created by ibotenic acid induced lesioning of nuclear basalis magnocellularis). It reversed both, the cognitive deficits and the reduction in cholinergic markers after 2 weeks of treatment. Reversal of perturbed cholinergic function was considered as the possible mechanism (Kumar and Singh, 1996).

Antinociceptive activity

Srinivasan et al., 2003 evaluated the analgesic activity of the various solvent extracts of *P. pinnata* roots. PEE, n-butanol extract (BE) and ethanol extract (EE) of the roots of *P. pinnata* showed significant analgesic effect in the tail flick test. The PEE and direct EE of the seeds also showed significant analgesic activity at doses higher than 100 mg/ kg (Srinivasan et al., 2003).

Protective effect against nephrotoxicity

Ethanolic extract of flowers of *P. pinnata* was studied for its protective effect against cisplatin and gentamicin induced renal injury in rats by Shirwaikar et al. (2004). When the extract (300 and 600 mg/kg) was administered orally for 10 days following cisplatin (5 mg/kg, i.p.) on day 5, the flowers of *P. pinnata* had a protective effect against cisplatin and gentamicin induced renal injury. The possible mechanism of its protective effect against nephrotoxicity was attributed to its antioxidant activity.

P. pinnata as a source of biodiesel

Biodiesel is expanding at a very rapid rate because of increasing demand, necessary policy support and technological availability. India consumes approximately 40 million tones of biodiesel and ranked fifth in the world after U S, China, Russia and Japan in terms of fossil fuel consumption. Recently, Government of India launched "National Mission on Bio-diesel" with a review to find a cheap and renewable liquid fuel based on vegetables oils. Biodiesel fuel can be defined as medium length (C16 ± C18) chains of fatty acids and is comprised mainly of mono-alkyl fatty acid esters. It has the benefits of being non-toxic, biodegradable and essentially free of sulfur and carcinogenic ring components (Yamane et al. 2001).

The *P. pinnata* is known for its multipurpose benefits and as a potential source of biodiesel (Naik et al., 2008). It has been recognized as "Biodiesel" as several parameters of diesel and *P. pinnata* oil are comparable (Gerphen et al., 2004; Shaine et al., 2004) as shown in Table 3.

Chemical composition of biodiesel

The seeds of *P. pinnata* contain 30 to 40% oil (thick, reddish brown oil known as pongam oil and

also called pongamol or hongay oil) (Natanam et al., 1989; Nagaraj and Mukta, 2004) which can be converted to biodiesel (fatty acid methyl esters; FAMEs) by transesterification with methanol in the presence of KOH.

The total saturated and unsaturated fatty acid composition was 20.5% and 79.4%, respectively. The major mono unsaturated fatty acid was oleic acid (46%) whereas linoleic acid (27.1%) and linolenic acid (6.3%) constitutes the total polyunsaturated fatty acid. Low molecular weight fatty acids such as lauric and capric acids occur in very small amount of about 0.1% each (Sarma et al. 2005 ; Ahmad et al. 2003) as shown in Table 4.

Table 3. Comparison of biodiesel properties of *Pongamia pinnata* (L.) Pierre with petroleum/ diesel (Source: Sangwan et al., 2010)

Property	Biodiesel	Petroleum / Diesel
Viscosity (Cp) (30°C) 52.6	5.51	3.60
Specific gravity (15°C / 4°C)	0.917	0.841
Solidifying point (°C)	2.0	0.14
Cetane value	51.0	47.8
Flash point (°C)	110	80
Carbon residue (%)	0.64	0.05
Distillation (°C)	284 to 295	350
Sulfur (%)	0.13 to 0.16	1.0
Acid value	1.0 to 38.2	-
Saponification value	188 to 198	-
Iodine value	90.8 to 112.5	-
Refractive index (30°C)	1.47	-

Table 4. Chemical composition of *Pongamia pinnata* (L.) Pierre oil. (Source: Sangwan et al., 2010)

Fatty acids	Structure	Composition (%)
Saturated fat	-	20.5
Monounsaturated fatty acid	-	46.0
Polyunsaturated fatty acid	-	33.4
Palmitic acid	16:0	10.8
Stearic acid	18:0	8.7
Oleic acid	18:1	46.0
Linoleic acid	18:2	27.1
Arachidic acid	20:0	0.8
Linolenic acid	18:3	6.3
Behenic acid	22:0	3.20
Myristic acid	14:0	0.23
Capric acid	10.0	0.1
Lauric acid	12:0	0.1

Conclusion

The extensive literature survey revealed that *P. pinnata* is an important medicinal plant with varied pharmacological activities. From the time immemorial, plants have been widely used as curative agents for variety of ailments. Concentrated fruits or seeds extract can be found in various herbal preparations are widely available in market today.
Pongam oil is widely available and employed by practitioners of natural health for the treatment of rheumatism. In the traditional systems of medicines, *P. pinnata* plant is used for various pharmacological and biological activities. Its oil serves as a source of biodiesel, which is in need of this hour.

References

Ahmad, S., Ashraf, S.M., Naqvi, F., Yadav, S., Hasnat, A., 2003. A polyesteramide from

Pongamia glabra oil for biologically safe anticorrosive coating. Prog. Org. Coat. 47, 95-102.

Akhtar, A.H., Ahmad, K.D., Gilani, S.N., Nazir, A., 1996. Antiulcer effects of aqueous extracts of *Nigella sativa* and *Pongamia pinnata* in rats. Fitoter. 67(3), 195-199.

Allen, O.N., Allen, E.K., 1981. The Leguminosae. The University of Wisconsin Press. 812p.

Ambasta, S.P., Ramchandran, K., Kashyapa, K., Chand R., 1992. The Useful Plants of India. Council of Science and Industrial Research (CSIR), New Delhi.

Ballal, M., 2005. Screening of medicinal plants used in rural folk medicine for treatment of diarrhea: Internet: Http: // WWW.Pharmoinfo.net.

Baral, S.R., Kurmi, P.P., 2006. A Compendium of Medicinal Plants of Nepal. Mrs. Rachana Publishers, Kathmandu, Nepal. 534p.

Bhattacharjee, S.K., 2001. Handbook of Medicinal Plants. 3rd Edn., Pointer Publishers, Jaipur, India. 478p.

Brijesh, S., Daswani, P.G., Tetali, P., 2006. Studies on *Pongamia pinnata* (L.) Pierre leaves: understanding the mechanism(s) of action in infectious diarrhea. J Zhejiang Univ. Sci. B. 7(8), 665–674.

Carcache, E.J.B., Kang, Y.H., Park E.J., Su B.N., Kardono L.B.S, Riswan S., Fong H.H.S., Pezzuto J.M., Kinghorn A.D., 2003. Constituents of the stem bark of *Pongamia pinnata* with the potential to induce quinine reductase. J. Nat. Prods. 66, 1197-1202.

CSIR, 1948. The Wealth of India: raw materials. Council of Scientific and Industrial Research (CSIR), New Delhi, India 1(10), 98.

Dakshayani, K.B., Velvizhi, S., Subramanian, P., 2002. Effects of ornithine alpha-ketoglutarate on circulatory antioxidants and lipid peroxidation products in ammonium acetate treated rats. Ann. Nutr. Metab. 46, 93–96.

Essa, M.M., Subramanian, P., Suthakar, G., Manivasagam, T., Dakshayani, K.B. 2005. Protective influence of *Pongamia pinnata* (Karanja) on blood ammonia and urea levels in ammonium chloride induced hyperammonemia. J. Appl. Biomed. 3, 133-138.

Gerpen, .JV., Shanks, R., Pruszko, D., Clement, K.O., 2004. Biodiesel production technology. Report from Iowa State University for the National Renewable Energy Laboratory.

Gills, A.S., Bisaria, A.K., Shukla, S.K., 1998. Potential of Agroforestry as Sources of Medicinal Plants. Ed.: Govil, J.N., Today and Tomorrow's Publishers, New Delhi, India.

GOI (Government of India), 1983. Troup's The Silviculture of Indian Trees, Volume IV, Leguminosae. Government of India Press, Nasik, India. 345.

GoN, 2007. Medicinal Plants of Nepal. Bulletin of the Department of Plant Resources NO.28. Ministry of Forest and Soil Conservation, Thapathali, Kathmandu, Nepal. pp.402.

Hartwell J.L., 1967. Plants used against cancer-a survey. Lloydia. 71, 30-34.

Joshi S.G., 2006. Medicinal Plants. Oxford & IBH Publishing, New Delhi, India.

Kirtikar KR, Basu BD., 1984. Indian Medicinal Plants. Bishen Singh Mahendra Pal Singh, Dehradun. 2, 830.

Krishnamurthi A. 1969. The Wealth of India, vol. VIII. Publication and Information Directorate CSIR, New Delhi, India.

Kumar A. and Singh R.K., 1996. Effect of *Pongamia pinnata* on perturbed central cholinergic markers of cognition in experimentally demented rats. J. Basic Appl. Biomed. 4, 43- 8.

Li L., Li X., Shi C., Deng Z., Fu H., Proksch P. and Lin W., Pongamone A–E, 2006. Five flavonoids from the stems of a mangrove plant, *Pongamia pinnata*. Phytochem. 67, 1347–1352.

Manandhar N.P., 2002. Plants and People of Nepal.Timber Press, Portland, Oregon, USA. pp.599.

Meera B., Kumar S., Kalidhar S.B., 2003. A review of the chemistryand biological activity of *Pongamia pinnata*. J. Med. Arom. Plant Sci. 25, 441–65.

Mumcuoglu, K.Y., 1999. Prevention and treatment of head lice in children. Pediatr. Drugs. 1, 211-218.

Nagaraj G, Mukta N., 2004. Seed composition and fatty acid profile of some tree borne oilseeds. J. Oilseed Res. 21, 117-120.

Naik M., Meher L.C., Naik S.N. and Dasa L.M., 2008. Production of biodieselfrom high free fatty acid Karanja (*Pongamia pinnata*) oil. Biomass Bioener. 32, 354–7.

Natanam R, Kadirvel, R, Chandrasekaran D., 1989.Chemical composition of karanja (*Pongamia glabra* Vent [*P.Pinnata*]) kernel

and cake as animal feed. Indian J. Anim. Nutr. 6, 270-273.

Orwa, C., Mutua, A., Kindt, R., Jamnagass, R., Anthony S., 2009. Agroforest Tree Database. 491p.

Philip T, Sharma DD., 1997. *In vitro* evaluation of leaf and oil cake extracts of *Azadirachta indica* and *Pongamia glabra* on mulberry root rot pathogens. Indian Sericult. 36, 150-152.

Prabha T., Dora Babu M., Priyambada S., Agrawal V.K. and Goel R.K., 2003. Evaluation of *Pongamia pinnata* root extract on gastric ulcers and mucosal offensive and defensive factors in rats. Ind. J. Exp. Biol. 41(4), 304-310.

Prasad, G., Reshmi M.V., 2003. A manual of medicinal trees. Agrobios India 132 p.a Propagation Methods. Foundation for Revitalization for Local Health Tradition, India.

Punitha R., Manohar, S., 2006. Antihyperglycemic and antilipidperoxidative effects of *Pongamia*
pinnata (Linn.) Pierre flowers in alloxan induced diabetic rats. J. Ethnopharmacol. 105, 39–46.

Rameshthangam P. and Ramasamy P., 2007. Antiviral activity of bis (2-methylheptyl) phthalate isolated from *Pongamia pinnata* leaves against White Spot Syndrome Virus of *Penaeus monodon* Fabricius. Virus Res. 126(1-2), 38-44.

Rastogi RP, Mehrotra BN. A Compendium of Medicinal Plants vol.1. Central Drug Research Institute, Lucknow and Publication and Information Directorate, New Delhi 1960-69: 497 p.

Sangwan, S., Rao, D.V., Sharma, R.A., 2010. A review on *Pongamia Pinnata* (L.) Pierre: A great versatile Leguminous plant. Nat. Sci. 8(11), 130-139.

Sarma A.K., Konwer. D. and Bordoloi P.K., 2005. A comprehensive analysis of fuel properties of biodiesel from Koroch seed oil. Energy Fuel. 19, 656–657.

Satyavati G.V., Gupta A.K. and Neeraj T., 1987. Medicinal Plants of India, vol II, ICMR, New Delhi, pp. 490.

Shaine K.T., Bozell J., Wallace R., Peterson B. and Moens L., 2004. Biomass oil analysis. Research Needs and recommendations, National Renewable Energy Laboratory.

Shameel S., Usmanghani K. and Ali M.S., 1996. Chemical constituents from seeds of *Pongamia pinnata* (L.) Pierre. Pak. J. Pharm. Sci. 9, 11-20.

Shirwaikar A., Malini S. and Chandrika Kumari S., 2004. Protective effect of *Pongamia pinnata* flowers against cisplatin and gentamicin induced nephrotoxicity in rats. Indian J. Exp. Biol. 41(1), 58-62.

Shoba G.F. and Thomas M., 2001. Study of antidiarrhoeal activity of four medicinal plants in castor-oil induced diarrhoea. J. Ethnopharmacol. 76(1), 73–76.

Simonsen HT, Nordskjold JB, Smitt UW, Nyman U, Palpu P, Joshi P, Varughese G., 2001. *In vitro* screening of Indian medicinal plants for antiplasmodial activity. J. Ethnopharmacol. 74, 195-204.

Singh R.K., Joshi V.K. and Goel R.K., 1996. Pharmacological actions of *Pongamia pinnata* seeds - a preliminary study. Indian J. Exp. Biol. 34, 1204- 1207.

Singh R.K., Nath G. and Acharya S.B., 1997. Pharmacological actions of *Pongamia pinnata* roots in albino rats. Indian J. Exp. Biol. 35, 831-836.

Srinivasan K., Muruganandan S., Lal J., Chandra S., Tandan S.K., Raviprakash V., 2001. Evaluation of anti-inflammatory activity of *Pongamia pinnata* leaves in rats. J. Ethanopharmacol. 78, 151-157.

Srinivasan K., Muruganandan S., Lal J., Chandra S., Tandan S.K., Raviprakash V. and Kumar D., 2003. Antinociceptive and antipyretic activities of *Pongamia pinnata* leaves. Phytother. Res. 17, 259–264.

Tanaka T., Iinuma M., Fujii Y., Yuki K., Mizuno M., 1992. Flavonoids in root bark of *Pongamia pinnata.* Phytochem. 31, 993-998.

Uddin Q., Parveen N., Khan N.U. and Singhal K.C., 2003. Antifilarial potential of the fruits and leaves extracts of *Pongamia pinnata* on cattle filarial parasite. Phytother. Res. 17 (9), 104 – 110.

Vismayaa, Sapna Eipesona W., Manjunathab J.R., Srinivasb P. and Sindhu Kanyaa T.C., 2010. Extraction and recovery of karanjin: A value addition to karanja (*Pongamia pinnata*) seed oil. Industr. Crops Prod. 32, 118–122.

Wagh P., Rai M., Deshmukh S.K. and Durate M.C.T., 2007. Bio-activity of oils of *Trigonella foenumgraecum* and *Pongamia pinnata.* African J. Biotech. 6(13), 1592-1596.

Warrier P.K, Nambiar V.P.K, Ramakutty C., 1995. Indian Medicinal Plants. Vol (IV) Orient Longman Ltd., Madras. p.339.

Yadav P.P., Ahmad G.A. and Maurya R., 2004. Furanoflavonoids from *Pongamia pinnata* fruits. Phytochem. 65, 439-443.

Yamane K., Ueta A., Shimamto Y., 2006. Influence of physical and chemical properties of biodiesel fules on injection, combustion and exhaust emission characterisiics in a direct injection compression ignition engine. Int. J. Engine Res. 2, 249-261.

Yang Y.C., Lee H.S., Clark J.M., Ahn Y.J., 2004. Insecticidal activity of plant essential oils against *Pediculus humanus* capitis (Anoplura: Pediculidae). J Med Entomol; 41, 699-704.

Yin H., Zhang S. and Wu J., 2005. Prenylated Flavonoids from *Pongamia pinnata*. Z. Naturforsch 60b, 356-358.

Yin H., Zhang S., Wu J., Nan H., Long L., Yang J. and Li Q., 2006. Pongaflavanol: a Prenylated Flavonoid from *Pongamia pinnata* with a Modified Ring A. Molecul. 11, 786-791.