

A Review on *Pongamia Pinnata* (L.) Pierre: A Great Versatile Leguminous Plant

*Savita Sangwan, D.V.Rao and R.A. Sharma

Biotechnology lab, lab no.5, Department of Botany, University of Rajasthan, Jaipur.

E.mail:- savita.sagwan@gmail.com

*Correspondence author: SAVITA SANGWAN

Institute address: - Biotechnology lab, lab no.5, Department of Botany, University of Rajasthan, Jaipur.

Residence address: - B-130, L.S.Nagar, Vidhyadhar Nagar, Jaipur.

E-mail:- savita.sagwan@gmail.com; **Phone:** - 9928195351

Abstract: *Pongamia pinnata* (L.) Pierre [family: Leguminosae] is a medium –sized glabrous tree popularly known as Karanja in Hindi, Indian beech in English and Pongam in Tamil. It is adaptable tree for tropical and sub-tropical regions which requires excellent drainage and a sunny location. It grows easily from seed. Historically, this plant has long been used in India and neighboring regions as a source of traditional medicines, animal fodder, green manure, timber, fish poison and fuel. Extract of the plant possess significant anti-diarrhoeal, anti-fungal, anti-plasmodial, anti-ulcerogenic, anti-inflammatory and analgesic activities. Its oil is a source of biodiesel. It has also alternative source of energy, which is renewable, safe and non-pollutant. This article briefly reviews the botany, distribution, ecology, uses of the plant and as a source of biodiesel. This is an attempt to compile and document information on different aspect of *Pongamia pinnata* and its potential use as a source of biodiesel.

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1. Introduction

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 which are widely available in market today. *Pongamia* is a genus having one species only *Pongamia pinnata* (L.) [Syn. *Pongamia glabra* (Vent); *Derris indica* (Lamk.)] which belongs to family Leguminosae and sub-family Papilionaceae (Merra et al. 2003)? It is a medium sized glabrous, perennial tree grows in the littoral regions of South Eastern Asia and Australia (Satyavati et al. 1987; Allen and Allen, 1981). *Pongamia pinnata* is a preferred species for controlling soil erosion and binding sand dunes because of its dense network of lateral roots. Root, bark, leaves, flower and seeds of this plant also have medicinal properties and traditionally used as medicinal plants. All parts of the plant have been used as crude drug for the treatment of tumors, piles, skin diseases, wounds and ulcers (Tanaka et al. 1992). In the traditional system of medicines, such as Ayurveda and Unani, the *Pongamia pinnata* plant is used for anti-inflammatory, anti-plasmodial, anti-nociceptive, anti-hyperglycemic, anti-lipidperoxidative, anti-diarrhoeal, anti-ulcer, anti-hyperammonic and antioxidant activity (Chopade et al. 2009).

The *Pongamia pinnata* seeds contain about 40% oil, which can be converted to biodiesel by transesterification method (Meher et al. 2006). *Pongamia* biofuel requires no engine modification, when blended with diesel in proportions as high as 20 percent. In the present article information on various aspects of *Pongamia pinnata* and its role as a source of biodiesel is reviewed.

1.1 Botanical Classification

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Fabales
Family	:	Leguminosae
Genus	:	<i>Pongamia</i>
Species	:	<i>Pinnata</i>

1.2 Botanical Name

Pongamia pinnata (L.) Pierre

1.3 Synonyms

Derris indica (Lam.) Bennett
Millettia novo-guineensis Kane. and Hat.
Pongamia glabra Vent.
Pongamia pinnata Merr.

1.4 Common Names

Hindi, Beng., Mar. and Guj:	Karanj, Karanja
Sanskrit	: Naktamala
English	: Indian beech
Telgu	: Pungu, Gaanuga
Tamil	: Ponga, Pongam
Malayalam	: Pungu, Punnu
Oriya	: Koranjo
Punjab	: Sukhehein, Karanj, Paphri
Assam	: Karchuw

2. Documented Species Distribution:

2.1 Native

Bangladesh, India, Myanmar, Nepal, Thailand.

2.2 Exotic

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).

3. Ecology

Native to humid and subtropical environments, pongam 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 is not found above 600 m (GOI, 1983).

Pongam can grow on most soil types ranging from stony to sandy to clayey, including Vertisols. 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.

4. Botanical Description

According to Allen and Allen (1981) the *Pongamia 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.

Table 1. Botanical Description of *Pongamia pinnata*

Plant type	Medium-sized, evergreen, perennial and deciduous tree (Figure A) 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
(a) Leaf	Alternate, odd pinnately compound, 2 to 4 inches, evergreen, hairless. (Figure B)
(b) Flower	Lavender, pink; white, 2- 4 together, short-stalked, pea shaped, 15-18mm long. (Figure C)
(c) Pods	3-6cm long and 2-3cm wide, smooth, brown, thick-walled, hard, indehiscent, 1-2 seeded. (Figure D)
(d) Seed	Compressed ovoid or elliptical, bean-like, 10-15cm long, dark brown, oily. (Figure E)
(e) Root	Taproot is thick and long, lateral roots are numerous and well developed. (Figure F)
(f) Bark	Thin gray to grayish brown and yellow on the inside. (Figure G)
Care and Pruning	All parts of the plant are toxic and will induce nausea and vomiting if eaten.

Figure



Figure A: Healthy *Pongamia pinnata* plant

Figure B: Leaf

Figure C: Flower

Figure D: Pods

Figure E: Seeds

Figure F: Root

Figure G: Bark

5. Growth Pattern

Growth is seen best from sea level to an altitude of approximately 1200m and an optimal annual rainfall of 500 to 2500mm. Further, *Pongamia pinnata* is regarded as both a saline and drought tolerant species. It is very tolerant of saline conditions and alkalinity. Reported soil pH range for growth is 6 - 9 with the optimum between 6.5 - 8.5. It sheds its leaves in April and develops new leaves from May onwards. Flowers appear in April to June and its pods ripen during March to May of the following year. Seed ripens from February to May (Sahni, 1998) as shown in Table 2.

Table 2. General growth pattern of *Pongamia pinnata*

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plant Parts												
Seed ripen		■	■	■	■							
Pods ripen			■	■	■							
Flowers				■	■	■						
Fruits												■
Leaf fall				■								
New leaf					■	■	■	■				

6. Chemistry

Reported to contain alkaloids demethoxy-kanugin, gamatay, glabrin, glabrosaponin, kaempferol, kankone, kanugin, karangin, neoglabrin, pinnatin, pongamol, pongapin, quercitin, saponin, β -sitosterol and tannin. Seeds have 19.0% moisture, 27.5% fatty oil, 17.4% protein, 6.6% starch, 7.3% crude fibre and 2.4% ash. Manurial values of leaves and twigs are respectively: nitrogen 1.16, 0.71; phosphorus 0.14, 0.11; potash 0.49, 0.62; and lime (CaO), 1.54, 1.58%. (Duke, 1983; Singh, 1982) as shown in Table 3.

Table 3. Nutrient Levels in *Pongamia Pinnata* Leaf and Fruit

Parameter	Leaf	Fruit (Pod and Seed)
Protein	-	17.4%
Fatty oil	-	27.5%
NFE	-	55.40%
CF	-	5.04%
ADF	40%	1.65%
Ash	-	2.4%
Tannin	-	2.32g/100g
ADL	-	6.67%
Trypsin	-	6.2g/100g
P	0.11, 0.14%	0.61%
Ca	1.58, 1.54%	0.65%
Mg	-	-
K	0.62, 0.49%	1.3%
CP	18%	19.5g/100g
NDF	62%	17.98%
N	0.71, 1.16%	5.1%
Moisture	-	19.0%
Starch	-	6.6%
Mucilage	-	13.5%
Na+	-	0.8%

NFE = Nitrogen free extract

CF = Crude fibre

ADF = Acid detergent fibre

ADL = Acid detergent lignin

CP = Crude protein

NDF = Neutral detergent fibre

7. Economical and Medicinal value

The plant *Pongamia pinnata* has immense medicinal and economical values which are tabulated in Table 4.

Table 4. Economic and Medicinal Importance of *Pongamia pinnata*

Root	
Economic value	- Root is used as fish poison (Oommen et al., 2000).
Medicinal value	<ul style="list-style-type: none"> - Juice of roots with coconut milk and lime water used for treatment of gonorrhoea (Joshi, 2006 and Manandhar, 2002). - Used for cleaning gums, teeth and ulcers (Bhattacharjee, 1998). - Roots are bitter anti-helminthic 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	
Economic value	<ul style="list-style-type: none"> - Used for stove top fuels, poles and ornamental carvings (Das and Alam, 2001). - Ash of wood used for dyeing (Allen and Allen, 1981). - Cabinet making, cart wheels, posts (NAS, 1980). - Agricultural implements, tool handles and combs (GOI, 1983).
Medicinal value	- Aqueous extracts of stem bark exhibit significant CNS sedative and antipyretic activity (Philip and Sharma, 1997).
Leaf	
Economic value	<ul style="list-style-type: none"> - Used as cattle fodder. (Ambasta et al., 1992). - Used in stored grains to repel insects. - Used as manure for rice (Dastur, 1968) and sugarcane fields (Drury, 1978).
Medicinal value	<ul style="list-style-type: none"> - Juice of leaves is used for cold, cough, diarrhea, dyspepsia, flatulence, gonorrhoea, leprosy (Ambasta et al., 1992; Oommen, et al., 2000. and Bhattacharjee, 2001). - Leaves are antihelminthic, digestive and laxative used for inflammations, piles and wounds. - As an infusion to relieve rheumatism. - As an extract to treat itches and herpes.
Fruit	
Economic value	- Fruits are edible (Singh et al., 1983).
Medicinal value	<ul style="list-style-type: none"> - 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	
Economic value	<ul style="list-style-type: none"> - After oil extraction has been used as "green manure" as it is rich in protein and nitrogen. - Used as insecticides (APROSC, 1991).
Medicinal value	<ul style="list-style-type: none"> - Used for keloid tumors. - 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	

Economic value	<ul style="list-style-type: none"> - Used as fuel for cooking and lamps, as a lubricant, water-paint binder, pesticide and in soap-making, candles and tanning industries (Burkill, 1966). - Used as lipids for commercial processes. - Used in cosmetics.
Medicinal value	<ul style="list-style-type: none"> - 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	
Economic value	<ul style="list-style-type: none"> - String and rope can be made from the bark fiber. - Used for paper pulp
Medicinal value	<ul style="list-style-type: none"> - For bleeding piles, for beriberi, reduce swelling of the spleen (Kirtikar, 1984). - Useful in mental disorder, cough and cold (Manandhar, 2002).
Flower	
Economic value	<ul style="list-style-type: none"> - Good sources of pollen for honey bees (Lakshmi et al., 1997). - Flowers are edible (Bhattacharjee, 2001).
Medicinal value	<ul style="list-style-type: none"> - 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).

8. Pharmacological Activities

8.1 Anti-Plasmodialactivity

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

8.2 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* leaf (Srinivasan et al. 2001). Anti-pyretic action was also significantly observed by the same extraction against Brewer's yeast-induced pyrexia.

8.2 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 *Pongamia pinnata* has selective anti-diarrhoeal action with efficacy against cholera (Brijesh et al. 2006).

8.4 Antioxidant and Anti-hyperammonemic Activity

Pongamia pinnata leaf extract shows circulatory lipid peroxidation and antioxidant activity. It has been evaluated in ammonium chloride-induced hyperammonium rats. That enhances lipid peroxidation in the circulation of ammonium chloride-treated rats, resulting in a significant decrease in the levels of vitamin A, C, E which further reduces catalase glutathione, glutathione peroxides and superoxide dismutase. (Essa and Subramanian, 2006).

8.5 Anti-ulcer Activity

The methanolic extract of *Pongamia pinnata* roots showed significant protection against aspirin and has a tendency to decrease acetic acid-induced ulcer after 10-days treatment. Having augmentation of mucosal defensive factors like - mucin secretion, life span of mucosal cells, mucosal cell glycoprotein's, cell proliferation and prevention of lipid per oxidation, the extract also shows ulcers protective effect (Prabha et al. 2003).

8.6 Anti-hyperglycaemic and Anti-lipidperoxidative Activity

The oral administration of ethanolic extract of *Pongamia pinnata* flower shows significant anti-hyperglycaemic and anti-lipidperoxidative effect and also enhance antioxidant defense system in alloxan-induced diabetic rats. Hence suggesting that the treatment of *P. pinnata* extract could be used as a better and safe alternative anti-hyperglycaemic drug for diabetic patients (Punitha and Manoharan, 2006).

9 *Pongamia 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 *Pongamia 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 *Pongamia pinnata* oil are comparable (Gerphen et al. 2004; Shaine et al. 2004) as shown in Table 5.

Table 5. A Comparison of Biodiesel and Standard Petroleum Diesel

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	-

7.1 Chemical Composition of Biodiesel

The seeds of *Pongamia 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 6.

Table 6. Fatty Acid Composition from Seed Oil of *Pongamia Pinnata*

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

8. Services:**8.1 Soil Improver**

Incorporation of leaves and the presscake into soils improves fertility. Decomposed flowers are valued in the tropics as rich nutrition for special plants, especially when grown in greenhouse.

8.2 Nitrogen Fixing

Nodulation is reported in pongam. In nurseries and fields the presence of nodules on uninoculated pongam seedlings is common. Therefore, this species may not be specific in its Rhizobium strain requirement. It nodulates and fixes atmospheric nitrogen with Rhizobium of the cowpea group.

8.3 Ornamental

Pongamia pinnata is often planted in homesteads as an ornamental tree and in avenue plantings, roadsides, stream and canal banks. However the large amounts of flowers, leaves and pods that it regularly sheds make it not very suitable for this purpose.

8.4 Shade or Shelter

Grass grows normally beneath the tree so it has been planted for shade in pastures. *Pongamia pinnata* is grown as a windbreak for tea plantation in Sri Lanka.

8.5 Erosion Control

A preferred species for controlled soil erosion and binding sand dunes because of its extensive network of lateral roots.

8.6 Reclamation

Because it tolerates moderate levels of salinity, pongam is an ideal candidate for recovering a variety of wastelands such as saline soil reclamation. It is also used in reforestation of marginal lands.

9. Conclusion:

Owing to its versatile characteristics *Pongamia pinnata* is rightly called as Biodiesel plant, being considered as excellent source of Biodiesel. This plant is a multipurpose tree with immense medicinal and economic value.

Thus, the future success of *Pongamia pinnata* as a sustainable source of feedstock for the biofuels industry is reliant on an extensive knowledge of the genetics, physiology, pharmacology and propagation of this legume. In particular, research should be targeted to maximize the plant growth as it relates to oil biosynthesis.

Correspondence to:**SAVITA SANGWAN**

Institute address: - Biotechnology lab, lab no.5
Department of Botany, University of Rajasthan,
Jaipur.

Residence address: - B-130, L.S.Nagar,
Vidhyadhar Nagar, Jaipur.

E-mail:- savita.sagwan@gmail.com

Phone: - 9928195351

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