Phytology

Pongamia pinnata (L.), constituents and agricultural benefits: a reviews

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Abstract

Another multipurpose leguminous tree with non-edible oil, Pongamia (*Pongamia pinnata*), grows all over India. Pongamia cake includes secondary metabolites in addition to a wealth of minerals and amino acids. Fatty acids are present in pongamia oil, and nutrients are present in the leaf. As a superior source of fertilizer in organic agriculture, *Pongamia pinnata* has a high nutritional value with macro and micronutrients including nitrogen, phosphorus, potassium, calcium, magnesium, zinc, copper, and iron. This plant has a long history of use in India and its nearby regions as a source of traditional medicines (for conditions including the common cold, leprosy, diarrhoea, and ulcers), fodder and feed, green leaf manure, lumber, fish poison, soil binder, and soil reclaimer, among others., both a biofuel and a source of pollen, mostly for honeybees. The soil fertility is enhanced by the good source of nutrients found in pongamia cake. Pongamia oil is derived from the seeds and utilized in biofuel, medicine, and agriculture. It works against a variety of pests and insects and has similar insecticidal characteristics to neem oil. Pongamia oil's primary active component is karanjin. While the cake, a byproduct of oil extraction, was discovered to be rich in all plant nutrients used as a source of plant nourishment, it also functions as an acaricide and pesticide.

Keywords: agriculture, pongamia oil, pongamia cake, biofuel

Introduction

The Pongamia cake, a byproduct of oil extraction from Pongamia seeds, is rich in secondary metabolites, minerals, and amino acids. It contains fatty acids and nutrients that make it a valuable source of fertilizer in organic agriculture. The cake is particularly beneficial due to its high nutritional value, providing macro and micronutrients like nitrogen, phosphorus, potassium, calcium, magnesium, zinc, copper, and iron, which enhance soil fertility. *Pongamia pinnata* has a long history of use in traditional medicine in India and neighboring regions. Its various parts, such as leaves, seeds, and bark, have been used to treat ailments like the common cold, leprosy, diarrhea, and ulcers.

Additionally, Pongamia serves as a source of fodder and feed for livestock. Its leaves are utilized as green leaf manure, which further enriches the soil with nutrients. The wood of the Pongamia tree is used as lumber, and the plant is also known for its fish-poisoning properties. Pongamia oil, derived from the seeds, has multiple applications. It is used as a biofuel, especially in biodiesel production. The oil is also employed in medicine and agriculture. Similar to neem oil, Pongamia oil possesses insecticidal characteristics and works against various pests and insects. Its primary active component is karanjin, which contributes to its insecticidal properties. Overall, *Pongamia pinnata* is a highly versatile plant with numerous benefits and applications. It serves as a valuable source of nutrients for soil enrichment, a biofuel, a traditional medicine, and an insecticide, among other uses.

Botanical and chemical characteristics

Pongamia pinnata is a medium-sized plant that grows extremely quickly. It typically reaches heights of 30 to 40 feet and extends its canopy to provide moderate shade (Orwa *et al.*, 2009) [32]. *Pongamia pinnata* can grow in a variety of environments and has a wide range of habitat distribution. It can thrive in a variety of soil types, including alkaline, salty, sandy, clay, stony, and waterlogged soils. It also has a great tolerance for drought and can withstand temperatures of up to 50°C. The trunk typically has a diameter of more than 1.64 feet and is short. According to Daniel (1997) [10], Pongamia has a deep and robust taproot system with numerous secondary lateral roots. The complex, alternate leaves have 5 or 7 leaflets, 2 or 3 pairs of which are oriented in opposite directions, and a single terminal leaflet. Leaflets have a pointed tip and measure 5-10 cm length by 4-6 cm wide. The tap root is thick and long, and the bark is thin, grey to grayish brown in colour, and yellow on the interior. According to Sangwan *et al.* (2010) [42], pea-shaped flowers are typically 15-18 mm long and pink, white, or light purple in hue. The elliptical pods, which are 3-6 cm long and 2-3 cm wide, contain a single seed inside of a thick-walled shell. The seeds are retrieved by thrashing after the pods have been sun-dried. The seeds are 1.0-1.5 cm long and have a light brown colour. One tree may produce between 9 and 90 kg of seed pods, and these seed pods can produce up to 40% oil per seed, 50% of which is C18:1, which is thought to be appropriate for making biodiesel. One tree provides 8-24 kg of kernels, which contain 30–40% oil (Lakshmikanthan, 1978; Bringi, 1987) [23, 4]. Normally, seeds last for around six months. 19.0% of the air-dried kernels are moist, 27.5% are oily, and 17.4% are solid.6.6% starch, 7.3% crude fibre, 2.3% ash, and 2.3% protein (Bringi, 1987) [4].

Cultivation of *Pongamia pinnata*

Pongamia pinnata is indeed a nitrogen-fixing tree, which

means it has the ability to convert atmospheric nitrogen into a form that can be used by plants. It is commonly propagated through seeds, and seed storage is a popular and cost-effective technique for preserving the genetic variety of the species (Hong and Ellis, 1996) [15]. When planting Pongamia trees, it is recommended to dig pits with dimensions of approximately 60 × 60 × 60 cm³. This size provides sufficient space for the roots to establish and grow. The spacing between rows should be around 5 meters, and the recommended distance between individual plants within a row is 4 meters. These spacing guidelines help ensure adequate light penetration and airflow for the optimal growth and development of the trees.

To support the better growth and development of Pongamia trees, it is generally recommended to provide three irrigations per year. Adequate water supply is crucial, especially during the early stages of establishment and during dry periods. However, specific irrigation requirements may vary depending on factors such as soil type, climate, and rainfall patterns in the particular region where the trees are grown. Monitoring soil moisture levels and adjusting irrigation practices accordingly is important for optimal plant health. Overall, following these guidelines for seed storage, planting spacing, and irrigation can contribute to the successful cultivation of *Pongamia pinnata* trees and their growth and development.

Propagation

Pongamia are often reproduced from seeds, which is labor-intensive and unsuitable for maintaining genetically superior lines. Pongamia is an obligate outcrosser, with bees serving as the main pollinators. Therefore, a pollen donor could be any tree that is close enough for a bee to transport and spread pollen from (approximately 3 km radius). After choosing the genetic material that would produce the greatest results, trees must be clonally propagated by stem cuttings, grafting, or tissue culture.

Chemistry

Pongamia pinnata contains alkaloids like demethoxykanugin, gamatay, glabrin, glabrosaponin, kanjone, kaempferol, karangin, kanugin, quercitin, pinnatin, neoglabrin, pongamol, pongapin, b-sitosterol, saponin, and tannin. Air-dry kernels have 19.0% moisture, 27.5% fatty oil (Fatty acid composition: stearic 2.4–8.9%, palmitic, 3.7–7.9%, lignoceric 1.1–3.5%, arachidic 2.2–4.7%, linoleic 10.8–18.3%, oleic, 44.5–71.3%, behenic 4.2–5.3%, and eicosenoic 9.5–12.4%), 17.4% protein, 6.6% starch, 7.3% crude fiber and 2.4% ash. Destructive distillation of the wood yields, on a dry weight basis: charcoal 31.0%, pyroligneous acid 36.69, acid 4.3%, ester 3.4%, acetone 1.9%, methanol 1.1%, tar 9.0%, pitch and losses 4.4%, and gas 0.12 cu m/kg.

Nitrogen Fixation

With a wide variety of Bradyrhizobium-tribe rhizobia, Pongamia can generate functional spherical nodules (Scott *et al.*, 2008) [45]. These microorganisms frequently nodulate Australian wattle species. It may be difficult to develop highly efficient Bradyrhizobium strains for Pongamia that will endure in field conditions because of their endurance in Australian soils. According to Ferguson *et al.* (2010) [13] and Caetano-Anolles and Gresshoff (1991) [6], pongamia plants are believed to exhibit the traditional legume nodulation response known as auto control of nodulation.

Factors which Influence the good growth of *Pongamia pinnata*

1. Soil and water

Pongamia has been growing on a wide range of soil types like acid soils, sodic, alkaline soils, and heavy clay soils with a sodic subsoil horizon and also reported to grow on a wide range of soil types from stony to clay to sandy (Kesari and Rangan, 2010) [18], though it is noted that the plant does not do well on dry sands. Despite tolerance to a wide range of soil types, soil conditions are likely to interact strongly with climate to markedly affect rates of Pongamia growth.

Water requirements for satisfactory rates of seed and oil production by Pongamia are poorly understood, but experts suggested that irrigation is required during the establishment phase of the plantings (first seven years) in dry tropical and subtropical areas, and sometimes subsequently in order to ensure seed set.

Salt tolerance Pongamia is promoted as being able to produce oilseeds on degraded, low productivity or salt-affected land thereby lessening competition for higher productivity land used for agricultural production (Kesari and Rangan, 2010; Odeh *et al.*, 2011) [18, 31]. The reduction in nodulation with increasing salinity in Pongamia is comparable with *Acacia ampliceps*, another salt-tolerant legume that has been widely used for the purpose of reclaiming salt-affected land (Wilkinson *et al.*, 2011) [55].

2. Temperature

Night-time temperatures play a crucial role in regulating the phenology of *Pongamia pinnata*. The species requires minimum temperatures that are consistently above 15°C for at least six months to support optimal foliage, flower, and seed production. A minimum temperature of 15°C is considered necessary for the proper growth and development of Pongamia trees. This temperature threshold is particularly important for various stages of the plant's life cycle, including the production of foliage, flowers, and seeds. Adequate night-time temperatures above this threshold are essential for triggering the physiological processes involved in these reproductive activities.

It's worth noting that the specific temperature requirements and duration can vary slightly depending on the local climate and specific genetic variations within the *Pongamia pinnata* species. However, the general guideline of minimum temperatures consistently exceeding 15°C for at least six months provides a good indication of the temperature conditions needed to support optimal phenological development in Pongamia trees.

Therefore, when selecting a suitable location for cultivating *Pongamia pinnata*, it is important to consider the local climate and ensure that the region experiences the necessary minimum

temperatures to support successful growth, flowering, and seed production of the species.

Frost

Pongamia has been seen to endure and bounce back from frost incidents (frost tolerant). Abscission and leaf blackening were observed after the frost but trees were able to undergo profuse vegetative growth again (Mukta and Sreevali, 2009; Prasad and Pandey, 1987) [26, 38].

3. Fertilizer management

Early growth and establishment success are presumably improved by fertilizer application to seedlings. To sustain soil fertility over the long term, addition of macronutrients like phosphorus and potassium as well as micronutrients may be necessary.

4. Weed control

Weed control (mechanical and chemical) during the first three years after planting for successful establishment. Seedlings < 30 cm high are very vulnerable to weed overgrowth. Planting seedlings that are 50–60 cm tall will significantly increase their chances of surviving in the field (Venkatesh *et al.*, 2003) [52]. Intercropping with suitable species during the establishment phase (i.e., the first 3–4 years) may help with weed control.

5. Pests and diseases

Pongamia pinnata can be susceptible to various fungal diseases that affect its leaves. One such disease is 'tar spot,' caused by the fungus *Phyllachora pongamiae* (Borah *et al.*, 1998) [3]. This disease leads to leaf discoloration but generally does not cause mortality or significant harm to mature trees. However, it may have more detrimental effects on seedlings.

In addition to *Phyllachora pongamiae*, there are several other fungi known to cause leaf spot and blight on Pongamia in India. These include *Fusicladium pongamiae*, *Microstroma pongamiae*, *Cercospora pongamiae*, and *Ravenelia hobsoni* (Arpiwi *et al.*, 2011) [2]. These fungal infections can impact the health and appearance of the leaves, and in some cases, they may affect overall tree vigor and productivity. *Pongamia pinnata* may also face potential threats from pests such as stem borers, leaf miners, locusts, and green ants. These pests can cause damage to various parts of the tree, including the stems, leaves, and flowers, which can impact its growth and productivity.

Regarding the composition of Pongamia leaf, Ullah *et al.* (2014) [51] and Khattak *et al.* (2015) [16] have provided information on the nutrient composition of *Pongamia pinnata* leaves. The exact nutrient composition may vary depending on various factors such as soil conditions, climate, and the age of the plant. However, Pongamia leaves generally contain a range of nutrients, including macronutrients (such as nitrogen, phosphorus, and potassium) and micronutrients (such as calcium, magnesium, zinc, copper, etc.). These nutrients contribute to the overall nutritional value of the plant and can have implications for its use in agriculture, fodder, and other applications.

It is important to monitor and manage fungal diseases and pests in Pongamia plantations to ensure the health and productivity of the trees. Implementing appropriate disease and pest management strategies, including cultural practices and, if necessary, targeted treatments, can help mitigate the impact of these challenges and maintain the overall health of *Pongamia pinnata* trees (Table 1)

Table 1: Leaf of *Pongamia pinnata* is nutrient-rich

Parameter	Value (g/g DM)
Na+	204
K+	197
Mg++	67
Ca++	80
Fe++	42
Mn++	22
Zn++	35
Total soluble phenolic content	1,39,000

Composition of pongamia cake

The seed of Pongamia consists of an outer hull portion (6% mass) and an inner kernel portion (94%). Following oil extraction, approximately two thirds by weight of the original seed is left as a residual meal or cake, containing 28-34 % crude protein (Vinay and Kanya, 2008) [53]. Main composition of pongamia cake was shown in Table 2. The Pongamia meal or cake (also known as karajin cake) has been used as manure, fungicide and insecticide and mainly in India, on utilization of this protein meal/ amino acids (Table 4) as animal feed (Kumar and Singh, 2002; Panda *et al.*, 2008; Pavela and Herda, 2007; Vinay and Kanya, 2008) [20, 33, 35, 53]. However, the meal's fluro-flavinoids and pongamol in the leftover oil make it unpleasant to eat. Vinay and Kanya (2008) [53] reported that pongamia cake contains anti-nutritional factors such as tannins, phytates, and protease inhibitors that affect rumen metabolites and the digestibility of protein and carbohydrates (Nitrogen digestibility).

Table 2: Key Ingredients in Pongamia Cake (Kumar *et al.*, 2007) [21]

Main Analysis	Composition
Crude protein	26.6 % Dry Matter
Crude fibre	5.6 % Dry Matter
Lignin	2.9 % Dry Matter
Ether extract	11.0 % Dry Matter
Ash	4.9 % Dry Matter

Table 3: Pongamia cake's mineral makeup (Chandrasekaran *et al.*, 1989; Gowda *et al.*, 2004) [7, 14]

Minerals	Composition
Calcium	7 g/kg dry matter
Phosphorus	6.2 g/kg dry matter
Potassium	2.3 g/kg dry matter
Magnesium	2.4 g/kg dry matter
Manganese	76 mg/kg dry matter
Zinc	199 mg/kg dry matter
Copper	12 mg/kg dry matter
Iron	23 mg/kg dry matter

Table 4: Pongamia cake's amino acid makeup (Ravi *et al.*, 2000) [40]

Amino acids	Composition (% protein)
Alanine	3.7
Arginine	4.5
Aspartic acid	8.6
Cystine	3.6
Glutamic acid	15.5
Glycine	3.6
Histidine	3.6
Isoleucine	4.8
Leucine	7.8
Lysine	4.5
Methionine	1.2
Phenylalanine	4.4
Proline	4.0
Serine	4.3
Threonine	3.4
Tyrosine	3.5
Valine	5.9

Composition of pongamia oil

Indeed, there are different methods used to extract Pongamia oil from the seeds, including cold pressing, solvent extraction, and expeller pressing. Each method has its own advantages and may result in slight variations in the physical properties of the oil obtained. In Table 6, the crude Pongamia oil's physical properties are displayed. The color of the oil typically ranges from orange yellow to brown, which is a characteristic attribute of Pongamia oil. It is important to note that Pongamia oil should not be consumed orally as it is known to be poisonous and can cause nausea and vomiting if ingested.

Despite its toxic nature, Pongamia oil has been traditionally used in various treatments. It is rich in fatty acids, as indicated in Table 5. Triglycerides are one of the major components of Pongamia oil. However, the presence of bitter flavonoid components, such as pongamol, karanjin, karanjachromene, and tannins, gives the oil an unpleasant taste and odor. These bitter components contribute to the characteristic properties of Pongamia oil but may limit its direct consumption or use in certain applications. However, they also contribute to the oil's bioactive properties, such as insecticidal and antimicrobial effects, which are valuable in agricultural and medicinal applications.

It is important to handle Pongamia oil with care and avoid oral consumption. When used in traditional treatments, it is typically applied topically or in specific formulations prepared by traditional practitioners who understand its appropriate usage and dosage.

Table 5: Composition of Pongamia oil's fatty acids (Pandey, 2008) [34]

Fatty acids	Nomenclature	Percentage
Palmitic	C16:0	3.7-7.9
Stearic	C18:0	2.4-8.9
Oleic	C18:1	44.5-71.3
Linoleic	C18:2	10.8-18.3
Linolenic	C18:3	2.6
Arachidic	C20:0	22.2-4.7
Eicosenoic	C20:1	9.5-12.4
Behenic	C22:0	4.2-5.3
Lignoceric	C24:0	1.1-3.5

Table 6: Crude Pongamia oil's physical characteristics (Pandey, 2008) [34]

Property	Unit	Value
Acid value	mg KOH/g	4-12
Calorific value	kcal/kg	8742
Cetane number	Nos.	42
Density	g/cc	0.924
Iodine value	g/100 g	86.5-87
Saponification value	mg KOH/g	184-187
Specific gravity	-	0.925
Unsaponifiable matter	% w/w	2.6-2.9
Viscosity	mm2/sec	40.2
Boiling point	ºC	316
Cloud point	ºC	3.5
Fire point	ºC	230
Flash point	ºC	225
Pour point	ºC	-3

Applications of *Pongamia pinnata*

Pongamia pinnata is a plant whose flower, seed, leaf, root, and other parts have all been used to make traditional remedies, animal feed, green manure, wood, fish poison, and other things.

1. *Pongamia pinnata* wood

Pongamia pinnata wood, which has a calorific value of 4600 kcal/kg, has been utilised as fuel traditionally in rural areas. The wood is utilised for manufacturing fuel for stove tops, poles and carvings for ornamentation (Das and Alam, 2001) [11], cabinets, posts, agricultural tools, tool handles, cart wheels, and other commonplace items. Wood burning ash is employed in the dyeing process (Allen and Allen, 1981) [1].

2. *Pongamia pinnata* as fodder and feed

The *Pongamia pinnata* leaves contain 43% dry matter, 18% crude protein, 62% neutral detergent fiber, and *in vitro* dry matter digestibility of 50% and are eaten by cattle and readily consumed by goats. Despite their uncommon use, trees are very valuable in arid areas. Once the oil has been extracted, the cake is bitter and unsuited for use as animal feed. It is rich in protein but possess several toxic flavonoids like 1.25 % karanjin and 0.85 % pongamol alkaloid, resin, mucilage, sugar and tannin. These toxins are oil soluble and most of the toxins are removed during solute extraction of oil from cake with hexane. Short term substitution is required for protein sources, but never serving more than 75 % replacement. Both cattle and fowl could be fed on the deoiled cakes.

3. *Pongamia pinnata* oil

The most important product made from *Pongamia pinnata* seeds is thought to be oil. It is a thick, yellowish or reddish-brown oil with a calorific value of 40.756 MJ/kg that is extracted using several methods, such as solvent extraction. The oil is non-edible, bitter in taste, and unpleasant smell and is used for commercial processes as medicine and lamp fuel

and to produce biodiesel. Additionally, it is utilized in the production of soap, candles, water-paint, lubricants, leather dressing, and tanning (Burkill, 1996) [5]. Crude karanjia oil (CKO) has also the application in body oils, salves, lotions, shampoos, hair tonics, and pesticides (Kesari *et al.*, 2010) [17]. Pongamia oil showed inhibitory effects on *Bacillus anthracis, Bacillus mycoides, Bacillus pulilus, Escherichia coli, Pseudomonas mangiferae, Salmonella typhi, Staphylococcus albus, Sarcina lutea, Staphylococcus aureus,* and *Xanthomonas campestris,* but did not inhibit *Shigella* sp. (Chaurasia and Jain, 1978) [8].

4. *Pongamia pinnata* as a medicine

The flowers, fruits, and seeds of the plant are utilized in many traditional treatments even though the entire plant is poisonous. While fruits can treat stomach ulcers, tumours, and haemorrhoids, flowers are utilized to treat bleeding haemorrhoids. Whooping cough, bronchitis, and other illnesses can all be treated with seed powder, which is also suggested as a febrifuge and tonic. The juices from leaves, on the other hand, are used to cure colds, diarrhoea, gonorrhoea, flatulence, and leprosy. Bark has been employed as a medication to lessen spleen enlargement. Coughs, colds, and mental disorders are relieved by bark. For oral hygiene, the root is used as a toothbrush, and the liquid from the root is used to treat ulcers. When applied to a wound, *Pongamia pinnata* oil can stop bleeding. It is also an anthelmintic and effective for treating ulcers, rheumatism, arthritis, piles, liver discomfort, and persistent fever (Warrier *et al.*, 1995) [54] and scabies (Prasad and Reshmi, 2003) [37]. A black gum produced from the bark is used to treat wounds brought on by poisonous fish. The roots of the black malodorous plant have a strong fish-stupefying component. It has been determined that the flowers have anti-diabetic properties.

5. Seed cake as fertilizer

The pongamia tree (*Pongammia glabra* and *Pongammia Pinnata*), which may be found all across India, is well-known for its therapeutic qualities and has been utilized for many years in traditional Indian medicine. The press cake produced by oil extraction can be utilized as fertilizer or as ruminant and poultry feed (Sreedevi *et al.*, 2009; Scott *et al.*, 2008) [50, 44]. The composition of the three main varieties of pongamia oil cakes-rotary pressed, expeller pressed, and solvent-extracted-depends on the degree of decortication and the technique used to extract the oil (Dutta *et al.*, 2012) [12]. Nitrogen and protein-rich seed cake is used as green manure to fertilize the soil. An effective organic fertilizer is pongamia oil cake (POC), which offers 3.2 to 3.7% nitrogen, 0.22 to 0.23% phosphorus, and 0.65 to 0.68% potassium. Additionally, it is employed as a pesticide, particularly against worms. Additionally, the seed cake can be utilized to create biogas.

6. Rich source of NPK

Pongamia cake has rich quantity of NPK in organic form. Being totally botanical product, it contains 100 % natural NPK content and other essential micronutrients as well. The pongamia cake is very good to use as organic fertilizers as they are a rich source of NPK which improves soil fertility. When the cake is spread over the soil, it also acts as a pesticide, notably against worms and other illnesses of a similar kind.

As a natural fertilizer, it can be mixed with neem cake pellets to give a synergic result. Manorial values of leaves: nitrogen 1.16%, phosphorus (P_2O_5) 0.14%, potassium (K_2O) 0.49% and lime ($CaCO_3$) 1.54% (Morton, 1990) and Manurial value of twigs: nitrogen 0.71%, phosphorus (P_2O_5) 0.11 %, potasssium (K_2O) 0.62% and lime ($CaCO_3$) 1.58%. These manures reduce the incidence of *Meloidogyne javanica*.

7. Soil erosion

To prevent soil erosion, *Pongamia pinnata* trees are typically planted alongside highways, roads, and canals. The plants create a lateral network of roots that binds sand dunes and prevents soil erosion. On sloping uplands, locals have historically utilized pongamia to bind the soil (Kumar, 2004) [22].

8. Soil reclamation

Pongamia may produce oil on poor, damaged, or salty soils, according to its advertising (Murphy *et al.*, 2012) [28]. Pongamia trees have been utilized in India for soil reclamation and revegetation near coal mines (Maiti, 2012) [24]. The capacity of Pongamia trees to endure a variety of abiotic stresses and improve soil nitrogen status is essential.

9. As an insecticide

According to reports, Pongamia extracts are efficient against a variety of pests, acting as larvicides, antifeedants, and oviposition deterrents in stored grains and on crops (Kumar and Singh, 2002) [20]. To achieve the desired insect-inhibiting effect, water-oil suspensions of up to 2% have often been applied as a spray (Pavela and Herda, 2007) [35].

10. Karanjin

Derris indica (Lam.) Bennet, also known as *Pongamia pinnata* (L.) Pierre, is the source of karanjin. In a variety of crops, karanjin is an effective insect and mite repellent against many distinct genera. Many insects avoid treated crops as a result of the powerful antifeedant or repellent effects of Karanjin. It blocks the actions of ecdysteroids, which has the effect of controlling insect growth and acting as an antifeedant. In insects and mites that are sensitive, it inhibits cytochrome P-450. As an insecticide, Karanjin has not found widespread popularity. According to Coping and Duke (2007) [9], there is no indication of allergic reactions or other negative side effects, and it is not anticipated that products based on karanjin will have any negative effects on non-target creatures or the environment.

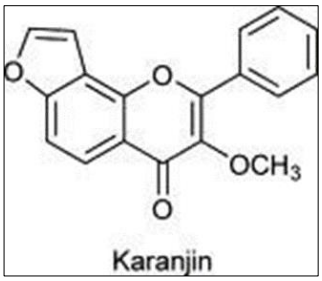

Fig 1

11. Flower source for bees

Pongamia pinnata L., a perennial flowering plant in the Fabaceae family, was grown as an avenue tree for aesthetic purposes. 21 species of pollinators from the hymenoptera, diptera, thysanoptera, and lepidoptera orders, including aves, were attracted to pongamia flowers. According to Shankar *et al.*, 2017 [46], megachilid bees were the most prevalent and made up more than 55% of the insects visiting Pongamia flowers. *Apidae bees, Apis dorsata, A. mellifera, A. cerana, Xylocopa latipes, Pithites smargdula*, and one species each of Halictidae (*Nomia iridipennis*), vespidae, thripidae, syrphidae, muscidae, danaidae, and Pongamia flowers have the potential to become significant floral sources and act as a reservoir for pollinators during the scorching summer.

12. *Pongamia pinnata* as a biofuel

Due to their high oil content, mature pongamia seeds have recently attracted significant commercial interest. Pongamia seed oils are rich in oleic acid, which may give biodiesel products more desirable fuel properties. This alternative source of fuel and energy is being investigated (Ravikanth *et al.*, 2009) [41]. Crop plants that produce oil are crucial to the expansion of the agricultural and energy industries. According to Sharma *et al.* (2005) [43] and Sharmin *et al.* (2006) [48], a major source of biodiesel is oil seeds that contain polyunsaturated fatty acids. In terms of physicochemical characteristics and biodegradability, these organic seed oils outperform diesel fuels (Scott *et al.*, 2008a) [45]. It is crucial to have a high oil yielding genotype of *Pongamia pinnata* in order to boost biodiesel production. The candidate plus tree (CPT) is a *Pongamia pinnata* individual tree with superior morphological characteristics to other individuals of the same species, including height, girth, number of leaves per unit weight, number of buds per inflorescence, number of flowers per inflorescence, and number of seeds per inflorescence (Kesari *et al.*, 2008) [19].

According to Raheman and Phadatare (2004) [39], *Pongamia pinnata* has the potential to produce a fuel that is safe for the environment and reduces existing emissions from diesel engines while producing no greenhouse gases. *Pongamia pinnata* seeds contain 30 to 40% oil (Nagaraj and Mukta, 2004) [30], that can be esterified with methanol in the presence of KOH to produce biodiesel (fatty acid methyl esters; FAMEs).

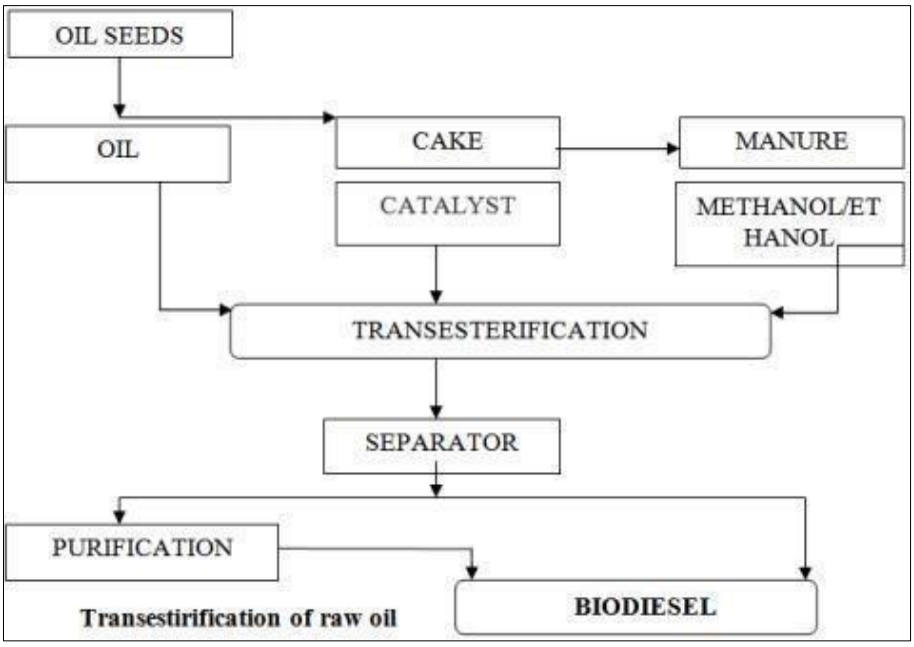

Fig 2: Schematic diagram of Pongamia Biodiesel production

Conclusion

Pongamia pinnata is a resource that can be used in a variety of ways, including as a biofuel, a good source of macro- and micronutrients for crops, a soil binder, etc., and in the medical field for its potential anti-microbial, anti-ulcer, anti-diarrheal, anti-plasmodial, anti-inflammatory, and antiviral properties. Pongamia oil, leaf, and cake were discovered to have good nutritional value as pesticides, acaricides, nematicides, and soil fertility management tools in agriculture.

References

1. Allen ON, Allen EK. The Leguminosae, The University of Wisconsin Press, 1981.
2. Arpiwi NL, Yan G, Barbour EL. Genetic diversity, seed traits and salinity tolerance of *Millettia pinnata* (L.) Panigraphi (syn. *Pongamia pinnata*), a biodiesel tree. in

review. 2011;21:132-141.
3. Borah RK, Dutta D, Hazarika P. Some new records of fungi from Northeast India. Bano Biggyan Potrika. 1998;27:41-13.
4. Bringi NV. Non-Traditional Oilseeds and Oils in India, Oxford and IBH, New Delhi, India, 1987.
5. Burkill JH. Dictionary of economic products of the Malay penimsula. The Ind. J Hosp. Pharm. 1996;15(6):166-168.
6. Caetano-Anolles G, Gresshoff PM. Plant genetic control of nodulation. Annu. Rev. Microbiol. 1991;45:345-382.
7. Chandrasekaran D, Kadirvel R, Viswanathan K. Nutritive value of pungam (*Pongamia glabra* Vent) cake for sheep. Anim. Feed Sci. Technol. 1989;22:321-325.
8. Chaurasia SC, Jain PC. Antibacterial activity of essential oils of four medicinal plants. Ind. J Hosp. Pharm. 1978;15(6):166-168.
9. Copping LG, Duke SO. Pest Mang. Sci. 2007;6:524-553.
10. Daniel JN. *Pongamia pinnata* - a nitrogen fixing tree for oilseed. NFT Highlights, NFTA. 1997;23:97-03.
11. Das DK, Alam MK. Trees of Bangladesh, Forest Research Institute, Chittagong, Bangladesh. 2001;19:256-263.
12. Dutta N, Panda AK, Kamra DN. Use of *Pongamia glabra* (karanj) and *Azadirachta indica* (neem) seed cakes for feeding livestock. In: Makkar, H.P.S, Biofuel co-products as livestock feed - opportunities and challenges, FAO, 2012, 379-402.
13. Ferguson BJ, Indrasumunar A, Hayashi S. Molecular analysis of legume nodule development and autoregulation. J Int. Plant Biol. 2010;52:61-76.
14. Gowda NKS, Ramana JV, Prasad CS, Singh K. Micronutrient content of certain tropical conventional and unconventional feed resources of Southern India. Trop. Anim. Health Prod. 2004;36(1):77-94.
15. Hong TD, Ellis RH. A Protocol to Determine Seed Storage Behaviour, IPGRI Technical Bulletin 1, International Plant Genetic Resources Institute, Rome, Italy, 1996.
16. Khattak A, Ullah F, Wazir SM, Shinwari ZK. Allelopathic potential of *Jatropha curcas* aqueous extracts on seedling growth of Wheat. Pak. J Bot. 2015;47:2449-2454.
17. Kesari V, Rangan L. Development of *Pongamia pinnata* as an alternative biofuel crop-current status and scope of plantations in India. J Crop Sci. Biotech. 2010;13:127-137.
18. Kesari V, Das A, Rangan L. Physico-chemical characterization and antimicrobial activity from seed oil of *Pongamia pinnata*, a potential biofuel crop. Biomass and Bioenergy. 2010;34(1):108-115.
19. Kesari V, Krishnamachari A, Rangan L. Systematic characterization and seed oil analysis in candidate plus trees of biodiesel plant, *Pongamia pinnata*. Annals Appl. Biol. 2008;152:397-404.
20. Kumar M, Singh R. Potential of *Pongamia glabra* vent as an insecticide of plant origin. Biol. Agric. Hort. 2002;20:29-50.
21. Kumar R, Kamra DN, Agarwal N, Chaudhary LC. *In vitro* methanogenesis and fermentation of feeds containing oil seed cakes with rumen liquor of buffalo. Asian-Aust. J Anim. Sci. 2007;20(8):1196-1200.
22. Kumar S. Indigenous communities' knowledge of local ecological services. In: Nathan D, Kelkar G, Walter P (Eds). Globalization and indigenous peoples in Asia: changing the local-global interface, SAGE Publications, India, 2004, 348.
23. Lakshmikanthan V. Tree Borne Oilseeds. Directorate of Nonedible Oils & Soap Industry, Khadi and Village Industries Commission, Mumbai, India, 1978.
24. Maiti SK. Ecorestoration of the coalmine degraded lands. Springer Science and Business Media, 2012, 333.
25. Morton JF. The pongam tree, unfit for Florida landscaping, has multiple practical uses in underdeveloped lands. Proc. Flo. State Hort. Soc. 1990;103:338-343.
26. Mukta N, Sreevali Y. Investigations on an uncommon accession of *Pongamia pinnata* (L.) Pierre. Indian For. 2009;135:293-295.
27. Mukta N, Sreevalli Y. Propagation techniques, evaluation and improvement of the biodiesel plant, *Pongamia pinnata* (L.) Pierre-A review. Ind. Crops Products. 2010;31(1):1-12.
28. Murphy HT, O'Connell DA, Seaton G, Raison RJ, Rodriguez LC, Braid AL, *et al.* A Common View of the Opportunities, Challenges and Research Actions for Pongamia in Australia. Bioenerg. Res. 2012;5(3):778-800.
29. Nagalakshmi D, Dhanalakshmi K, Himabindu D. Replacement of groundnut cake with sunflower and karanj seed cakes on performance, nutrient utilisation, immune response and carcass characteristics in Nellore lambs. Small Rumin. Res. 2011;97(1-3):12-20.
30. Nagaraj G, Mukta N. Seed composition and fatty acid profile of some tree borne oilseeds. J Oilseeds Res. 2004;21:117-220.
31. Odeh I, Tan D, Ancev T. Potential suitability and viability of selected biodiesel crops in Australian marginal agricultural lands under current and future climates. Bio Energy Res. 2011;4:165-179.
32. Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S. Agroforestree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya, 2009.
33. Panda AK, Kumar AA, Singh SD. Growth performance and pathological lesions in broiler chickens fed raw or processed karanj (*Pongamia glabra*) cake as protein supplement. Ind. J Anim. Sci. 2008;78:997-1001.
34. Pandey A. Handbook of Plant-Based Biofuels. CRC, 2008, 255-266.
35. Pavela R, Herda G. Effect of pongam oil on adults of the greenhouse whitefly *trialeurodes vaporariorum* (Homoptera: Trialeurodidae). Entomologia Generalis. 2007;30:193-201.
36. Plummer J, Arpiwi NL, Yan G. *Millettia pinnata* (Pongamia) a biodiesel tree from the tropics. Presentation at the Bioenergy Australia conference, Sydney, 2010.
37. Prasad G, Reshmi MV. A Manual of Medicinal Trees, Propagation Methods. Foundation for Revitalization for

Local Health Tradition, Agrobios India, 2003.
38. Prasad R, Pandey RK. Vegetation damage by frost in natural forests of Madhya Pradesh. J. Trop. For. 1987;3:273-278.
39. Raheman H, Phadatare AG. Diesel engine emissions and performance from blends of karanja methyl ester and diesel. Biomass Bioenergy. 2004;27:393-407.
40. Ravi U, Singh P, Garg AK, Agrawal DK. Performance of lambs fed expeller pressed and solvent extracted karanj (*Pongamia pinnata*) oil cake. Anim. Feed Sci. Technol. 2000;88(1/2):121-128.
41. Ravikanth K, Thakur M, Singh B, Saxena M. TLC based method for standardization of *Pongamia pinnata* (Karanj) Using Karanjin as Marker. Chromatographia, 2009.
42. Sangwan S, Rao DV, Sharma RA. A review on *Pongamia pinnata* (L.) Pierre: A great versatile leguminous plant. Nature Sci. 2010;8(11):130-139.
43. Sharma AK, Konwer D, Bordoloi PK. A comprehensive analysis of fuel properties of biodiesel from Koroch seed oil. Energy Fuels. 2005;19:656-707.
44. Scott PT, Pregelj L, Chen N. *Pongamia pinnata*: an untapped resource for the biofuels industry of the future. Bio Energy Res. 2008;1:2-11.
45. Scott PT, Pregelj L, Chen N, Hadler JS, Djordjevic MA, Gresshoff PM. An untapped resource for the biofuels industry of the future. Bio Energy Res. 2008a;1(1):2-11.
46. Shankar U, Abrol DP, Singh AK. Plants for Bees *Pongamia pinnata* (L.) Pierre. J Palynol. 2017;53:133-137.
47. Sharma YC, Bhaskar S, Korstad J. High yield and conversion of biodiesel from a non-edible feedstock (*Pongamia pinnata*). J Agric. Food Chem. 2010;58:242-247.
48. Sharmin E, Ashraf SM, Ahmad S. Synthesis, characterization, antibacterial and corrosion protective properties of epoxies, epoxy-polyols and epoxypolyurethane coatings from linseed and *Pongamia glabra* seed oils. Int. J Biol. Macromol. 2006;40:407-22.
49. Shivas RG, Alcorn JL. A checklist of plant pathogenic and other microfungi in the rainforests of the wet tropics of northern Queensland. Aust. Plant Path. 1996;25:158173.
50. Sreedevi TK, Wani SP, Osman M, Singh SN. Participatory research and development to evaluate Pongamia seed cake as source of plant nutrient in integrated watershed management. J Sat Agric. Res, 2009, 7.
51. Ullah F, Ullah A, Wazir SM, Shinwari ZK. Phytotoxic effects of safflower yellow exposure on seed germination and early seedling growth of canola (*Brassica napus* L). Pak. J Bot. 2014;46:1741-1746.
52. Venkatesh A, Vanangamudi M, Vanangamudi K. Effect of seedling grade on growth and survival of pungam (*Pongamia pinnata*). J Trop. For. Sci. 2003;15:231-233.
53. Vinay BJ, Kanya TCS. Effect of detoxification on the functional and nutritional quality of proteins of karanja seed meal. Food Chem. 2008;106:77-84.
54. Warrier PK, Nambiar VPK, Ramakutty C. Indian Medicinal Plants, Orient Longman, Madras, India, 1995.
55. Wilkinson CS, Fuskhah E, Indrasumunar A. Growth, nodulation and nitrogen gain of *Pongamia pinnata* and *Glycine max* in response to salinity. Bio Energy Res, In press 2011.