

Pongamia Pinnata Plant Used For Biodiesel Production

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ABSTRACT

Pongamia pinnata is a multi-purpose tree commonly used in agriculture industry and traditional medicine. The evergreen foliage and high oil content of its seeds (30-40%) make it perfect for producing biodiesel, thus contributing to the advancement of renewable energy. It is highly appreciated for its ability to enhance the fertility of soil function as a windbreak and offer shade in agroforestry due to its nitrogen-fixing properties.

Introduction

Pongamia pinnata, known as Indian beech, is a versatile plant native to the Indian subcontinent, Southeast Asia, Australia, and parts of Africa. This tree has many applications and potential advantages.

Botanical Information

Sr#	Classification	
1	Scientific Name	<i>Pongamia pinnata</i>
2	Family	Fabaceae (Leguminosae)
3	Genus	Pongamia
4	Species	Pinnata

Pongamia pinnata plant part used for diesel production

Biodiesel is often made from seeds. The oil extracted from *Pongamia pinnata* seeds is valuable for biodiesel production. The key component for biodiesel production from *Pongamia pinnata* is its seeds.

Pongamia pinnata plant constituent

Pongamia pinnata contains various constituents, including phytochemicals and compounds

Sr. No	<i>Pongamia pinnata</i> plant constituent	
1	Oil	Biodiesel production: Oil is rich in triglycerides and fatty acids
2	Proteins	Seeds are a protein source in animal feed and a byproduct post oil extraction
3	Alkaloids	Karanjin & pongamol. These alkaloids are insecticidal and pesticidal
4	Flavonoids	Secondary metabolites potentially with antioxidant and medicinal properties
5	Phenolic Compounds	Phenolic acids and polyphenols can be found in various plant parts and may boost antioxidant properties
6	Carbohydrates	The plant's seeds and other parts have carbohydrates like starch and sugars
7	Tannins	Astringent properties
8	Minerals and Vitamins	Some parts of <i>Pongamia pinnata</i> may have minerals and vitamins
9	Terpenoids and Steroids	Organic compounds with diverse bioactivities
10	Saponins	Saponins are glycosides with foaming and detergent properties

Appearance of *Pongamia pinnata*

Pongamia pinnata is a tree that grows to 15-25 meters. The compound leaves have a paired arrangement of 6 to 9 leaflets. The tree has small, scented flowers that attract pollinators. Fruits have flat pods in a hard shell with seeds.

Ecological Significance

Pongamia pinnata enhances soil fertility through nitrogen fixation, aided by symbiotic bacteria. Provides nourishment for animals and supports diverse life forms.

Traditional and Medicinal Uses

The traditional use of various parts of the *Pongamia pinnata* tree for healing benefits has been widely practiced in medicine. The seeds, leaves, and oil have been used for treating illnesses.

Biodiesel Production

The *Pongamia pinnata* seeds have oil that can make biodiesel, a renewable energy option. The seed oil is rich in triglycerides and can be made into biodiesel via transesterification.

Agroforestry and Soil Improvement

Pongamia pinnata is often used in agroforestry to improve soil fertility, provide wind protection, and offer shade for nearby crops. The nearby plants derive advantage from the nitrogen-fixing abilities of this organism.

Environmental Benefits

Pongamia pinnata is an environmentally conscious tree that effectively captures carbon and produces biodiesel, thereby reducing the amount of greenhouse gas emissions.

Cultural Significance

Pongamia pinnata holds great cultural and religious importance in India.

Challenges and Concerns

Although *Pongamia pinnata* holds promise for both the environment and economy, there are challenges to overcome in utilizing it for biodiesel production. The obstacles consist of enhancing both the quality of seeds and the methods used for processing them.



Pongamia pinnata plant is capable of generating oil that can be used as biodiesel

Pongamia pinnata is a species with a high content of oil commonly utilized for the production of biodiesel. The process of transesterification allows the conversion of the oil's fatty acids and triglycerides into biodiesel. *Pongamia pinnata* oil biodiesel presents a viable and environmentally conscious substitute for conventional diesel, providing a renewable energy source. This particular crop does not pose a risk to the competition in food production. *Pongamia pinnata* is a versatile plant that can be grown in different soil types and climates, making it a great option for biodiesel production. Utilizing *Pongamia pinnata* for biodiesel is a proactive measure aimed at promoting sustainable energy, mitigating greenhouse gas emissions, and decreasing dependence on traditional fossil fuels. The economic and efficiency of biodiesel production from *Pongamia pinnata* can be influenced by factors like seed quality and the chosen production approach [1].

Explanation of biodiesel production

The process of biodiesel production includes transforming organic oils/fats to create an eco-friendly alternative to diesel fuel. *Pongamia pinnata* oil is utilized in the production of biodiesel.

Feedstock Selection

To produce *Pongamia pinnata* biodiesel, the process involves obtaining seeds from the *Pongamia pinnata* tree. The seeds possess oil that is employed as a primary ingredient.

Seed Pre-Treatment

To effectively remove impurities such as dust and dirt, it is essential to clean and thoroughly dry the *Pongamia pinnata* seeds.

Oil Extraction

Oil is made from seeds. This can be accomplished using methods such as compression or solvent extraction. One method of obtaining oil from seeds is through mechanical pressing, where pressure is applied to the seeds. The other approach, solvent extraction, involves the use of chemicals to extract oil from the seeds.

Oil Refining

The oil extracted from the seeds may contain impurities and needs to be purified. To improve the quality of the oil, processes like degumming, neutralization, and bleaching are typically employed to remove impurities.

Transesterification

The method of transesterification is employed to transform refined oil into biodiesel. In this process, the triglycerides in the oil react with either methanol or ethanol, commonly known as alcohol, and a catalyst like sodium hydroxide or potassium hydroxide. This process involves breaking down triglycerides into glycerol and methyl (or ethyl) esters, which then combine to create biodiesel fuel.

Separation and Washing

After transesterification, the resulting biodiesel and glycerol form distinct layers. The two parts are separated and the water is employed to purify the biodiesel by removing any remaining impurities or catalyst residue.

Drying

To guarantee the high quality and stability of biodiesel, it undergoes a drying process after being washed, effectively eliminating any remaining water that can potentially affect its overall performance.

Biodiesel Quality Testing

The end biodiesel product undergoes testing to ensure it complies with the required specifications and standards. Tests might involve examining characteristics such as cetane number, cloud point, flash point, and viscosity.

Storage and Distribution

The biodiesel is subsequently stored in suitable containers and can be distributed for utilization in diesel engines [2].

Methods for oil extraction from *Pongamia pinnata* seeds

Mechanical Pressing

Mechanical pressing is a widely used and straightforward technique for extracting oil from *Pongamia pinnata* seeds. The seeds undergo an initial process of cleansing and drying to eliminate impurities and eliminate any moisture. Afterwards, the seeds that have been dehydrated are either crushed or finely ground to create a thick paste. The oil is extracted from this paste by applying mechanical force. Hydraulic presses or screw presses can be used to exert pressure. The oil is extracted from the seeds that have been crushed and can be gathered.

Solvent Extraction

Another method to extract oil from *Pongamia pinnata* seeds is solvent extraction. The seeds are crushed into a powder or meal after cleaning and drying. Next, crushed seeds are mixed with hexane. Using a solvent helps break down seed oil. Seeds and a solvent undergo extraction and separation methods. The seed meal is isolated from the oil and solvent mixture. The oil remains after evaporation of the solvent.

Combination Method

To improve oil production, both mechanical pressing and solvent extraction methods can be used. Seeds are mechanically squeezed to extract maximum oil. The leftover seed cake, rich in oil, can be further processed to extract more oil using solvent extraction. After oil extraction, it can be improved through refining methods like degumming, neutralization, and bleaching described in biodiesel production. The oil can be used for biodiesel, food, or industry.

***Pongamia pinnata* plant toxic for human**

Pongamia pinnata seeds, although they possess beneficial oil and diverse substances, can be harmful to humans if consumed in large amounts or if not adequately processed.

Alkaloids: *Pongamia pinnata* seeds consist of various alkaloids, such as karanjin and pongamol. The presence of these alkaloids has been known to possess insecticidal and pesticidal attributes, rendering them harmful to insects. However, if humans consume them, particularly in excessive quantities, they can pose a risk and lead to poisoning symptoms.

Saponins: Saponins are a distinct class of substances present within the seeds. Saponins possess detergent-like characteristics and can be harmful when consumed in excessive amounts. They have the potential to disrupt the functioning of the digestive system.

Tannins: Tannins, which are astringent substances, can be found in the seeds of *Pongamia pinnata*. Although tannins are not extremely toxic, consuming too much can cause digestive discomfort.

Medicinal use of *pongamia pinnata* plant

Various plant parts, such as leaves, seeds, bark, and roots, have diverse medicinal uses

Sr.No	Medicinal properties	
1	Anti-Infective	Antimicrobial properties
2	Skin Conditions	Oil treatment for skin conditions like eczema and psoriasis
3	Anti-Inflammatory	Potential anti-inflammatory effects [4].
4	Digestive Ailments	Treat digestive issues, including indigestion and diarrhea
5	Rheumatism and Arthritis	Managing rheumatic and arthritic conditions with anti-inflammatory properties
6	Respiratory Ailments	Used for respiratory conditions such as asthma and bronchitis
7	Wound Healing	Uses leaves and oil for wounds and skin ailments. Oil's antimicrobial properties
8	Pain Relief	Analgesic properties
9	Anti-Fungal	Extracts may have anti-fungal properties
10	Antiseptic	Oil has antiseptic properties, cleaning and disinfecting wounds

Formulation of biodiesel

The amount of biodiesel from *Pongamia pinnata* seeds depends on factors like oil content, extraction process, transesterification efficiency, and production conditions. The oil content of *Pongamia pinnata* seeds is typically 30-40% by weight. This oil can be converted to the same amount of biodiesel. To calculate biodiesel production from *Pongamia pinnata* seeds, simplify the process. Find the weight of *Pongamia pinnata* seeds for biodiesel production. Determine oil quantity in seeds, typically 30-40% of total weight. To calculate oil volume in liters, 1 kg ≈ 0.88 to 92 L of biodiesel varies with specific gravity.

Example, if you have 1,000 kg (1 metric ton) of *Pongamia pinnata* seeds with 35% oil content:

$$1,000 \text{ kg} \times 0.35 \text{ (oil content)} = 350 \text{ kg of oil}$$

$$350 \text{ kg} \times 0.88 \text{ (conversion factor to liters)} = 308 \text{ liters of biodiesel}$$

The potential biodiesel production from 1 metric ton of *Pongamia pinnata* seeds with 35% oil content is estimated to be around 308 liters. Nevertheless, it is crucial to acknowledge that the actual yields may differ due to the effectiveness of oil extraction and biodiesel production processes, seed quality, and the specific conversion technique employed. These figures are approximate calculations and can differ in reality.

Cleaning of biodiesel

The process of purifying biodiesel, commonly referred to as biodiesel washing, is a crucial stage in the production of biodiesel. This process effectively eliminates impurities, remaining catalyst, soaps, and any excess amounts of methanol or ethanol found in biodiesel.

Procedure

Collect Biodiesel: Start with the fresh biodiesel, which has recently finished the process of transesterification. Currently, the biodiesel is contaminated and requires a purification process.

Prepare Wash Water: Get ready some fresh water in a different vessel. Usually, the volume of water needed for washing is approximately 20-30% of the biodiesel's volume. Make sure the water is heated to the same temperature as the biodiesel.

Mix Water and Biodiesel: Move the biodiesel into a wash tank or another suitable container. Mix the water and biodiesel together carefully and gradually by using agitation or appropriate mixing machinery. The objective is to achieve a comprehensive blend without causing a mixture of water and biodiesel, which can be difficult.

Settle: Let the mixture rest for a prolonged duration, usually spanning several hours or even until the following day. In this period, the impurities, leftover catalyst, soaps, and excess methanol or ethanol will segregate and accumulate at the lower part of the receptacle.

Decant or Drain: After the biodiesel has settled, cautiously remove or separate the upper layer while leaving the impurities and water that have settled behind. It might be necessary to repeat this process in order to maximize the removal of impurities.

Repeat the Washing: If needed, the washing procedure can be performed again several times to enhance the purification of the biodiesel.

Dry Biodiesel: Following the last cleaning process, there could still be a presence of water in the biodiesel. The process of eliminating the water from the biodiesel involves heating and drying it. One may utilize a heat source or a specifically designed dryer for this intention.

Quality Control: Ultimately, it is crucial to assess the quality of the biodiesel after it has been cleaned and dried. This assessment needs to cover important characteristics like acidity, moisture content, and other relevant properties to ensure that the biodiesel meets the specified requirements and established standards [3].

Conclusion

The seeds of the *Pongamia pinnata* plant are a valuable source of biodiesel due to their high oil content. This aids in bolstering the renewable energy sector and reducing our reliance on fossil fuels.

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