

Property Evaluation of Garcinia Gummigutta as a Biodiesel

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Abstract - Energy production is heavily dependent on fossil fuels that is not only diminishing, but also are considered the main cause of harmful emissions and global warming. Therefore using vegetable oils such as *Jatropha*, palm, algae and waste cooking oils as alternative fuels in diesel engines has drawn a great attention. Biodiesel from *Pongamia*, *Simarouba*, *Calophyllum*, palm, algae and waste cooking oils has been already produced using transesterification process. Biodiesel from different feedstock is compared with conventional diesel fuel and its physical and chemical properties are measured according to ASTM standards. A newly found *Garcinia gummigutta* seed available mainly in Western Ghats regions are used to produce biodiesel through transesterification process. Properties were investigated according to ASTM standards and compared with conventional diesel and other different types of biodiesel.

Key Words: Transesterification, *Garcinia gummigutta*, *Pongamia*, *Simarouba*, *Calophyllum*, ASTM standards.

1. INTRODUCTION

Energy is one of the most important resources for mankind and its sustainable development. Today, the energy crisis becomes one of the global issues confronting us. Fuels are of great importance because they can be burned to produce significant amounts of energy. Many aspects of everyday life rely on fuels, in particular the transport of goods and people. Main energy resources come from fossil fuels such as petrol oil, coal and natural gas. Vegetable oils cannot be directly used in the diesel engine for its high viscosity, high density, high flash point and lower calorific value. So it needs to be converted into biodiesel to make it consistent with fuel properties of diesel.

Biodiesel is an alternative diesel fuel made from vegetable oil and animal fats. It can act both as substitute and an additive to diesel fuel. Importance of biodiesel increases due to

1. Increasing petroleum prices,
2. Limited fossil fuel reserves, and

3. Environmental benefits of biodiesel.

1.1 ABOUT GARCINIA GUMMIGUTTA

Botanical name is *Garcinia gummi-gutta* Linn Rox. It is a tropical species of *Garcinia* native to Indonesia. Common names include *Garcinia cambogia* (it is former scientific name) as well as brindle berry, Malabartamarid and kudampulli (pot tamarind). The fruit looks like a small pumpkin and is green to pale yellow in colour. *Garcinia gummi-gutta* is usually grown for its fruit in Southeast Asia, coastal Karnataka/Kerala, India, and west and central Africa. It commonly grows in most moist forests. *Garcinia gummi-gutta* is one of several closely related *Garcinia* species from the plant family Clusiaceae. With thin skin and deep vertical lobes, the fruit of *G. gummi-gutta* and related species range from about the size of an orange to that of a grapefruit; *G. gummi-gutta* looks more like a small yellowish, greenish, or sometimes reddish pumpkin. The colour can vary considerably. When the rinds are dried and cured in preparation for storage and extraction, they are dark brown or black in colour.

Along the west coast of South India, *G. gummi-gutta* is popularly termed as "Malabar tamarind", and shares culinary uses with the tamarind (*Tamarindus indica*). The latter is a small and the former a quite large evergreen tree. *G. gummi-gutta* is also called goraka or, in some areas, simply kattcha puli (souring fruit). It is called uppage in Kannada language and seeds are collected from dealers in Sirsi, Karnataka.



Fig -1: *Garcinia gummi-gutta* tree


Fig -2: Garcinia gummi-guttarripe fruit

Fig -3: Garcinia gummi-gatta seeds.

1.2.1 Botanical description and Environmental preference

Garcinia trees, amongst the many species, which can yield oil as a source of energy in the form of bio-fuel, "Garcinia gummigutta" (Sour Garcinia) has been found to be one of the most suitable species in the evergreen forests of Western Ghats, i.e. from Konkan south to Travancore had being grown. It is tolerant to water logging, saline and alkaline soils. It is grown in high rainfall region. The tree usually grows in forest regions and it is a preferred species for controlling soil erosion and binding soil to roots because of its dense network of lateral roots. Its root, bark, leaves, and flower also has medicinal properties and traditionally used as medicinal plants. The seeds are largely exploited for extraction oil. But so far there is no systematic organized collection of seeds. The yield of oil is reported to be about 35 to 40% if mechanical expellers are used. The crude oil which is obtained from these seed is usually brown to creamy in colour. It has a bitter taste and disagreeable odour. It consist hydroxycitric acid up to 50 to 60%, a toxic appetite suppressant found in rind. It can grow up to an altitude of 6000 ft from sea level. It usually flowers in November-February, and fruits ripen in April-May.

Garcinia gummigutta (Garcinia tree) is an evergreen, small or medium-sized dioeciously, understory tree and grows up to 5 to 20 m tall, with a rounded crown and horizontal

or drooping branches. The bark is dark and smooth. Leaves are with opposite etiolate, dark green shining in colour are present. Flowers are in clusters of 4 to 20 are usually present and they are in red colour, but some trees have yellow ones also. Petals are normally 4 in number and about 12 mm wide, 11 mm long, anthers attached to a pistil lode with a non-functional stigma. Female flowers occur singly or in clusters of up to 4. The stigmatic surface is normally enlarged, and there is no style. Neither male nor female flowers produce nectar. Fruit are green, ovoid berry, 5 cm in diameter, yellow or red when ripe, with 6 to 8 grooves. Seed are 6 to 8 in number in single fruit, smooth, large, about 5 cm long and 2 cm wide surrounded by a succulent aril.

1.3. ABOUT PONGAMIA PINNATA

Pongamia pinnata is a genus of legume in the Fabaceae family. Recently it has been proposed that the genus Pongamia be rejected in favor of the genus Millettia, and many species have been reclassified. Due to recent interest in biofuels, pongamia is often the generic name given for Millettia pinnata, a tree being explored for producing biodiesel. Among the sources of non-edible oils, Pongamia pinnata is found almost all part of India mainly in the Western Ghats of India and it grows on any types of soil ranging from clayey to sandy. Pongamia pinnata is a native to many countries including India, Malaysia, Indonesia, Taiwan, Bangladesh, Sri Lanka and Myanmar. The Pongamia pinnata kernel contains about 30 - 40% of oil and hence, it is considered as a potential source for the biodiesel production.

1.4. ABOUT WASTE COOKING OIL (WCO)

Waste cooking oil refers to the used vegetable oil obtained from cooking food. Repeated frying for preparation of food makes the edible vegetable oil no longer suitable for consumption due to high free fatty acid (FFA) content. Waste oil has many disposal problems like water and soil pollution, human health concern and disturbance to the aquatic ecosystem, so rather than disposing it and harming the environment, it can be used as an effective and cost efficient feedstock for Biodiesel production as it is readily available. WCO collected can also be used to prepare soaps and additive for lubricating oil. Many researchers have successfully converted used cooking oil into biodiesel.

1.5. ABOUT Calophyllum inophyllum

Calophyllum inophyllum is a large evergreen plant, commonly called tamanu, mastwood, beach calophyllum, or beautyleaf. It is native to tropical Asia. Due to its

importance as a source of timber for the traditional shipbuilding of large outrigger ships, it has been spread in prehistoric times by the migrations of the Austronesia peoples to the islands of Oceania and Madagascar, along with other members of the genus Calophyllum. It has since been naturalized in regions in the East African coast. It is also a source of the culturally important tamanu oil.

1.6. ABOUT SEMAROUBA

Simarouba glauca is grown widely across South America, Central America, and India. The most economically important part of the plant is the seed oil. The Simarouba seed contain between 55-65% oil content. The oil has many industrial uses, including its ability to be turned in to fat or margarine. The fruits have a semi-sweet pulp that is suitable for eating or use in the beverage industry. The leaf litter and seed cake are good sources of manure. Lastly, the bark and leaves have been known to have medicinal qualities and have at least one patent has been applied for using Simarouba glauca. It is popular because all the parts of the tree can be used in different processes

2. GARCINIA OIL EXTRACTION GARCINIA OIL EXTRACTION

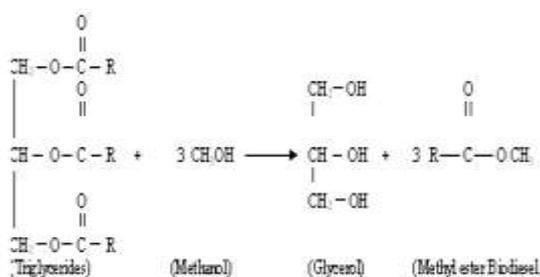
2.1 Extraction of oil by expeller method

Sour Garcinia oil is extracted from the Sour Garcinia seeds through a mechanical expeller process. By this process 35% of oil could be extracted from one kg of Sour Garcinia seeds from this process.

2.1.1 Transesterification

Transesterification is also known as alcoholysis. It is the reaction of fat or oil with an alcohol to form esters and glycerin. The chemical reaction involved in this process is shown below.

2.1.2. Determination of free fatty acid in the oil



The standard titration method is used to calculate the FFA

present in the oil. NaOH(0.1N) prepared using distilled water and NaOH pellets are taken in a burette. Calculated quantity of Garcinia oil and isopropyl alcohol is added in a clean and dry 250 ml conical flask. Few drops of NaOH(0.1N) is added and shaken well and the mixture is heated to about 60°C. Few drops of phenolphthalein indicator is added to this mixture. The titration process is carried out by drop by drop addition of NaOH(0.1N) from the burette into the mixture in the conical flask, mixing vigorously until a pink faint colour is obtained. The titration is stopped and the burette reading is noted down to calculate FFA as below.

Titration value = 7.9 ml.

$$\text{FFA} = \frac{28.2 \times (\text{Normality of NaOH}) \times (\text{Titration Value})}{\text{Weight of oil}} + 3.5$$

$$\text{FFA} = 28.5 \times 0.1 \times 7.9 / 10 = 5.9\%$$

2.2. Stages of Transesterification process



Fig -4: Experimental Trans-esterification setup

2.2.1. Strong acid catalyzed transesterification

Step 1: In first stage the raw oil is reacted with methanol in presence of 1.5ml H₂SO₄ acid in order to neutralize the PH value of sour garcinia oil. The first stage removes organic matter and other impurities present in the oil in the presence of H₂SO₄ acid, used as reagent sour garcinia oil containing the impurities in considerable quantity and causes the transesterification difficulty. Hence, this necessitated the use of first stage. This is a type of reaction that takes place in the presence of methanol and H₂SO₄ acid, helps in the separation of impurities which were dissolved in the methanol as an upper layer and oil in the lower layer.

Step 2: In second stage the sour garcinia oil is allowed to react with methanol in presence of H_2SO_4 again in order to remove free fatty acid from sour garcinia oil. In this stage 1 liter of sour garcinia oil is taken into strong acid and 150ml of methanol and calculated quantity of concentrated H_2SO_4 around 1.15ml is added to the oil in the flask. And whole set up is kept ready. Then the mixture is kept agitated and heated in the reaction vessel (3-neck flask) at $60^\circ C$ for 1hr30min. A dark layer was observed at the top layer of the oil. The mixture is then transferred to conical shaped separating funnel and allowed to settle at least 2 to 3 hours. The black acid layer rises up and the bottom acid transesterified oil is drained back into the 3-neck flask to separate the glycerol.



Fig-6: Separation of Glycerin

2.1.2. Base catalyzed transesterification



Fig-4: Separation of free fatty acid

In third stage transesterification process is done to reduce the complex chain into simple long chain of ester. In this stage the oil collected in the 3-neck flask from the previous stage is once again tested for FFA using the same titration method explained earlier and the FFA is calculated to be 3%. On the basis of existing FFA 6.5 gm of NaOH is added to 150 ml of methanol in the separate beaker and mixed to prepare Methoxide mixture and the same is added to the oil present in the 3-neck flask. This mixture of oil and methoxide is agitated and heated at $60^\circ C$ for 1hr30min. At the end of the process 2 distinct layers are obtained. The mixture is then transferred to conical shaped separating funnel and allowed to settle at least 2 to 3 hours as shown in the figure 5. Glycerine settles at the bottom and the biodiesel is separated at the top. Glycerine is drained out from bottom and the biodiesel is taken for water wash.

Table 1: The brief description of three stages

Parameter	1st stage	2nd stage	3rd stage
Methanol	150 ml	150 ml	150 ml
H_2SO_4	1.5ml	1.15ml	-
NaOH	-	-	3.6gms
Reaction time	1hr30min	1hr30min	2hr
Settling time	3hr	3hr	4hr
Reaction temperature	$60^\circ C$	$60^\circ C$	$60^\circ C$

2.1.5. Water wash

Water washing is done to remove any moisture and emulsion. To do this, water of about 30% by volume of the ester is added and heated the mixture to $120^\circ C$ for 1 hour to make the ester free from moisture. After heating, the mixture is once again transferred to the separating funnel where in again the water with any emulsion formed settled at the bottom. The upper layer is pure methyl ester i.e., bio-diesel, ready for the use in diesel engine.



Fig-7: Washing with hot water



Fig-8: Sour Garcinia bio diesel

3. TESTING THE PROPERTIES OF FUELS

3.1. Kinematic Viscosity

Viscosity is an important physical property of a diesel fuel. Improper viscosity leads to poor combustion, which results in loss of power and excessive exhaust smoke. Diesel fuels with extremely low viscosities may not provide sufficient lubrication for the closely fit pumps and Injector plungers. They can promote wear and cause injector and injector pump leakage and dribbling leading to loss of power as fuel delivered by the injector is reduced. Diesel fuel with higher viscosity is also not desirable as too viscous fuel increases pumping losses in injector pump and injectors, which reduces injection pressure resulting in poor atomization and ultimately affecting the combustion process.

Kinematic Viscosity = time in second's x constant of calibration
 $v = t \cdot c$



Fig-9: Viscometer

3.2. Flash Point and Fire Point

Flash point of a fuel is defined as the temperature at which it will ignite when exposed to a flame or spark. The flashpoint of bio-diesel is higher than the petroleum based diesel fuel. Flashpoint of bio-diesel blends is dependent on the flashpoint of the base diesel fuel used, and increase with percentage of bio-diesel in the blend. Thus in storage, biodiesel and its blends are safer than conventional diesel. The flashpoint of biodiesel is around 160, but it can reduce drastically if the alcohol used in manufacture of bio-diesel is not removed properly. Residual alcohol in the bio-diesel reduces its flashpoint drastically and is harmful to fuel pump, seals, elastomers etc. It also reduces the combustion quality.



Fig-10: Pensky Martin Apparatus

3.3. Calorific Value

Calorific value of a substance is the amount of heat released during the burning of specified amount of substance. It is generally determined by the use of bomb calorimeter. Pure biodiesel and their blends in MJ/Kg The bomb calorimeter reading gives the various fuel and blends we observed that, diesel fuel has higher calorific value about 43.98 MJ/Kg and calorific values of the fuel decreases when we use higher blending of biodiesel. This shows that biodiesel has lower energy density than diesel fuel, so more quantity of biodiesel is required for generating the same amount of energy as compared to diesel fuel.



Fig 11: Bomb Calorimeter

3.4. Density

The density of a material or liquid is defined as its mass per unit volume. Many researchers prefer the dimensionless term specific gravity, which is defined as the ratio of the density of a substance to the density of a reference substance (usually water). Biodiesel fuels are, in general, characterized by higher density than conventional petroleum diesel, which means that volumetrically-operating fuel pumps will inject greater

mass of biodiesel than conventional diesel fuel. This in turn will affect the air—fuel ratio hence the local gas temperatures, as long as the engine retains its diesel-fuel calibration.



Fig-12: Hydrometer

Table 2: ASTM Standard for bio diesel

Property	Units	ASTM Standard	GG Biodiesel
Kinematic Viscosity	CSt	1.9 - 6.0	4.25
Flash Point and Fire Point	°C	Min 130	161
Calorific Value	MJ/kg	-	41.87
Density	kg/m ³	880	860

Table 3: Fuel Property Comparison

Property	Kinematic Viscosity	Flash Point and Fire Point	Calorific Value	Density
Diesel	2.83CSt	76°C & 84°C	45.8 MJ/kg	850 kg/m ³
GG Biodiesel	4.3CSt	181°C & 192°C	41.87 MJ/kg	870 kg/m ³
Pongamia	4.2CSt	108°C & 113°C	38.2 MJ/kg	860 kg/m ³
Waste cooking oil	3.7CSt	116°C & 123°C	39.4 MJ/kg	865 kg/m ³
Calophyllum oil	3.9CSt	176°C & 184°C	42.4 MJ/kg	875 kg/m ³
Simarouba oil	4.4CSt	165°C & 181°C	37.6 MJ/kg	886 kg/m ³

4. CONCLUSION

Garcinia gummi-gutta is usually grown for its fruit in Southeast Asia, coastal Karnataka, Kerala, India, and west and central Africa. It commonly grows in most moist forests. The properties such as viscosity, density, flash and fire point and calorific value of extracted oil from the seeds of Garcinia gummigutta are similar to the properties of other vegetable oils which are widely used to produce biodiesel. Hence Garcinia gummigutta commonly known as sour garcinia and it could be considered as promising source for biodiesel.

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