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Elicitation and Characterization of Fatty Acids and Biodiesel Production from the Seeds of Caryota urens

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Abstract

Biodiesel from non-edible plants can compete economically with petroleum diesel fuels as a future prospective fuel. The bio-oil was extracted from the non-edible seed *Caryota urens* by soxhlet extraction using hexane as an organic solvent and then further, the oil was analyzed for moisture content, pH, specific gravity, density, viscosity, saponification value, refractive index, peroxide value, acid number, free fatty acid and iodine value. The results showed that the bio-oil content was 21.57% and characterized by GC-MS which showed Palmitic acid and oleic acid as dominant fatty acids. The bio-oil extracted from the plant seeds was converted into biodiesel using KOH catalyst and the biodiesel yield was calculated as 82%.

Keywords: Bio-Diesel; Base Catalyst; *Caryota urens* Linn; Physicochemical Analysis

Introduction

Recently, World energy demand is expected to increase due to the expanding urbanization, better living standards and increasing population. At a time when society is becoming increasingly aware of the declining reserves of fossil fuels beside the environmental concerns, it has become apparent that bio-diesel is destined to make a substantial contribution to the future energy demands of the domestic and industrial economies [1,2]. Biodiesel is a chemical compound of methyl ester derived from raw or used vegetable oils and animal fats and it is considered as "carbon dioxide neutral" because all of the carbon dioxide released during combustion is sequestered out of the atmosphere during crop growth. Biodiesel is a product of great interest for its environmental characteristics. It is biodegradable, non-toxic, and renewable and does not damage water quality. It has the advantages of dramatically reduced sulfate and hydrocarbon emissions and reduces particulate matter. As a future prospective fuel, biodiesel has to compete economically with petroleum diesel fuels and using less expensive feedstock containing fatty acids such as inedible oils, animal fats, waste food oil and byproducts of the refining vegetables oils is one way of reducing the biodiesel production costs [3]. Two types of renewable energy are promising such as alcohol produced as the product of fermentation using microbial sources and biodiesel from plant oils [4]. Plant derived seed oil play a vital role in the production of bio-diesel. Non-edible vegetable oils which are known as the second-generation feed stocks can be considered as promising substitutions for traditional edible food crops for the production of biodiesel [5,6]. The use of non-edible plant oils is very significant because of the tremendous demand for edible oils as food source. Moreover, edible oils' feedstock costs are far expensive to be used as fuel [7]. Therefore, production of biodiesel from non-edible oils is an effective way to overcome all the associated problems with edible oils [8].

Caryota urens belongs to the family Arecaceae (Palmae). It consists of Twenty-seven species and widely distributed throughout the Asian Countries [9]. *Caryota* species are used for the treatment of rheumatic swellings and snake bite [10]. The bark and seeds were used to treat boils and the root is used for tooth ailments. Palm sap collected from the inflorescence is fermented with mixed inoculum of yeast to obtain toddy. However, no reports have been presented concerning *C. urens* crude oil as potential feedstock for biodiesel [11].

The present is mainly focused on the physicochemical analysis and elicitation of fatty acid present in the seeds of *Caryota urens*. The physical and chemical properties of the bio-oil were analyzed. Biodiesel was produced from the oil of *Caryota urens* using basic catalyst and the produced biodiesel was characterized by GC-MS.

Materials and Methods

Collection of Raw Material and Extraction of Bio-Oil From the Seeds of *Caryota urens*

Fresh *Caryota urens* plant seeds were collected from VIT University, Tamil Nadu, and India. The plant seeds were washed with water and kernels were separated from seeds. The seeds were dried in the Hot-Air Oven for about 3 hours. After drying, kernels were separated from seeds. The separated kernels were finely grounded. The bio-oil was extracted using Soxhlet extractor. The crude bio-oil is extracted with 200mL of hexane as a solvent for about 72 hours at 80°C. Then the extract was concentrated using rotary evaporator at 50°C. Extracts were stored at 20°C until further use.

Characterization of *Caryota* Seed Oil

The percentage (%) yield of the seed oil was calculated gravimetrically. Odour, colour, and physical state of the oil were estimated by sensory evaluation. They were characterized for specific gravity using specific gravity bottle, pH was determined using pH meter, moisture content by the oven dry method, ash content by heating to dryness in furnace, kinematic viscosity using a viscometer, refractive index using Abbe refractometer. Other properties analyzed were the saponification values determined by titrimetry method. Acid value, iodine value, and peroxide value were determined by titrimetry according to FAO.

Gas Chromatography

An Agilent 6890 gas chromatograph was equipped with a straight deactivated 2 mm direct injector liner and a 15m Alltech EC-5 column (250 µ I.D., 0.25µ film thickness). A split injection was used for sample introduction and the split ratio was set to 10:1. The oven temperature program was programmed to start at 35°C, hold for 2 minutes, then ramp at 20°C per minute to 300°C and hold for 5 minutes. The helium carrier gas was set to 2 ml/minute flow rate (constant flow mode).

Mass Spectrometry

A JEOL GCmate II bench top double-focusing magnetic sector mass spectrometer operating in electron ionization (EI) mode with TSS-2000[1] software was used for all analyses. Low-resolution mass spectra were acquired at a resolving power of 1000 (20% height definition) and scanning from m/z 25 to m/z 700 at 0.3 seconds per scan with a 0.2 second inter-scan delay. High resolution mass spectra were acquired at a resolving power of 5000 (20% height definition) and scanning the magnet from m/z 65 to m/z 750 at 1 second per scan. Qualitative analyses were performed on an HR, high resolution mass spectrometer Samples were introduced into the electron ionisation source using a drawn micro capillary at a flow rate of 1 ml/min. The mass spectrometer was operated in positive ion mode with a spray voltage of 2.4 kV, a capillary temperature of 250, a capillary voltage of 29.0 V, a 1.5-u ion isolation window, and a 100-ms maximum inject time. The average Scans of the MS spectra approximately 100 scans were averaged for the MS^2 and MS^3 spectra.

Mass Spectrometry Library Search

Identification of the components of the purified compound was matching their recorded spectra with the data bank mass spectra of NIST library V 11 provided by the instruments software. Based on the GC-MS spectral data, six fatty acids were identified and further the bio-oil will be converted into biodiesel using trans-esterification process. The Bio-oil from *Caryota urens* was converted into biodiesel using NaOH catalyst. The produced biodiesel yield was calculated gravimetrically.

Results and Discussion

The bio-oil content of *Caryota urens* was calculated and was found to be 21.57%. This oil could be used for biodiesel production that would be highly economical. The oils had agreeably oily odour and very dark in colour, which might fade during transesterification. Physical state of the oil was liquid at room temperature. Specific gravity of the oil was 0.86, which is close to the standard range of 0.87-0.90 for biodiesel. Density and other gravities are important parameters for diesel fuel injection systems. The values must be maintained within tolerable limits to allow optimal air to fuel ratios for complete combustion. Moisture content of the oil was in limit to the ASTM Standard. The results of the physical properties are tabulated in (Table 1)

S. No	Physical properties	*Caryota urens*
1	Colour	Light Brown
2	Odour	Agreeably Oily
3	Moisture (%)	3.52
4	Oil Content (%)	21.57
5	Specific Gravity	0.86
6	Physical State at RT	Liquid
7	Density ($g/cm^{3)}$	0.93
8	Viscosity, at 40°C, centistokes	3.5

Table 1: Physical properties of *Caryota urens* seed oil.

The results of the chemical properties are tabulated in (Table 2). The pH value of the oil was neutral. Iodine value is a measure of the unsaturation of fats and oils. High iodine value of the indicated high unsaturated oil content, thus making it to exist in liquid state. The iodine value of bio-oil was within the limits of standard. Saponification value is used in checking adulteration which was found to be lesser than the ASTM standard. The refractive index of oils actually depends on their molecular weight, fatty acid chain length, degree of unsaturation, and degree of conjugation. Triglycerides have higher refractive indices than do their constituent free acids. Values of refractive index for different oils generally vary between 1.447 and 1.482. All these physicochemical properties suggest that the seed oil adoptable for biodiesel production.

S. No	Chemical properties	*Caryota urens*
1	pH	7.27
2	Iodine value (g/100g)	121.02
3	Acid value (mgKOH/g)	5.2
4	Saponification value (mgKOH/g)	107.18
5	Peroxide value (meq/kg)	7.89
6	Refractive index	0.72

Table 2: Chemical properties of *Caryota urens* seed oil.

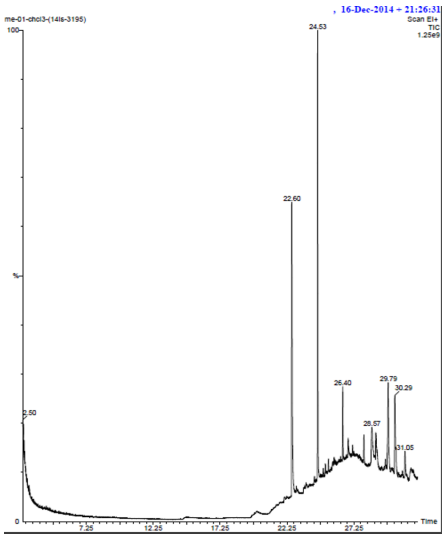

Figure 1: GC-MS Spectra of *Caryota urens* seed oil.

Fatty acid composition of *Caryota urens* seed analyzed by GC-MS was shown in (Table 3). (Figure 1) represents the GC-MS spectra of dominant fatty acids present in the bio-oil. Fatty acid profile shows that the *Caryota urens* seed oil has dominating fatty acids, which easily gets converted into their respective methyl esters during transesterification. It was found that Palmitic acid and oleic acid concentration were high of about 41.24% and 28.48% respectively. It was clear that most of the fatty acids present were saturated fatty acids which can be converted into good biodiesel. This bio-oil was then subjected for transesterification reaction for converting it into biodiesel.

Fatty acid	Percentage composition (%)
Stearic Acid	15.7
Palmitic Acid	41.24
Myristic Acid	8.01
Lauric Acid	0.24
Oleic Acid	28.48
Linoleic acid	0.63
Caprylic acid	4.31

Table 3: Fatty acid profile of *Caryota urens* seed oil.

Since the acid value of the oil was found to 5.20, it was subjected to single stage esterification followed by transesterification. In esterification, the oil was reacted with methanol with 60% of oil weight taken and 1ml of concentrated sulphuric acid. The reaction was carried out for 1hour at 60°C. Post esterification, the oil was transesterified by mixing methanol in a molar ratio of 1:3, with 5% of KOH as catalyst. This reaction was carried out for 2 hours under continuous stirring of 350 RPM at 60°C. After the reaction was completed, the mixture was allowed to settle in the separating funnel, where the biodiesel was collected at top and glycerol at the bottom. This biodiesel obtained from *Caryota urens* linn seed oil, was then washed and subjected for various testing and applications. Maximum yield of biodiesel achieved from this bio-oil was found to be 82%

Conclusion

The following conclusions were made by biodiesel production; (i) The production of biodiesel from the different feedstocks was identified from the literature and optimum blending ratios was also identified; (ii) The physicochemical properties of bio-oil clearly confirmed that the bio-oil from *Caryota urens* can be used for biodiesel production; (iii) Totally seven fatty acids were identified using GC-MS spectral data and these fatty acids were only responsible for biodiesel production; ((v) The percentage yield achieved was 82%; (v) Finally, concluded the produced biodiesel will be used to check their performance and emission characteristics in engine.

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