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Biodiesel Production By Alkaline Transesterification Of Mamey Sapote Oil

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Abstract—* Bio- Diesel can also prepared from fruit seed oil to Diesel Engines .Mamey Sapote seeds are easily available and non-edible to all human being. Since most of the biodiesel were derived from edible oils like soybean, sunflower, rapeseed, palm etc. these oils are essentially edible in India and other developing countries and use in biodiesel leads to food crisis. Because of the non-edible oil having high free fatty acid (FFA) content, which is not suitable for normal transesterification process, hence a two-step catalyzed method was adopted to prepare the biodiesel. In the present investigation Mamey Sapote seed oil was used to extract the biodiesel. Therefore, this research mainly concentrates the non-edible oil as a feed stock for biodiesel production to reduce the cost of bio-diesel. The results showed that this bio-fuel can be produced at a yield of 92.48 % with a 0.760% of catalyst, 6 methanol equivalents in excess with respect to oil, at 60°C, and 90 min of reaction time. Biodiesel from Mamey Sapote seed oil is mainly composed of methyl esters of oleic, stearic and palmitic acids. Hence could be considered as a suitable substitute for fossil diesel in unmodified diesel engine applications.
Key words—* Transesterification, non-edible, biodiesel, and feed stock, acid catalyzed.

I. INTRODUCTION

Fossil fuels play a major role in development of any country in the present scenario. Petroleum derived products are the critical sources of energy for fuelling of automobiles for the entire world. But, these fossil fuels are depleting day by day and they are non renewable. It is also assessed that these sources will be depleted in a certain period of time and it is not possible to meet the future requirements. Hence there is a need for development of renewable energy sources to meet the requirements of future and it has become an essential to explore the reasonable substitution of diesel with alternative fuels within the country on a massive production for commercial usage. Alcohols (methanol/ethanol), Liquefied Petroleum Gas (LPG), compressed natural gas (CNG), Hydrogen, fruit & Vegetable seed oils have been tested for suitability on diesel engines in the past few years. The advantage with vegetable oils is air fuel ratio is high in vegetable oil mixture because of oxygen content in the fuel and it is free from sulphur. The calorific value of these oils is almost 90% of the diesel fuel. Vegetable oils are costly than diesel oils in the present market, the viscosity is also one of the serious drawback associated with vegetable oils and this can be reduced by various methods. Biodiesel helps in saving the environment in many ways. It produces lower emissions and is more energy efficient when compared to other forms of energy. Biodiesel helps in the reduction of greenhouse emissions, biodegradation and pollution. It also helps in reducing the demand for first generation bio fuels which are very likely to cause over reliance on other forms of energy. Biodiesel, a promising renewable substitute source of fuel produced from tree born oils, vegetable based oils, fats of animals and even waste cooking oil has been identified as one of the key solutions for the alarming global twin problems of fossil fuel depletion and environmental degradation [1–4]. The future of sapodilla appears to be promising, given the attention the crop is receiving from growers and consumers in many countries. Indian production of sapodilla continues to grow and there is an active research program in that country with specific goals toward improving storage, transport, and marketing strategies [5]. Cultivation is most extensive in coastal India (Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, Telengana and Bengal States). The seed kernel (50% of the whole seed) contains 1% saponin and 0.08% of a bitter principle, sapotinin. Ingestion of more than six seeds causes abdominal pain and vomiting [6]. The crushed seeds have a diuretic action and are claimed to expel bladder and kidney stones. A fluid extract of the crushed seeds is employed in Yucatan as a sedative and soporific. A paste of the seeds is applied on stings and bites from venomous animals [6]. The present study is based on use of the Mamey Sapote for production of bio-diesel. Biodiesel has gained greater attention because of the advantages such as (i) being renewable and biodegradable, (ii) higher cetane number, (iii) lower emission of carbon monoxide, particulate matters and un-burnt hydrocarbon and (iv) lower sulfur and aromatic content. However, still it is not fully replacing fossil diesel, because of disadvantages such as higher NO_x

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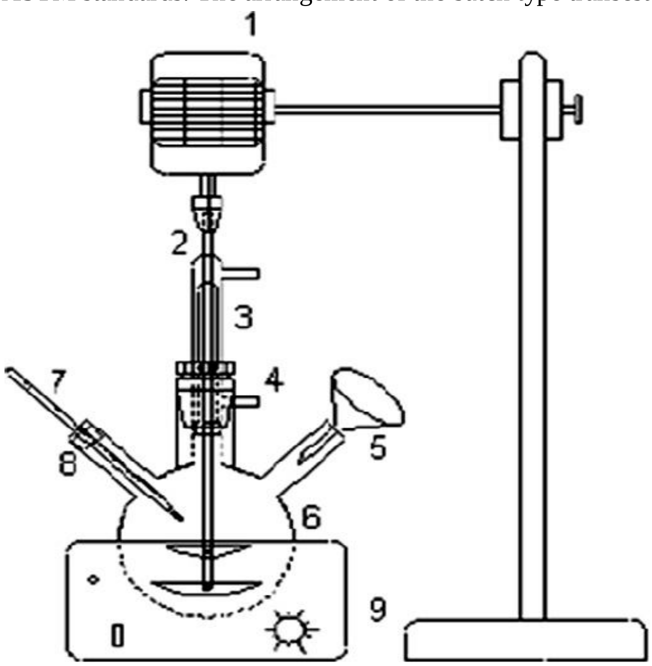
emission, higher viscosity, lower oxidative and storage stability which need to be addressed [7–11].

Mamey Sapote, popularly known as sapodilla, a forest tree with long life span is mostly found in southern Mexico, Caribbean and Central America. It is also cultivated in larger scale in India, Thailand, Cambodia, Malaysia, Indonesia, Bangladesh mainly for its fruit. It is known as chikoo (chiku) in Northern India, and sapota in southern parts of India. It is evergreen tree grows in wide range of climatic conditions and all tropical lands like wet tropics to dry cool subtropical areas. The soils can be slightly alkaline, well dried with medium textured loams. Even though the tree flowers and fruits throughout the year, maximum yield occurs during the period of March to June. The evergreen Mamey Sapote (sapota) is a large tree mainly cultivated for its fruit. Its normal growth can reach up to around 30 m height with the maximum diameter of trunk 1.5 m. The fruits have a rough brownish skin with 1–4 seeds of color brown or black.

The seeds are covered by a juicy sweet brownish flesh which is eaten raw or made into jam and juice. The seeds are not utilized for any major purpose except seedling. Mamey Sapote seeds have an oil content of 25–30% and hence this underutilized oil seed can be considered for biodiesel production. The present study is based on use of the Mamey Sapote seed for production of biodiesel. Bio Diesel helps in saving the environment in many ways. It produces lower emissions and is more energy efficient when compared to other forms of energy. Biodiesel helps in the reduction of greenhouse emissions, biodegradation and pollution. It also helps in reducing the demand for first generation bio fuels which are very likely to cause over reliance on other forms of energy.

II. MATERIALS AND METHODS

Mamey Sapote seeds were collected and pure analytical grade methanol and potassium hydroxide (KOH) in pellet form of were used for the biodiesel production. Only seeds that were not damaged were chosen and stored under cool dry storage conditions until needed .The experimental setup consists of a half liter four-necked batch type spherical glass reactor, with a water-cooled condenser in one of the necks, a speed controlled mechanical stirrer, and a temperature controlled heating mantle and a thermometer. The collected seeds were dried and moisture content is eliminated from the seeds. After that by using Mechanical screw pressing machine raw oil was extracted from the dry seeds. The oil was filtered and dried; the collected oil was approximately 25% of raw seeds. The various properties of oil like density, viscosity, flash point were estimated from the various instruments as per the ASTM standards. The arrangement of the batch type transesterification reactor used in the study is shown in Fig. 1.



Part no	Part name
1	Stirrer motor with chuck and stand
2	Glass rod with Teflon stirrer
3	Condenser
4	Stuffing box
5	Funnel
6	Four neck round bottom flask
7	Thermometer
8	Stopper box
9	Heating mantle

Fig 2.1 Experimental setup for the batch type transesterification process

A. *Transesterification Process*

The non-edible oils having high FFA content, which is not suitable for normal transesterification process. If the FFA content of the oil is less than 2.5%, then one step transesterification process with a base catalyst should be used and if it exceeds 2.5%, two step transesterification process should be the choice. In this study as the FFA content of MSO was 3.26%, single step base catalyst transesterification method has been adopted. In the present analysis the following parameters are chosen for the production of biodiesel.

Table: 2.1 parameters are chosen for the production of biodiesel

Parameter	Levels
Methanol to oil (molar ratio)	6:1
Concentration of catalyst (wt%)	1
Time of reaction (min)	90
Temperature of reaction (ºC)	60

Tab 2.2: Fatty acid composition of mamey sapote seed oil

S.No	Fatty acids	Content
1.	Palmitic acid	13.15
2.	Stearic acid (C18:0)	2.69
3	Oleic acid (C18:1)	64.62
4	Linoleic acid (C18:2)	17.78
5	Linolenic acid (C18:3)	1.76
6	Total saturated	15.87%
7	Total unsaturated	84.13%

Fig 2.2: Mamey Sapote fruit, seeds with Kernal,

Fig 2.3: Mamey Sapote biodiesel

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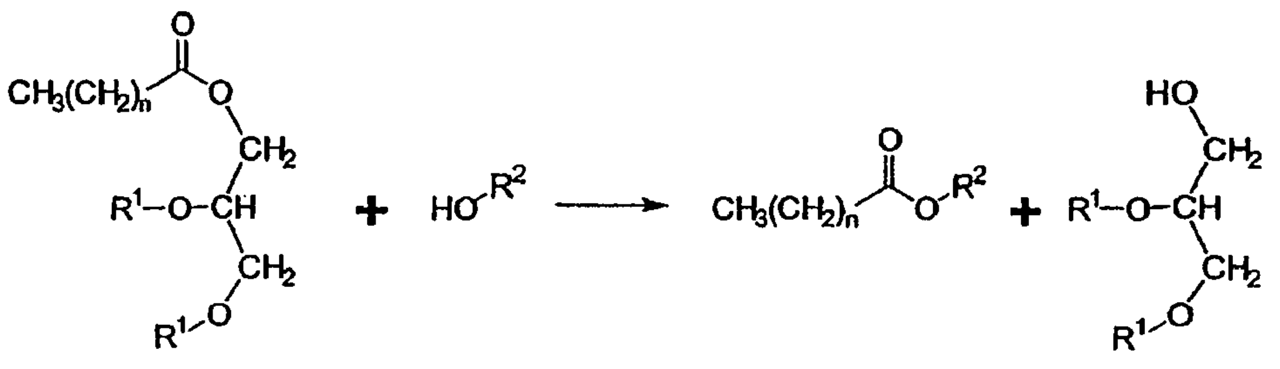
In a batch reactor Mamey Sapota oil of 100 gm was placed and heated it up to 60º C temperature The stirrer speed was maintained at 500 rpm for constant mixing. The methoxide solution was prepared by dissolving the exactly measured quantity of solid catalyst (KOH) in premeasured quantity of methanol. Once the oil reached the up to 60º C temperature, the prepared methoxide was slowly poured into the reactor. The completion of pouring instant was taken as the start of reaction. The condenser was installed on one of the four necks to capture and reuse any vaporized methanol. Upon reaching the predefined time of reaction, the reactor was taken out of the heating mantle and the products of the reaction were shifted to a 500 ml separating conical funnel. After 24 h of settling, the heavy glycerol layer settled at the bottom of the funnel was removed through a drainage valve. The remaining crude biodiesel produced from MSO was gently washed with distilled water at 40 ºC in order to remove the un reacted methanol, catalysts and impurities. The percentage yield of biodiesel has been calculated using the formula

$$\text{Biodiesel yield \% Y} = \frac{\text{grams of methyl ester produced}}{\text{grams of oil used in reaction}} \times 100$$

Transesterification process



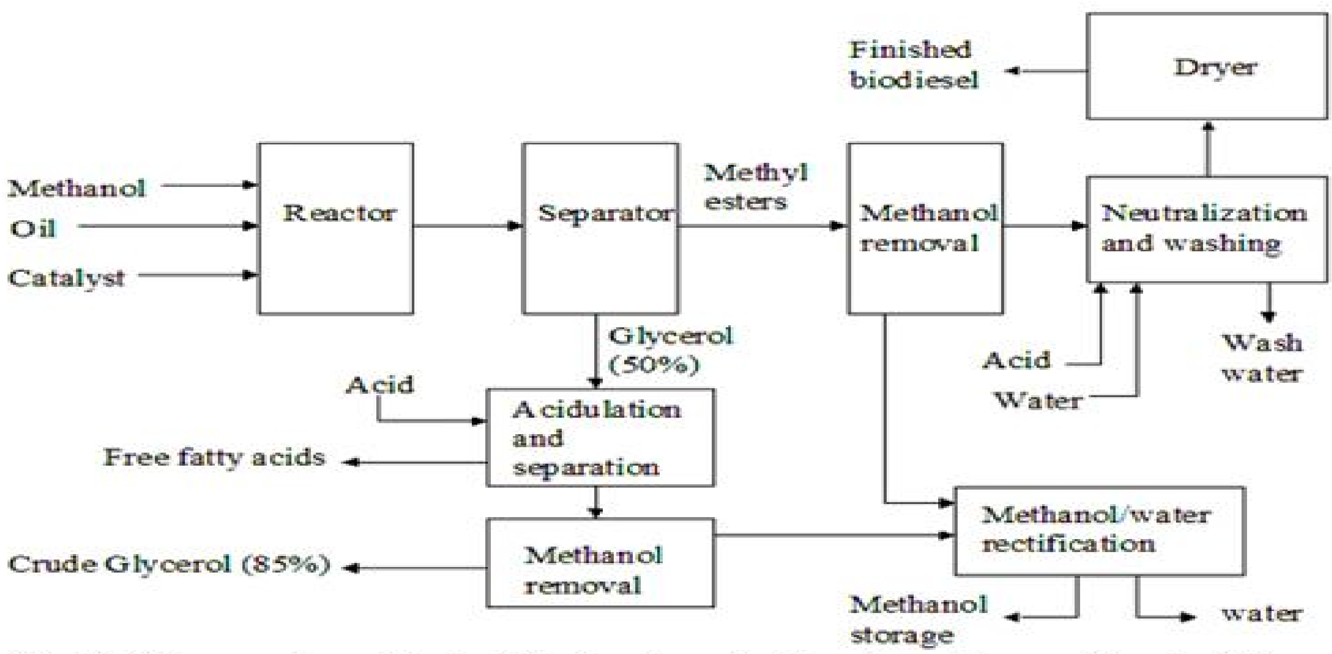


Fig: 2.2 Process flow chart of biodiesel production from Mamey Sapote Oil

Tab: 2.3 physicochemical properties of raw mamey sapota seed oil.

Volume 4 Issue II, February 2016
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S.No	Property of Mamey Sapota Oil	Value	Units
1.	Density at 15 °C	0.875	Kg/m^3
2.	Boiling Point	160	°C
3.	Acid value	6.57	mg KOH/gram
4.	Free Fatty Acid	3.26	% of mass
5.	Specific gravity	0.902	-----
6.	Kinematic viscosity	64.75	CSt.
7.	Percentage of oil content	23 to 30%	-------
8.	pH	3.25	

A. Purification Of Biodiesel

After transesterification, the ester layer may contain un reacted catalyst, methanol and residual glycerol. These impurities were removed by warm water treatment. During the washing process, gentle agitation is required to avoid the emulsion. After separation of the layer for 30 min, the wash water layer was drained off from the bottom of the separating funnel. The water washing method was continued (2-3 times) until the water layer becomes clear. For this process, equal amount of hot distilled water was used to remove the impurities.

B. Drying Of Biodiesel

After the completion of purification process, the ester layer may contain some amount of water and methanol. This should be removed because methanol reduces the flash point of fuel and it has corrosive nature to fuel hoses. Water content is responsible for the growth of biological organisms and it increases the acid value of fuel. Hence the ester layer was subjected to distillation at 100°C for 15 to 30 min to remove the water and methanol content present in the product (biodiesel). Final biodiesel product after purification is obtained acid catalyzed transesterification followed by alkaline catalyzed transesterification. Finally, the biodiesel fuel was saved for further analysis.

Tab: 2.4 Mamey sapota bio diesel properties as per the EN 14214 biodiesel standards

S.No	Property of Biodiesel	Values	Units
1.	Gross Calorific Value	37.120	Mj/kg
2.	Ash content	0.6	% mass
3.	Carbon residue	0.16	% mass
4.	Kinematic Viscosity	4.5	Mm^2/s
5.	Flash Point	174	°C
6	Pour point	-6	°C
7	Acid Value	0.16	Mg KOH/g
8	Cetane Number	52	-------
9	Glycerol	0.165	% m/m

III. RESULTS AND DISCUSSION

In the present investigation crude Mamey Sapota oil has been used for the production of biodiesel and its physicochemical properties and fatty acid composition have been studied to find the suitability as feed stock for biodiesel production. Based on its properties and fatty acid content, suitable production process was selected. Table 2.2 shows the composition and the percentage weight content of different types of saturated and unsaturated fatty acids of MSO. The highest content of unsaturated fatty acid was found to be oleic acid (64.62%) and the next one was linoleic acid (17.78%). Palmitic acid tops the list with saturated fatty acid content. The total unsaturated and saturated fatty acid content of MSO was found to be 84. 13% and 15.87% respectively. Major properties of Mamey Sapote namely density, viscosity, acid value, peroxide value, heating value, pour point, flash point pH, and cetane number were estimated using ASTM standards and reported in Table 2.3. The results show that all the properties of MZME are meeting the requirements of EN14214 biodiesel standards and hence MZME could be a potential substitute to petro diesel.

IV. CONCLUSION

In this experimental investigation on the production, characterization and the transesterification process of a new biodiesel derived from Mamey sapote seed. The experimentally determined conditions for the production of Mamey sapote are: 6:1 methanol to oil molar ratio, 0.76 % (w/w) concentration of catalyst, 90 min time of reaction and 60 °C temperature of reaction and the corresponding yield rate is 92.48%.

V. ACKNOWLEDGEMENT

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