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Characterization and Optimization of Biodiesel from Custard Apple Seed: A Review

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Abstract: ***Biodiesel is an alternative to conventional diesel fuel made from renewable resources, such as non-edible vegetable oils. The oil from seeds (e.g., Jatropha and Pongamia) can be converted to a fuel commonly referred to as "Biodiesel." No engine modifications are required to use biodiesel in place of petroleum-based diesel. Biodiesel can be mixed with petroleum-based diesel in any proportion. This interest is based on a number of properties of biodiesel including the fact that it is produced from a renewable domestic source, its biodegradability, and its potential to reduce exhaust emissions. The climate change is presently an important element of energy use and development. Biodiesel is considered "climate neutral" because all of the carbon dioxide released during consumption had been sequestered out of the atmosphere during crop growth. The use of biodiesel resulted in lower emissions of unburned hydrocarbons, carbon monoxide, and particulate matter. Biodiesel also increased catalytic converter efficiency in reducing particulate emissions. Chemical characterization also revealed lower levels of some toxic and reactive hydrocarbon species when biodiesel fuels were used. The fuel consumption in the world particularly in developing countries has been growing at alarming rate. Petroleum prices approaching record highs and they will deplete within few decades, it is clear that more can be done to utilize domestic non-edible oils while enhancing our energy security. The economic benefits include support to the agriculture sector, tremendous employment opportunities in plantation and processing. Jatropha and Pongamia are known just crude plants which grow on eroded soils and require a hot climate and hardly any water to survive. These are the strong reasons, enforcing the development of biodiesel plants.***

Keywords: Custard apple seeds, Methanol, Potassium Hydroxide

1. Introduction

It was a Belgian inventor in 1937 who first proposed using transesterification to convert vegetable oils into fatty acid alkyl esters and use them as a diesel fuel replacement. ... The transesterification reaction is the basis for the production of modern **biodiesel**, which is the trade name for fatty acid methyl esters

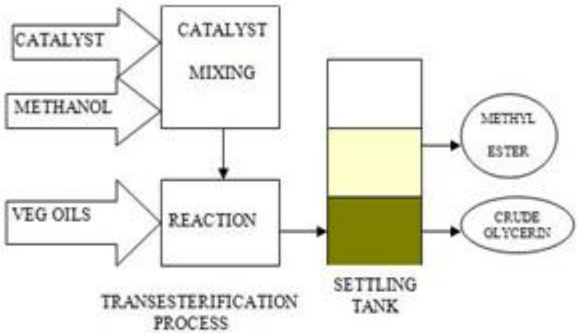
Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats which conform to ASTM D6751 (American Society for Testing & Materials). It is the name of a clean burning alternative fuel, produced from domestic, renewable resources and animal fats. Today's diesel engines require a clean –burning, stable fuel that performs well under a variety of operation conditions. It is the only alternative fuel that can be used directly in any existing, unmodified diesel engine. Because it has similar properties to petroleum diesel fuel, biodiesel can be blended in any ratio with petroleum diesel fuel. Specifications for use in diesel engines. Biodiesel refers to the pure fuel before blending with diesel fuel. Biodiesel blends are denoted as "BXX" with "XX" representing the percentage of biodiesel contained in the blend (i.e.: B20 is 20% biodiesel, 80% petroleum diesel). It is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It is made though a chemical process called transesterification where by the glycerin is separated from the fat or vegetable oil. Fuel-grade biodiesel must be produced to strict industry specifications in order to insure proper performance. It is better for the environment because it is made from, renewable resources and has lower emissions compared to petroleum diesel. It is less toxic than table salt and biodegrades as fast as sugar. It can be made in India from renewable resources such as Jatropha and Pongamia. Its use decreases our dependence on foreign oil and contributes to our own economy.

Dr. Rudolf diesel actually invented the diesel engine to run on a myriad of fuels including coal dust suspended in water, heavy mineral oil and you guessed it, vegetable oil. Dr. Diesel's first engine experiments were catastrophic failures. But by the time he showed his engine at the World Exhibition in Paris in 1900, his engine was running on 100% peanut oil. Dr. Diesel was visionary. In 1911 he stated "The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it. "In 1912, Diesel said, "The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time". Since Dr. Diesel's untimely death in 1913, his engine has been modified to run on the polluting petroleum fuel we now know as "diesel". Nevertheless, his ideas on agriculture and his invention provide the foundation for a society with clean, renewable, locally grown fuel.

Biodiesel Production

The production of Biodiesel, or alkyl esters, is well known. There are three basic routes to ester production from oils and fats.

1) Base catalyzed transesterification of the oil with alcohol.
2) Direct acid catalyzed esterification of the oil with methanol.
3) Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis**.**



Veg Oil: Custard apple seed
Alcohols: Methanol, Ethanol.
Catalyst: Sodium hydroxide, Potassium hydroxide.

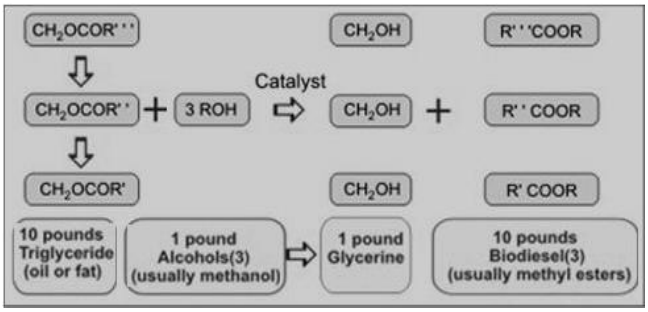
For the production of the biodiesel we mostly used as a transestrification process. Because this process is easy to handle. So now what exactly is ***a transesterification process*** and how it works are as follows:

Transesterification
The most common derivatives of agricultural oil for fuels are methyl esters. These are formed by transesterification of the oil with methanol in the presence of a catalyst (usually basic) to give methyl ester and glycerol. Sodium hydroxide (NaOH) is the most common catalyst, though others such as potassium hydroxide (KOH) can also be used.

100 kg oil+ 10 kg methanol+ 1 kg KOH a 100 kg biodiesel+26 kg glycerin
(For sample test – 500 ml of veg oil

The reaction is as follows:
KOH (5 gm& 6%) & CH3OH (50 ml & 10%)

Transesterification reaction:



Reaction Temperature: 60 to 65 ċ
Reaction Time: 60 minutes
R' R'' R''' = oil acids; R = (CH2)xCH3

The methanol and KOH are premixed and added to the oil, mixed for a few hours, and allowed to gravity settle for about 8 hours. The glycerin settles to the bottom, leaving biodiesel on the top.

2. Characterization of Biodiesel

2.1 Physical Properties

Table 2.1: Properties of biodiesel

Sr. No.	Test Description	REF. STD. ASTM 6751	Reference		Diesel	Custard Apple Biodiesel
			Unit	Limit	B00%	B100%
1.	Density	D1448	gm/cc	0.800-0.900	0.830	0.878
2.	Calorific value	D6751	MJ/Kg	34-45	42.50	38.20
3.	Cetane no.	D613	-	41-55	49.00	51.10
4.	Viscosity	D445	mm^2 /sec	3-6	2.700	4.78
5.	Moisture	D2709	%	0.05%	NA	NA
6.	Flash point	D93	ºC	-	64	158.00
7.	Fire point	D93	ºC	-	71	169.00
8.	Cloud point	D2500	ºC	-	-4	5.00
9.	Pour point	D2500	ºC	-	-9	3.00
10.	Ash	D	%	-	0.05	0.05

2.1.1 Effect of Temperature

Data on effect of temperature:

Table 2.2: Effect of temperature

Temperature	Yield %
45	57
50	70
55	79
60	88
65	90
70	87

2.1.2 Graphical representation of effect of temperature

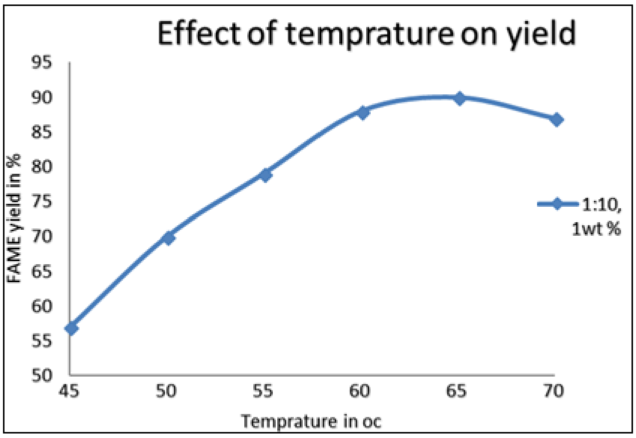


Figure 2.1: Effect of temperature on yield

2.1.3 Effect of Temperature

The low level of temperature was chosen as the room temperature and the high level was chosen as 70ºC. Higher temperature not only decreased the time required to reach maximum conversion but also the cost of energy for heating the apparatus would not exceed the value of time saved. Therefore high temperature of 65ºC is considered to be optimum temperature for conversion**.**

2.2 Effect of Reaction Time

2.2.1 Data for the effect on reaction time

Table 2.3: Effect on reaction time

Reaction time	yield %
25	60
35	66
45	72
55	80
65	86
75	90
85	90

2.2.2 Graphical Representation of Effect on Reaction Time Yield:

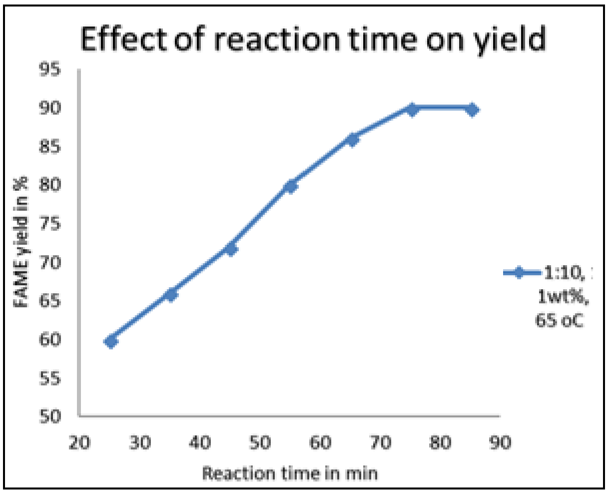


Figure 2.2: Effect of reaction time on yield

2.2.3 Effect of Reaction Time

The aim is to find the optimum value for reaction time. It is clear from the result that as the reaction time increases then the product yield is also increases. It shows that at maximum reaction we get a better yield of the product. The optimum value obtained here is 85 min to which conversion is 90%.

2.3 Effect of % Catalyst on Yield

2.3.1 Data for the effect of % catalyst on yield

Table 2.4: Effect of % catalyst on yield

% Catalyst	Molar Ratio 1:10
0.40	59
0.60	76
0.80	80
1.00	89
1.20	88

2.3.2 Graphical Representation of Effect of % Catalyst on Yield

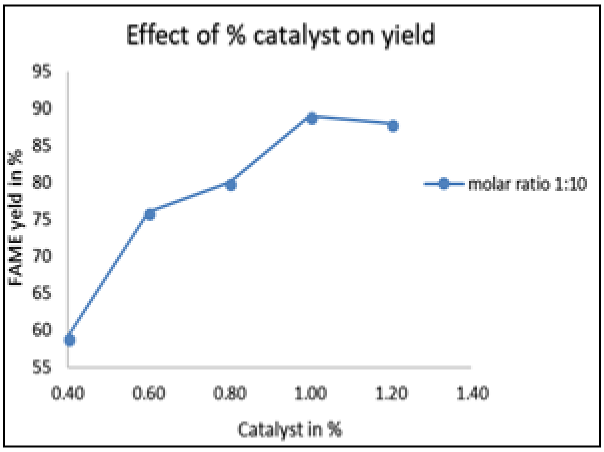


Figure 2.3: Effect of % catalyst on yield

2.3.3 Effect of % Catalyst on Yield

The next in optimizing the process for production of biodiesel was to study effect of catalyst concentration on biodiesel yield. It is clearly shown that biodiesel yield increases and then reaches the optimum conversion at 0.40-1.20% the weight of the catalyst. Hence this value was chosen for the production of biodiesel from the custard apple oil.

2.4 Effect of Molar Ratio on Yield:

2.4.1 Data for the effect of molar ratio on yield

Table 2.5: Effect of molar ratio on yield

ratio	0.40%	0.60%	0.80%	1.00%	1.20%
01:04	42	55	64	69	70
01:06	47	63	72	74	74
01:08	55	69	79	84	85
01:10	59	76	80	89	88
01:12	69	77	82	91	87

2.4.2 Graphical representation of effect of molar ratio on yield:

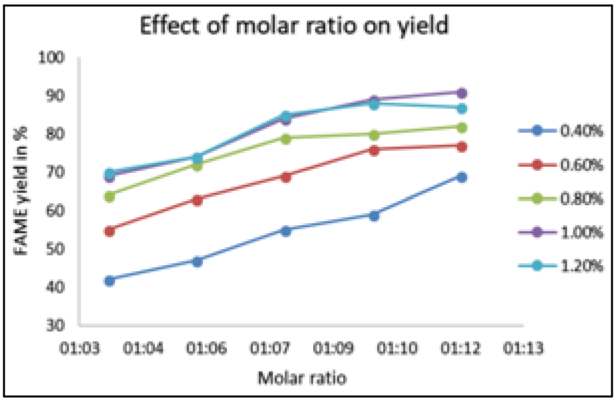


Figure 2.4: The effect of molar ratio on the yield of biodiesel

2.4.3 Effect of Molar Ratio on Yield of Biodiesel

To optimize the loading of the catalyst and molar ratio of oil and methanol, the experiment was carried out by varying the molar ratio of methanol to oil from 4 to 12 for each wt % loading of the catalyst 0.40-1.20 considering the weight of oil in grams. From the figure it is clear that methyl ester yield increases constantly with the increasing molar ratio of oil.

2.5 Effect of Stirring Speed on Yield of Biodiesel:

2.5.1 Data for the effect of stirring on yield of biodiesel

Table 2.6: Effect of stirring speed on yield

Stirring Speed	Yield
200	55
300	63
400	69
500	78
600	90
700	90

2.5.2 Graphical representation of effect of stirring speed on yield of biodiesel

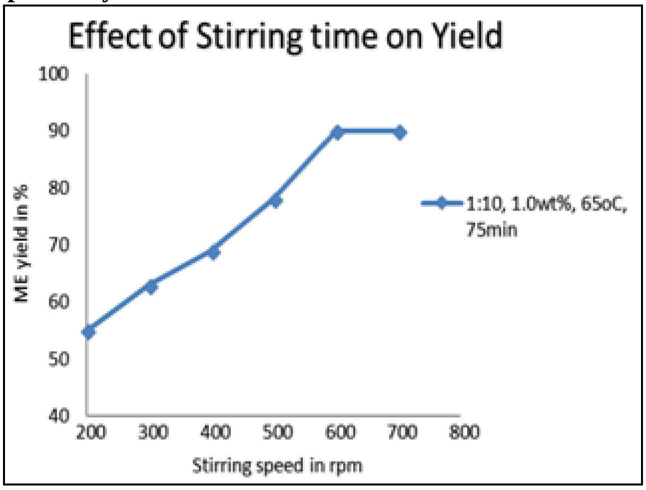


Figure 2.5: The effect stirring speed on yield of biodiesel.

2.5.3 Effect of Stirring Speed on Yield of Biodiesel

At higher temperature 70±0.5ºC the yield will decrease since the loss of some amount of methanol at a high temperature may occur. In 30 min of reaction time 55% conversion of biodiesel was obtained, which rises gradually with an increase in time. A reaction time of 2.5 h was optimum to obtain a yield of up to 90% of biodiesel. Further increase in time could not raise the yield of biodiesel, because the maximum amount of triglyceride was converted into its corresponding ester. Hence, 2.5 h is the optimum time for the reaction. The rate stirring was studied from 200 rpm to 700 rpm. The maximum yield was obtained with agitation at 600 rpm. As the agitation speed was lowered below 600 rpm the yield decreased and with an increase in agitation higher than 600 rpm, no further increment in yield was observed.

3. Comparisons and Discussions

Biodiesel contains no sulfur or aromatics, and use of biodiesel in a conventional diesel engine results in substantial reduction so unburned hydrocarbons, carbon monoxide and particulate matter. Biodiesel can be manufactured using existing industrial production capacity and used with conventional equipment, is provides substantial opportunity for immediately addressing our energy security issues. Increased utilization of renewable biofuels results in significant microeconomic benefits to both the urban and rural sectors.

Biodiesel Emission Compared to Conventional Diesel

Emission Type	B100	B20
Regulated		
Total Unburned Hydrocarbons	-93%	-30%
Carbon Monoxide	-50%	-20%
Particulate Matter	-30%	-22%
Nox	+13%	+2%

To diminish the present dependency on imported fuels:
We are spending Rs 82000 crores per annum for imported crude petroleum. We are losing max amount of foreign exchange on crude oils. If we can save percentage of this amount, it will be useful for the construction of a heavily irrigation project sources.

To develop the renewable energy sources:
The energy consumption in the world particularly in the industrialized countries has been growing at alarming rate. Fossil fuels which today meet major part of the energy demand are being depleted quickly world has started running out of oil and it estimated that 80% of the world's supplies will be consumed in our lifetimes. Coal supply may appear to be large but even this stock may not last longer than a few decades. Thus we are forced to look for renewable energy.

To boost up the rural economics:
India has "rain shadow area" about 8crore hectares Jatropha; the prime element for the extraction of biodiesel can be grown. It was known just a crude plant which grows on eroded soil and requires a hot climate and hardly any water to survive. The Jatropha cactus plants grow on poor degraded soils and are able to ensure a reasonable production of seeds with very little input. The production rate is 5-15 tons per year per hectare. The farmer gets profit of nearly Rs 40, 000 per hectare per year. It also increases the employment in rural areas.

To develop eco friendly fuels:
Biodiesel contains no sulfur or aromatics, and use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbon, carbon monoxide and particulate matter.

A US department of energy study showed that the production and use of biodiesel, compared petroleum diesel, resulted in a 78.5% reduction in carbon dioxide emissions.

4. Advantages of Biodiesel

- The higher cetane number of biodiesel compared to petro-diesel indicates potential for higher engine performance. Tests have shown that biodiesel has similar or better fuel consumption, horsepower, and torque and haulage rates as conventional diesel
- The superior lubricating properties of biodiesel increases functional engine efficiency

- Their higher flash point makes them safer to store
- The biodiesel molecules are simple hydrocarbon chains, containing no sulfur, or aromatic substances associated with fossil fuels
- They contain higher amount oxygen (up to 10%) that ensures more complete combustion of hydrocarbons
- Biodiesel almost completely eliminates lifecycle carbon dioxide emissions. When compared to petro-diesel it reduces emission of particulate matter by 40%, unburned hydrocarbons by 68%, carbon monoxide by 44%, sulphates by 100%, polycyclic aromatic hydrocarbons (PAHs) by 80%, and the carcinogenic nitrated PAHs by 90% on an average. The use of biodiesel complements the working of the catalysator and can help a current EURO-1 motor attain the EURO-111 standards.
- Fixation of up to 10 t/ha/yr CO2 that could be internationally traded
- Production of 1 t/ ha/yr of high protein seed cake (60% crude protein) that can be potentially used as animal and fish feeds and organic matter that could be used as organic fertilizer particularly in remote areas
- Various other products from the plant (leaf, bark and seed extracts) have various other industrial and pharmaceutical uses
- Localized production and availability of quality fuel
- Restoration of degraded land over a period of time
- Rural employment generation

5. Disadvantages of Biodiesel

- High cost of production: will eventually solve itself when large-scale production and use starts. Also, the price of petro-diesel does not take into account its actual cost (when environmental and military costs are included).
- Modifications are required to the automobiles for use of biofuel: many automobile brands are currently marketed ready for use of bio diesel.
- High CFPP (cold filter plugging point) values and hence solidification and clogging of the system at low temperatures: this problem occurs only in places where the temperature goes down to around 0°C, even here the problem is currently solved by adding additives.

6. Conclusion

Biodiesel is safe to handle because it is biodegradable and non-toxic. Biodiesel reduces all the emission. Biodiesel can be used alone or mixed in any amount with petroleum diesel fuel. Biodiesel runs in any conventional, unmodified diesel engine. No engine modifications are necessary to use biodiesel and there is no “engine conversion”. Increased utilization of renewable biofuels results in significant microeconomic benefits to both the urban and rural sectors, and the balance of trade. It is clear that more can be done to utilize domestic surpluses of vegetable oils while enhancing our energy security. Because biodiesel can be manufactured using existing industrial production capacity, and used with conventional equipment, it provides substantial opportunity for immediately addressing our energy security issues.

Reference

[1]. WuXuan, Leung Dennis YC. Optimization of biodiesel production from Camelinaoil using orthogonal experiment. Appl Energy 2011; 88(11): 3615–24.
[2]. Karabas Hulya. Biodiesel production from crudeacorn (QuercusfrainettoL.) kerneloil: an optimization process using the Taguchi method. Renew Energy 2013; 53:384–8.
[3]. Sureshkumar K, Velraj R, Ganesan R. Performance and exhaust emission characteristics of a CI engine fueled with Pongamiapinnatamethylester (PPME) and its blends with diesel. Renew Energy 2008; 33(10): 2294–302.
[4]. Sathish Kumar R, Suresh Kumar K. Effect of methanol blending with Pongamiapinnata biodiesel and diesel blends on engine performance and exhaust emission characteristics of an unmodified compression ignition engine. Ambient Energy doi:10.1080/01430750.2013.823108
[5]. wikipedia.org/wiki/Biodiesel#Biodiesel_feedstock\