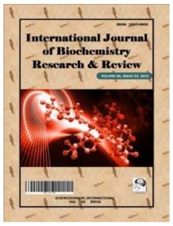

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Biodiesel Production from Selected Used Cooking Oils and Animal Fats and Its Implementation

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Authors' contributions

This work was carried out in collaboration between both authors. Author ABMSH designed the study, wrote the protocol and supervised the work. Authors ABMSH and MSA carried out all laboratories work and performed the statistical analysis. Author MSA managed the analyses of the study. Author ABMSH wrote the first draft of the manuscript. Author ABMSH managed the literature searches and edited the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Significance of the Study: Biomass derived bio-fuel is biodegradable, nontoxic, sustainable and substitute for fossil fuel as well as capable of removing emission like CO_2, CO, SOx, HC and NO_X. It is renewable and outstanding energy resource for the generation of steam and electricity, transportation fuel, manufacturing industries. Biomass (animal and plants based like, fruits, vegetable, crops, fish, chicken and other animal byproducts or waste biomass) can be used for bioenergy production like biofuel and nanocatalyst for biofuel. Agro waste like animal waste biomass can be the sources of biodiesel in the industry. The energy is an important factor for the development of social and economic development of any country. In recent years, using renewable energy as a reducing agent of environmental pollution has become an important

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issue in the whole world.
Aim: In this study it is highlighted that biofuel can be produced from from waste cooking oil, fish and chicken byproduct.
Results: The highest yield of fatty acid methyl esters (FAME) was found in fish oil (99.8%). However, the 2nd highest yield o biodiesel was found in chicken oil (99.2%). The kinematic viscosity at 40℃ accepted the limited value between 1.9 to 6. 0 cSt according to the ASTM D445. In addition, TAN value was followed the ASTM D664 standard. Fuel consumption, CO, HC and NOx were lower in fish and chicken biodiesel than palm and sunflower.
Conclusion: The less expensive waste feedstock can be used in the commercial and industrial purposes in future for vast energy supply.

Keywords: Bienergy; biofuel; waste cooking oil; fish; chicken byproduct.

1. INTRODUCTION

The occurrence of oil depletion, global warming and the greenhouse effect has put us on an alarming condition where we need to search for an alternative energy. Hydro, wind, solar, biomass, hydrogen and geothermal energy are the types of natural energy that are readily available and sustainable [1].

Among all the renewable energies, biofuel (biodiesel) is one of the most promising energy sources despite diesel-fuel. Biodiesel is the mono-alkyl esters of fatty acids derived from animal fats and vegetable oils. It is produced when vegetable oil or animal fat is reacted chemically with an alcohol to produce fatty acid alkyl esters (transesterification) [2,3]. Biodiesel has a low emission profile and are environmental friendly, hence not posting dangers to our vulnerable earth. The reason that biodiesel is not utilized widely around the world is due to the high cost of raw materials. To overcome this, less expensive feedstock such as waste cooking oil can be a resort of low quality oils that are produced in excess in food processing industries. By utilizing these wastes oil could help to overcome the problem of waste oils disposal [4].

The high diesel fuel price today made biodiesel an attractive alternative fuel. Biodiesel has been chosen as one of the main alternative fuel because of its better characteristics and advantages such as: a renewable source, highly biodegradable, high flash point, excellent lubricity, nontoxic, relatively low amount of polycyclic aromatics hydrocarbons as domestically available. That is why this environmental friendly biofuel can be utilized in engines without any modification [5]. It is also reported that bio-energy can be produced from starch, cellulose and lignocelluloses based vegetable and animal waste and byproducts by fermentation process using different enzyme [6].

Few researches have been carried out on the production of biodiesel from vegetable oil, animal fats and byproducts as well as fish fats. Therefore, the objectives of this present research were to produce biodiesel from waste cooking oil, fish and chicken fats and to investigate its characteristic and its application in engine emission.

2. MATERIALS AND METHODS

2.1 Preparation of Oil Samples

Fish and chicken byproducts, waste cooking sunflower and palm oil were used in this study. Waste sunflower and palm oil were collected from restaurants. Waste fish and chicken byproducts were collected from the fishes processing market and chicken slaughtered house, Kuala Lumpur, Malaysia. Firstly, the fish and chicken fats were heated at 80℃ and melted it to fish and chicken oil (Fig. 1). Secondly, filtration was done by utilizing a filter funnel with a piece of filter paper, (whatman filter paper from Sigma-Aldrich, product no. Z240249).

2.2 Biodiesel Production through Transesterification Reaction

NaOH (1%) were used as a catalyst to determine its effect on biodiesel yield. The filtered palm, sunflower, fish and chicken oil was preheated in the oven for approximately 15 minute at 60℃ before subjecting it to the transesterification process. When the transesterification process was completed, the solution was separated into two distinct layers of crude biodiesel and glycerol. distinct layers (Fig. 1). The methyl esters obtained was washed with distilled water to remove impurities such as pigments, excess alcohol, excess catalysts, glycerol, and soaps.

(A) (B) (C) (D) (E)

Fig. 1. A) Straight and waste sunflower oil, B) filtered waste sunflower cooking oil, C) fish oil and D, E) chicken fats

2.3 Drying Process

Little quantity of water was eliminated when biodiesel was dried in the oven. After drying, water was eliminated and biodiesel was produced and used for subsequent gas chromatography-mass spectrometer analysis.

3. BIODIESEL CHARACTERIZATION

3.1 Biodiesel Analysis

3.1.1 Gas-chromatography-mass spectro-metry (GC-MS) analysis

The specific component of methyl esters in the biodiesel were determined using an Agilent 6890 Gas Chromatography installed with a mass spectrometry detector. A capillary column, (length: 30 m, film thickness: 0.25 m and ID: 0.25 mm) was used. Helium was used as the carrier gas. One micro-liter of the biodiesel sample was injected manually. Samples were introduced to the column via an inlet. Once in the inlet, the heated chamber vaporizes the biodiesel and a constant flow of helium moves through the inlet. A portion of the helium flow acts to transport the sample into the column. Another portion of the helium flow gets directed to purge the inlet of sample following injection. Yet another portion of the flow is directed through the split vent in a split ratio.

3.1.2 Characterization of the biodiesel

The produced biodiesel under optimum conditions was sent to the Engine Tribology Laboratory of Department of Mechanical Engineering to determine the properties of the biodiesel.

3.2 Viscosity

Samples of the biodiesel were sent to Tribology Laboratory at Faculty of Engineering, UM to determine the viscosity. Using ASTM D445, viscosity of all samples were analyzed by heating up at 40℃ and then measured using Houillon viscometer set at rpm 30 and spindle size 63 (ASTM Inc. 2005) [7].

3.3 Total Acid Number (TAN)

Total acid number was measured by using the amount of potassium hydroxide (KOH; mg) that was needed to neutralize the acids in one gram of oil.

For all samples by using ASTM D664 standard (ASTM Inc., 2006) [8].

3.4 Engine Exhaust Emission Test

The exhaust emission test was also conducted to evaluate the exhaust emission characteristics of the biodiesel. For these, the 2.50 liters of biodiesel was required to perform the engine emission test. The BOSCH gas analyzer model EET 008.36 was used to measure carbon monoxide (CO) and unburned hydrocarbon (HC). Whereas, the Bacharach model CA300NSX analyzer was used to measure NO_x concentration. The measurement of CO and NO_x were according to SAE J117 June'95 standards and HC to SAE J215 March'95 standards. Fuel consumption of the biodiesel was also measured and compared with the fuel consumption of normal petro diesel. The model of the engine was YANMAR TF120-M. This engine is horizontal, water-cooled and single cylinder. The accumulation of deposit was carried out for 8 hours at 2000 rpm constant engine speed and 15 Nm load for each test fuel.

3.5 Metal Analysis by Multielements Oil Analyzer

Samples of biodiesel were sent to the Tribology Laboratory at Faculty of Engineering, UM. By using multi element oil analyzer (MOM II) as ASTM D800 standard, lube oil analysis was conducted to all samples to determine the metal content P, K, Ca, Mg, S, Cu, Pb, and Fe in biodiesel (ASTM Inc., 2006) [9].

4. RESULTS AND DISCUSSION

It has been seen that there are a total 7, 6, 5 and 4 compounds that are present in the biodiesel samples produced from fish, chicken, palm and sun flower waste, respectively Table 1). The highest yield of fatty acid methyl esters (FAME) was found in fish oil (99.8%). However, 2nd highest was found in chicken oil (99.2%).

From Table 2, the viscosity of biodiesel produced from transesterification of waste sunflower oil was the highest, 5.7 cSt. The kinematic viscosity at 40℃ accepted the limited value between 1.9 to 6.0 cSt according to the ASTM D445. TAN value was followed the ASTM D664 standard.

The result shown in Table 3 showed that only all elements value maintained the limits of ASTM D6751 ≤5 ppm for Na, Mg, and Ca ≤10 ppm for P, Pb lead≤5, cu ≤5. This result was similar to the result found by [10].

Table 4 shows the specific fuel consumption (SFC) in ml/sec. Fuel consumption, CO, HC and NOx were lower in fish and chicken biodiesel than palm and sunflower. Carbon monoxide concentration from fish oil derived biodiesel was much lower compared to other samples because, they were possessed a lower acid and viscosity value. The amount of NOx emission is directly related to the exhaust gas temperature and engine combustion chamber temperatures.

Table 1. Identification of methyl esters in fish, chickrn, palm and sunflower based biodiesel

Total peak for different samples	Peak serial	RT (min)	Methyl ester	% relative	Total % biodiesel yield number
Fish waste	1	12.1	$C_{13}H_{24}O_2$ CH_3	9.9	99.8
	2	16.4	$C_{13}H_{30}O_2$ CH_3	6.8	
	3	20.1	$C_{12}H_{30}O_2$ CH_3	5.6	
	4	20.5	$C_{17}H_{34}O_2$ CH_3	19.7	
	5	23.7	$C_{19}H_{34}O_2$ CH_3	14.2	
	6	23.8	$C_{19}H_{36}O_2$ CH_3	40.6	
	7	24.3	$C_{19}H_{36}O_2$ CH_3	3.0	
Palm oil	1	20.1	$C_{16}H_{29}O_2CH_3$	2.1	98.4
	2	20.5	$C_{16}H_{31}O_2CH_3$	36.1	
	3	23.7	$C_{18}H_{31}O_2CH_3$	11.1	
	4	23.8	$C_{18}H_{33}O_2CH_3$	44.2	
	5	24.3	$C_{18}H_{35}O_2CH_3$	5.1	
Sunflower	1	20.5	$C_{16}H_{31}O_2CH_3$	6.1	98.6
	2	23.7	$C_{18}H_{31}O_2CH_3$	48.2	
	3	23.8	$C_{18}H_{33}O_2CH_3$	42.1	
	4	24.3	$C_{18}H_{35}O_2CH_3$	2.2	
Chicken oil	1	12.2	$C_{13}H_{24}O_2$ CH_3	9.8	99.2
	2	16.0	$C_{13}H_{30}O_2$ CH_3	6.5	
	3	20.2	$C_{12}H_{30}O_2$ CH_3	5.3	
	4	23.6	$C_{19}H_{34}O_2$ CH_3	28.4	
	5	23.1	$C_{19}H_{36}O_2$ CH_3	44.0	
	6	24.2	$C_{13}H_{36}O_2$ CH_3	5.2	

Table 2. Determination of acid value and viscosity of different waste biodiesel

Property	Unit	ASTM value	Fish waste	Chicken waste	Palm waste	Sunflower waste
Acid value	mg KHO/g oil	0.50 max	0.42	0.41	0.43	0.44
Viscosity	cSt at 40℃	1.9-6.0	5.4	5.3	4.42	5.7

Table 3. Elements present in different biodiesel compared to ASTM standard

Biodiesel sample	P (PPM)	Ca (PPM)	Mg (PPM)	Na (PPM)	Pb (PPM)	Cu (PPM)
Pure diesel	10	5	5	5	4	4
Fish biodiesel	8	2	3.5	1.5	3.5	3
Palm biodiesel	9	5	5 .5	6.0	4	4
Sunflower	9.5	5	5	5.1	4	4
Chicken waste	8.5	2.5	4.0	2.0	3.5	3

Table 4. Fuel consumption test of different biodiesel

Biodiesel sample	Load	Speed	Fuel consumption (ml/sec)	CO emission (%)	NOx emission (PPM)	HC emission (PPM)
Pure diesel	15 Nm	2000 rpm	0.588	0.030		28
Fish biodiesel	15 Nm	2000 rpm	0.581	0.025		17
Palm biodiesel	15 Nm	2000 rpm	0.613	0.029		25
Sunflower	15 Nm	2000 rpm	0.612	0.028		26
Chicken waste	15 Nm	2000rpm	0.58	0.026		20

As the exhaust gas temperature increases, NOx emission also increases. Hence, biodiesel fuelled engine had a higher potential to emit more NOx because of the exhausted gas temperature lower as the biodiesel concentration increased [11,12].

5. CONCLUSION

Fish and chicken waste oil showed the higher yield than palm and sunflower biodiesel and the quality of biodiesel produced was the best according to the engine test. Since fish and chicken waste biodiesel showed the good results, It can be the sources of less engine emission like HC, CO.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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