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ORIGINAL ARTICLE

Transesterification of biodiesel from the purified fish oil and characterization of Fatty Acid Methyl Ester (FAME)

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ABSTRACT
Biodiesel is a renewable fuel of key importance to meet environmental and economic sustainability. The present study focusing on transesterification of biodiesel from purified fish oil extracted from fresh and marine fish discarded waste. The transesterification efficiency of fish-oil-biodiesel was noticed in 74% yield from both fish oil samples. The essential parameters of saturated fatty acids, mono unsaturated fatty acids and poly unsaturated fatty acids percentages were estimated from marine and freshwater FAME's. Particularly, the marine oil biodiesel was identified in high levels of palmitic (21.72 %), octadecenoic (17.95%) and docosahexaenoic acids (9.20 %). The characteristic properties of Density, Specific gravity, Flash point, Cloud point, Viscosity, Cetane Number, Acid value and Moisture experiment samples with commercial diesel were made. Characteristic investigation of biodiesel showed insignificant dissimilarity with commercial diesel fuel. Considering the major parameters, both marine and fish oil-biodiesel were found as effective fuel products.
Keywords: Biodiesel, Fatty Acid Methyl Ester (FAME), Transesterification

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INTRODUCTION

The International Energy Agency has an objective for bio-fuels to meet more than a quarter of world demand for transport fuels by 2050 to reduce dependence on petroleum and coal. The global fish oil production was 1.01 million tonnes as stated by international fishmeal and fish oil organization. Hence, fish oil serves to be a good source of biodiesel for diesel engine that can substitute conventional diesel fuel thereby reducing the energy crisis and environmental pollutants by fish-waste [1]. Biodiesel is a fuel derived from oils or fats using transesterification and is a liquid similar in composition to fossil diesel. It is an alternative diesel fuel derived from a variety of fatty-acid-methyl-ester-producing processed vegetable oils, animal fats, or waste frying oils.This fuel has similar properties to that of diesel produced from crude oil and can be used directly to run existing diesel engines or as a mixture with crude oil diesel[2].Considering the growing demand and benefits renewable energy, in the present study an attempt was made in Transesterification process of biodiesel from fish oil produced from fish waste and characterization of biodiesel properties.

MATERIAL AND METHODS

The present study effort made on Transesterification of biodiesel from purified fish oil extracted from fresh and marine fish discards [3].The detailed characterization and Fatty Acid Methyl Easter (FAME) of both biodiesels were estimated by standard Gas chromatography methods.The physical and chemical characterization of Specific Gravity/Density, Flash Point, Cloud Point, Kinematic Viscosity,Cetane Number and Acid Value ranges were measured above products [4-8].

RESULTS AND DISCUSSION

In the present study, the biodiesel was produced transesterified process from purified fish oil of marine and freshwater fish waste. The production efficiency of fish-oil-biodiesel was noticed in 74% yield from both fish oil samples. In the present study, the biodiesel was produced from purified fish oil of marine and freshwater fish waste. The transesterification efficiency of fish-oil-biodiesel was noticed in 74% yield from both fish oil samples. Earlier studies on biodiesel production result showed the higher yield of 98.5 % for fish oil, reaching 90% for palm oil (33.3 wt. %) and waste frying oil (66.7 wt. %) biodiesel[9].Similarly, the marine fish waste oil was used as the raw material to produce the biodiesel, the transesterification efficiency was noted in 92%, which implies that 689 g of biodiesel was produced per 1000 g of fish oil [10].The conversion process of 20 L mackerel fish oil was delivered 90% volume ratio of methyl ester phase with 10% volume ratio of glycerol phase. The transesterification of biodiesel production was noticed higher (1.5 %) in using NaOH as catalyst when compare to KOH yield percentage (1.5%)[11].

The gas chromatography analyses of biodiesel from marine and freshwater have showed presences of essential fatty acids in significant percentages. Particularly, the marine oil biodiesel was identified in high levels of palmitic (21.72 %),octadecenoic (17.95%) and docosahexaenoic acids (9.20 %). In freshwater fish biodiesel showed high amount of alpha Linolenic acid in 5.65 %. Similarly, the characteristics assessment of biodiesel produced from marine and freshwater fish oil showed that the marine fish waste contains high lipids compare to freshwater fish-waste. The GC-MS analysis indicated the presence of methyl ester of palmitoleic acid methyl (C-16:1), palmitic acid methyl (C-16:0), oleic acid methyl (C-18:1), Stearic acid methyl (C-18:1) and eicosapentaenoic acid methyl (C-20:5) which is essential component of biodiesel [12].

Fatty-acid composition of marine fish oil biodiesel is more complex than that of general vegetable-oil biodiesels and consists of 20.94 wt.% oleic acid (C18:1), 19.61 wt.% palmitic acid (C16:0), 5.24 wt.% stearic acid (C18:0), and 5.16 wt.% palmitoleic acid (C16:1) 12. In addition, long chain polyunsaturated fatty acid (PUFA) compounds such as docosahexaenoic acid (DHA, with a carbon chain structure C22:6) and eicosapentaenoic acid (EPA, with a structure C20:5) of marine fish-oil biodiesel are as high as 15.91 wt.% and 3.70 wt.%, respectively [13].

The production of fish oil biodiesel from discarded Mackerel was noted in 0.55 wt. %. The fatty acid property of biodiesel was determined, mysteric acid in 4.08 wt. % of palmatic acid in 1.73 wt. % of stearic acid in 12.08 wt. % of oleic acid (C18:1), 4.25 wt. % of linoleic acid in 1.39 wt. % of linolenic acid (C18:3) [14].The comparative study in Salmon (*Oncorhynchus gorbuscha*) oils separated from processing waste hydrolysate their derived methyl esters with corn oil and its methyl ester. The Salmon oil methyl esters contained 26.64% saturated fatty acid methyl esters compared to 13.68% in corn oil methyl ester. Salmon oil methyl esters also contained relatively high concentrations of eicosapentaenoic acid (C20:5) and docosahexaenoic (C22:6) acid methyl esters [15].

In the present study, character analysis of marine and freshwater fish biodiesel showed significant variations between the experiment samples. The densities were found in 0.878 kg/m^2 and 0.886 kg/m^2 respectively. It is little higher than that of commercial diesel. The specific gravityof biodiesels was found in 0.870 kg/m^{3}and 0.876 kg/m^3. The Cloud pointwas found at 4.1 ^{0}C and 4.3 ^{0}C. The kinematic viscosity was measured at 4.13 mm^2/s and 5.76mm^2/s at 40 °C respectively. The results of Flash point at 130^0 C were recorded for both samples. The CN of the marine and freshwater fish oil-biodiesels were recorded 47 and 48minutes. The acid values identified at 1.17 mg KOH/g and 1.19 mg KOH/g respectively. The moisture content of marine and freshwater fish biodiesel was recorded 0.056%. Several studies of characteristics of biodiesel showed narrow range of variations between the transesterified biodiesel and wide range of variationswere registered with commercial diesel. However, the biodiesel blend with commercial fuel diesel proved satisfactory results in diesel engines.

The biodiesel derived from fish-oil was used as fuel in diesel engine to investigate its performance, combustion and emission characteristics. The various blends of biodiesel with diesel were tested in running a diesel engine as B25 (25% biodiesel and 75 %commercial diesel), B50, B75, B100. The efficiencies of kinematic viscosity (6.0, 6.1, 6.2, 6.2 cSt), specific gravity (0.87, 0.88, 0.89, 0.92 kg/m^3), flash point (111, 130,141,147 ^{0}C), pour point (-1.7, -0.2, 0.7, 1.0^{0}C), and calorific value (41.1, 40.7, 39.9, 39.5 MJ/kg) were measured. The biodiesel blend fuel efficiency showed that except flash point, satisfactory results were noticed with conventional diesel (Diesel, 5.8cSt, 0.867, 72^{0}C, -3.0^{0}C, 42.0 MJ/kg) [16].The recent measurements of standard biodiesel specifications (ASTM) were showed that the Flash point of 164^{0}C, Kinematics viscosity of 4.7mm^2/s and Density of 869 kg/m^3. Consequently, the study recommended the substantial potential for utilization of fish oil as biodiesel [17].

The investigated the engine performance and emission characteristics of biodiesel produced from mixed marine fish oil compared with other three fuels[13].It included the marine fish-oil biodiesel, a commercial biodiesel produced from waste cooking oil and ASTM No. 2D diesel. The specific gravities of marine fish-oil biodiesel and commercial biodiesel were 0.86 and 0.87, respectively,which are somewhat larger than the 0.83 recorded for the (ASTM No. 2D) diesel. The investigation performance evaluation of biodiesel produced from fish oil, the acid value (0.20 mg KOH/g), kinematic viscosity (4.60 cSt at 40 8C), and higher heating value (42.1 MJ/k) biodiesel quality standards were suitable. The length of the carbon chain of fish oil was frequently greater than that of general vegetable oils. Therefore, the use of fish-oil based biodiesel with larger cetane number may improve diesel engine performance and result in a reduction of pollutant emissions [13].

The fuel properties of biodiesel from various animal fats (beef tallow, pork lard, and chicken fat) and fish oil (sardine oil) were carried out by Teresa *et al.,* (2014). Biodiesels were characterized using the standard methods described in EN Standard. The characterization of reaction yield was recorded in 76.8, 90.8, 91.4, 89.5 wt% respectively. Heating value (39.4, 40.0, 39.9, 39.7 MJ/kg), Density at 15^0C (883, 870, 872, 886kg/m^2), Kinematic viscosity at 40^0C(5.85, 5.40, 4.96, 4.33), Water content (1237, 585, 149, 200 mg/kg), Iodine value (76,45, 76, 163g/100g), Acid value (0.32, 0.21, 0.20, 0.20 mg KOH/g), Group I metals (Na+ + K+) (53.5, 3.9, 39.7, 13.0 mg/kg), Flash point (171, 172, 147, 160^0C) in beef tallow, pork lard, chicken and sardine oil respectively.

The significant fuel property of viscosity assessment was made from fish oil, palm oil and waste frying oil as raw material of biodiesel. The result was illustrated that after transesterification, the biodiesels had viscosity of 4.2mm2/s, 5.6mm2/s and 5.3mm2/s, respectively. Viscosity of fish biodiesel has registered high reduction demonstrated in transesterification process [9].The biodiesel production form fish oil showed adequate conversion percentage using transesterification method.

Fatty Acids	**Carbon Atom (n)**	**Fatty Acids (%)**	
		Marine fish waste FAME	**Freshwater fish waste FAME**
Saturated Fatty Acids			
Lauric acid	C12:0	1.94±0.02	1.01±0.01
Myristic acid	C14:0	2.16±0.03	2.12±0.01
Palmitic acid	C16:0	21.72±0.01	20.07±0.11
Stearic acid	C18:0	5.71±0.01	4.03±0.1
Total		31.53±0.07	27.31±0.23
Mono Unsaturated Fatty Acids			
Palmitoleic acid	C16:1	14.84±0.01	14.43±0.1
Octadecenoic acid	C18:1	17.95±0.14	11.16±0.02
Gondoic acid	C20:1	3.48±0.02	2.11±0.01
Eicosenoic Acid	C20:1 n-9	1.50±0.02	1.59±0.02
Total		36.4±0.18	30.66±0.16
Poly Unsaturated Fatty Acids			
Linolenic acid	C18:2	3.72±0.01	4.56±0.19
Alpha Linolenic acid	C18:3	1.53±0.02	5.65±0.01
Stearidonic acid	C18:4	4.00±0.02	3.78±0.02
Arachidonic acid	C20:4 n-6	3.24±0.02	2.52±0.01
Eicosatetraenoic acid	C20:4	3.37±0.03	2.99±0.02
Docosapentaenoic acid	C22:5	1.92±0.01	1.65±0.02
Docosahexaenoic acid	C22:6	9.20±0.03	3.03±0.02
Total		26.98 ±0.14	34.99 ± 0.28
Others		5.09±0.11	6.07±0.3

Table: 1. GC-MS peaks of Marine fish waste FAME and Freshwater fish waste FAME.

Properties	Standard Method for test	Commercial Diesel	Values of biodiesel	
			Marine fish	Freshwater fish
Density 150 C	ASTM1298	0.850 kg/m2	0.878 kg/m2	0.886 kg/m2
Specific gravity	ASTM 270	0.850	0.870	0.876
Flash point	ASTM D93	56	1300C	1300C
Cloud point	ASTM D2500	-15-50 C	4.10C	4.30C
Viscosity at 400 C	ASTM D445	1.9-3.05	4.13 mm2/s	5.76mm2/s
Cetane Number	ASTM D613	45-55	49min	50min
Acid value	ASTM D664	0.50mg	1.17 mg KOH/g	1.19 mg KOH/g
Moisture	ASTM E203	0.1	0.056wt/%	0.056%

Table: 2. Characteristics properties of biodiesel form marine and freshwater fish waste.

CONCLUSION

Characteristic investigation of biodiesel showed partial insignificant dissimilarity with commercial diesel fuel. However, considering the major parameters, both marine and fish oil-biodiesel were found as effective fuel products.Development of biodiesel which is a renewable alternative energy source, could easily reduce global dependence on petroleum, and could also help to reduce air pollution.

REFERENCES

1. Sakthivel, G., G. Nagarajan, M. Ilangkumaran, A. B. Gaikwad, (2014). Comparative analysis of performance, emission and combustion parameters of diesel engine fuelled with ethyl eter of fish oil and its diesel blends, Fuel, 132: 116-124.
2. Demirbas, A. (2007). Progress and Recent Trends in Biofuels. *Progress in Energy and Combustion Science*, 33: 1-18.
3. Bart, Jan & Palmeri, Natale & Cavallaro, Stefano. (2010). *Transesterification processes for biodiesel production from oils and fats.* Woodhead Publishing, Elsevier, 285-321.
4. ASTM D1298-12b. (2017). *Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method,* ASTM International, West Conshohocken, PA,,
5. ASTM D445-21. 2021. *Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity),* ASTM International, West Conshohocken, PA,.
6. ASTM D93-20. (2020). *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*, ASTM International, West Conshohocken, PA.
7. ASTM D2500-17a. (2017). *Standard Test Method for Cloud Point of Petroleum Products and Liquid Fuels,* ASTM International, West Conshohocken, PA.
8. ASTM D613-18ae1. (2018). *Standard Test Method for Cetane Number of Diesel Fuel Oil*, ASTM International, West Conshohocken, PA.
9. Vanessa F., P. J.G. Moreno, A. Guadix, E.M. Guadix, (2015), Biodiesel production from mixtures of waste fish oil, palm oil and waste frying oil: Optimization of fuel properties, *Fuel Processing Technology*,133:152-160.
10. Lin and Li, (2009). Fuel properties of biodiesel produced from the crude fish oil from the soapstock of marine fish. *Elsevier,Fuel Processing Technology,*90:130 – 136.
11. Rummi D.S., (2017). Conversion of Waste Cooking Oil to Biodiesel, *International Journal of Petroleum Science and Technology,* 11 (1): 9-21.
12. Krishna K. J., B. Jha, R. A. Prasath, (2014). Biodiesel production from discarded fish waste for sustainable clean energy development, *Journal of Chemical and Pharmaceutical sciences,* 4:133-114.
13. Cherng-Yuan Lin, Rong-Ji Li, (2009). Engine performance and emission characteristics of marine fish-oil biodiesel produced from the discarded parts of marine fish. Elsevier, Fuel Processing Technology, 90: 883–888.
14. Pavan Pujar, B. K. Venkanna, (2014). Production and characterization of biodiesel from Mackerel fish oil International Journal of Scientific & Engineering Research, 5(11): 819 – 822.
15. Chiou B.-S., H. M. El-Mashad, R. J. Avena-Bustillos, R. O. Dunn, P. J. Bechtel, T. H. McHugh, S. H. Imam, G. M. Glenn, W. J. Orts, R. Zhang, (2008). biodiesel from waste Salmon. *American Society of Agricultural and Biological Engineers,* 51(3): 797-802.
16. Savariraj, S., T. Ganapathy, C. G. Saravanan, (2013), Performance, emission and combustion characteristics of fish-oil biodiesel engine, European Journal of Applied Engineering and Scientific Research, 2 (3):26-32.
17. Yahyaee, R, Ghobadian, B, Najafi, G, (2013). Waste fish oil biodiesel as a source of renewable fuel in Iran, *Renewable and Sustainable Energy Reviews*, 17: 312-319.
18. Hong I. K., Jung W. P., Seung B. L., (2013). Optimization of fish-oil-based biodiesel synthesis. *Journal of Industrial and Engineering Chemistry*, 19:764–768.