

EXTRACTION AND CONVERSION OF FISH WASTE OIL TO BIODIESEL

Submitted in partial fulfilment of the requirements for the award of Master
of Technology degree in Biotechnology

By

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PROJECT PHASE II-REPORT

**DEPARTMENT OF BIOTECHNOLOGY
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
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This is to certify that this Project Phase II Report is the bonafide work of **MANEESWARI. T (41810011)**, who carried out the project entitled "**EXTRACTION AND CONVERSION OF FISH WASTE OIL TO BIODIESEL**" under our supervision from January 2023 to May 2023.

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ABSTRACT

Biodiesel is frequently considered to improve energy security and lessen the impact of fuel during climate change. When the life cycle of biodiesel is taken into account, there are questions regarding its impact. It is feasible to improve the performance of the assets and manage the discharge of pollution to the air, water, and land thanks to global initiatives for cleaner production. Reusing fish contributes significantly to overall environmental pollution. In this work, biodiesel made from fish is employed as a fuel alternative for stationary diesel engines. Low-solid fish were importance into the United States as raw material for the biodiesel in this investigation. After a quick technique of purification, the biodiesel pattern is carried out using a twin step esterification, transesterification, acid base process to reduce the higher FFAs content of fish oil.

Keywords: Biodiesel, Fish oil, Alternative fuel, Transesterification, Free fatty acids

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LIST OF ABBRIVATIONS

FAO	Food Authority Organisation
PUFA	Polyunsaturated Fatty Acids
GAGs	Glycosaminoglycans
ASTM	American Society for Testing and Materials
GC-MS	Gas Chromatography Mass Spectrometry
WFF	Waste Fish Fat
OPEC	Organization of the Petroleum Exporting Countries
EPA	Eicosapentaenoic Acid
DHA	Docosahexaenoic Acid
FFAs	Free Fatty Acids

1 INTRODUCTION

Biodiesel, a renewable energy source, has the potential to totally replace diesel. This biofuel has the potential to reduce pollution since it produces fewer hazardous gases than fossil fuels and is virtually totally free of sulphur and aromatic compounds. It is also recognized as being biodegradable due to how rapidly biological agents degrade it.

Alkyls of long-chain carboxylic acid ester are used to create the alternative fuel known as biodiesel which can be used as diesel. Any ratio of fat and petroleum diesel, in addition to other types of fats and oils may be used to create it. It is produced by transesterifying an alcohol and a lipid in the presence of catalyst.

A robust biodiesel industry needs to have access to cheap, plentiful raw materials. Vegetable oils like soybeans and canola are often utilized to make biodiesel on an industrial scale, which results in an excess of land used for oilseed production. In this work using cheap fish instead of veggies to gain fish oil as a replacement for fuel.

Marine environment has a huge resource of natural by-products. It is offering plenty of valuable natural products including food, medicine, fuel, industrial requirements and so on. However, overexploitation of natural resources is being a big issue today. For example, more than 91 million tons of fish are caught each year globally and only about 50-60% of the catch is used for human consumption. A small percentage of by-products have been used for human consumption and the rest of them have become wasted (Rustad *et.al.*, 2011).

According to the Food Authority Organisation (FAO) 2018, the marine fishery production has been around 108 million tons in recent years. By 35% of the worldwide harvest, a significant amount of aquaculture and fisheries products would either be lost or squandered (FAO, 2018). The creation of several lucrative by-products using these fractions would undoubtedly increase our profits from foreign exchange. By-products can be divided into numerous different categories. One method is to separate them into consumables like feed, food, fertiliser, and speciality goods. Fish meal, fish oil, fish silage, fish protein concentrates, etc., which are mostly made from under-utilised fish species and by-catch fishes, are among the significant by-products of commercial value. Due to its high moisture and nutritional content, fish is a very perishable food item that

starts to deteriorate as soon as it dies. It is the outcome of several chemical processes that the microbial invasion caused in a dead fish. In the work lot of protein- rich foods and components, such fish sauce and fish silages, from fish (Rustad *et.al.*, 2011). Products made from fish are thought to be an excellent source of several important micronutrients. The most popular and affordable sources of animal protein is fish. (Abbey *et.al.*, 2017).

Gelatin and collagen are now used in a wide range of culinary products. (Atay *et.al.*, 2018; Rahman, 2019), cosmetics and pharmaceutical/biomedical products. The industrial use of collagen has been limited to bovine skin, porcine skin, and bone. Scales, fins, bones, and skin of fish have all been extensively researched as potential sources of collagen. In addition, it has been discovered that additional collagen sources include the adductor of pearls oysters, the muscular layer of ascidians, and the mantle of scallops. By-catch and by-products of fisheries are the primary sources of fish oil. (Rustad *et.al.*, 2011).

The by-products of the fish business are cartilaginous tissues. They include important glycosaminoglycans (GAGs), namely chondroitin-4-sulfate and chondroitin-6-sulfate, which are found as proteoglycans and come from marine sources as opposed to those from terrestrial creatures.

Recent years have seen a rise in the usage of oils made from fossil fuels due to the growing population and quick industrialisation. The sustainability of the world's energy supply is continually threatened by the need for fossil fuels in industries like heating and electricity generating. Additionally, the development of internal combustion engines and the transportation industry are causing a quicker pace of exploitation of petroleum reserves. In addition, using fossil fuels causes environmental pollution. Therefore, due to the reasons that fossil fuels are reducing and its adverse environmental impacts, there is a need to search for an important alternative energy source (Behçet, 2011). Consequently, the globe must overcome the issue of the scarcity of fossil fuels and bring down how much energy costs. The only potential renewable energy source that solves the issue of the market's rising energy fuel

prices is biomass. Due to the shortage of petroleum production from Organization of the Petroleum Exporting Countries (OPEC), intensive research for alternative source for biodiesel started (Kahn *et al.*, 2002). It is seen as a substitute fuel that addresses the issues of environmental degradation and a worldwide energy shortage (Edlund *et al.*, 2002).

Additionally, it will take the place of petro-diesel, reducing the amount of pollutants produced by combustion equipment (C.Y Lin and H.A Lin., 2006). Vegetable oil, animal oil, waste oil, waste from plants and animals, agricultural byproducts, and municipal waste are all possible sources for biodiesel manufacturing (Balat, 2008). Recent research has focused on using vegetable oil, used cooking oil, and industrial oil to produce biodiesel. The created biodiesel may be recycled several times, has a higher flash point, is more easily degradable, and produces less pollutants. Because biodiesel's physical and chemical characteristics are comparable to those of diesel, it may be combined with diesel oil and utilised in engines (Zhao, 2012). One of the basic materials used to make biodiesel is thought to be fish excrement. 60–70% of the total fish produced is utilised for human consumption, as well as for the manufacture of fishmeal and oil (Eslick *et al.*, 2009). Due to the fact that fish oil is thought to have several therapeutic purposes (Sharma *et al.*, 2014). Most fish portions are not consumed; others are even thrown away. Backbones, skin, skulls, tails, and stomachs are among the inedible and wasteful body parts.

It is found in the literature that fish oil contains more than 60 different fatty acids. They are divided into four categories of fatty acids, including (a) C14:0 and C16:0, (b) C16:1 and C18:1, (c) C20:1 and C22:1, and (d) C20:5, C22:5, and C22:6. Approximately 80–85% of these fall into these categories. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which make up more than 90% of all polyunsaturated fatty acids, are added to fish oil (PUFA). Currently, fish oil is a viable feedstock for biodiesel production, but there is little study on the resulting fuel (Nelson and Schrock, 2006). The study demonstrates that there are just a few uses for fish waste. About half of the entire amount of fish processed is garbage. Between 40% and 65% of the total oil content is oil (Wisniewski Jr *et al.*, 2010). As a result, there is

potential for using this fish waste to create biodiesel. According to the literature, wasted fish waste may be turned into useful goods like biodiesel, manure, and biogas as well as used for energy production (Yahyaee et.al., 2010). The biowaste can be converted by biological, physical, or chemical processes into bio-gas, bio-oil, and bio- char (Balat and Demirbas, 2006). Gasification, pyrolysis, and anaerobic digestion all yield bio-gas (Demirbas et al., 2006). By using partial gasification with steam or CO₂, pyrolysis, or chemical activation, bio-char can be produced. Pyrolysis, fermentation, hydrolysis, and extraction or conversion procedures are used to create bio-oils (Jayasinghe and Hawboldt, 2012). Trans esterification, a straightforward chemical process, produces the bio-based energy oil. In this reaction naturally available oils and fats made up of triglycerides combines with alcohol (i.e. methanol or ethanol) in the presence of a catalyst to produce biodiesel (mono alkyl esters of fatty acids) (Meher et.al., 2006).

2 Literature survey

The annual production of fish waste by fish processing facilities is in billion tones. When these wastes are discharged into the environment, they produce pollutants that damage the soil. Their conversion into biofuel, pharmaceutical components, fertilizer, and feed is an alternate approach to the issue. A popular idea and fuel substitute for modern fuels is biofuel. Because they don't cause pollution, biofuels have an advantage over conventional fuels. Seaweed, microalgae, and organic waste are all used to make biofuels. Because fish wastes are harmless and biodegradable, there is now a lot of investigation into using them to make biodiesel (Yuvaraj *et.al.*, 2016).

Energy security is crucial to the global economy as fossil fuel supplies are quickly running out. The need for alternate energy sources has led to studies into using leftover food as next-generation fuel. Due to its ability to lower greenhouse gas emissions, biodiesel is typically seen as being ecologically benign. Fish wastes with high fatty acid content can be utilised as the starting material for a transesterification process to make biodiesel. The findings indicated that all of the triglycerides were effectively methylated to methyl esters since the seven peak are fatty acid methyl esters in Gas Chromatography with Flame Ionization Detection(GC/FID). Under engine loads of 15 (Nm), fish-based biodiesel significantly reduced carbon monoxide (CO) and hydrocarbon (HC) emissions without modifying the engine. The generated biodiesel's viscosity was within the acceptable range for international norms (ASTM). In comparison to conventional diesel, the biodiesel was shown to have a low base number and reduced specific fuel consumption. The work suggested that wasted fish oil could be used as a source of biodiesel for commercial purposes(Saifuddin and Boyce, 2017).

2.1 Oil extraction methods

2.1.1 Wet reduction(wet pressing)

In the wet reduction method, 200 g of ground fish by- products were combined with 1 L of water and boiled at 95°C for 15 minutes after being thawed at room temperature for 12 hours. The tissues were first pressured after cooking, and then water was removed by centrifuging together with the oil (Centrikon T-124, Kontron Instruments). technique of enzyme extraction. Protease (alkalase) of food grade (bacterial protease from *Bacillus licheniformis*, Novozyme, Denmark) was added to the samples along with 1000 g of milled raw material. The samples were then hydrolyzed for 120 minutes at 56°C with the enzyme at a ratio of 1/20 to the substrate. Then centrifugation was performed at speed 104 g and temperature 20°C for 10 minutes, and the hydrophilic phase was separated (Gbogouri *et.al.*, 2006).

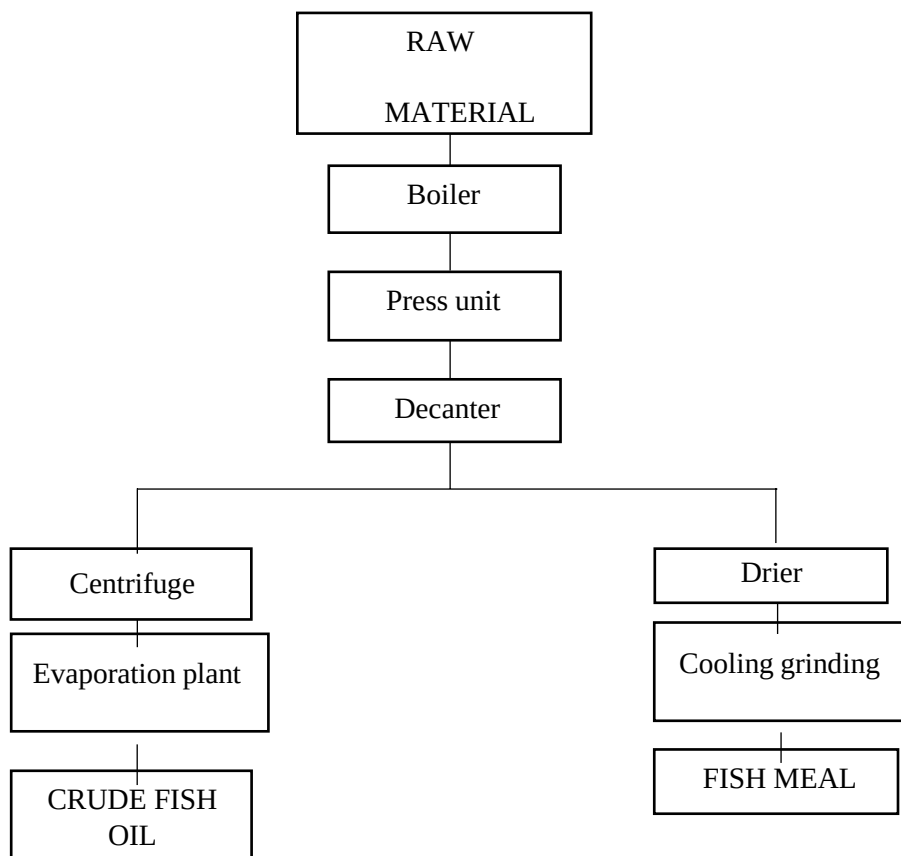


Figure 2.1 : The Flowchart for producing fish oil from fish waste

2.2 The conditions for biodiesel production

Transesterification was performed on filtered fish oil after it had been cooked inside the oven for around 15 minutes at 60°C.

In order to create biodiesel from leftover fish oil, transesterification was carried out using methanol. In this process, oil and alcohol were utilised in a 1:6 molar ratio. As a catalyst, sodium hydroxide (NaOH) was employed. 1% of the utilised oil's weight in base catalyst (NaOH) is required. On the hotplate with a magnetic stirrer spinning at a speed of 250 rpm, a mixture of the catalyst and the solvent methanol was heated for two hours at 55.2 °C.

2.2.1 Transesterification process

Transesterification is a catalytic reaction that converts lipids into fatty ester methyl esters and glycerol as coproduct through four steps. The first step is preparing the catalyst and mixing the catalyst with alcohol. The second step is the transesterification reaction that takes place through the reaction between the mixture of catalyst/alcohol and with the fatty acid (triglycerides). The optimum temperature range is about 40–60°C for transesterification reaction, and the rate of reaction increases with the increase of temperature. The third step is to separate glycerol from biodiesel, and the fourth step concerns the addition of water to both the biodiesel and glycerol for purification, especially the glycerol that may remain in the biodiesel. The acid should be added to glycerol for the production of neutralized glycerol.

Transesterification process facilitates the recovery of the high amount of mixture of fatty esters, but it requires a high amount of alcohol to prevent the production of soap, which is an unwanted reaction. Enzymes (i.e., enzymatic reaction) can be used instead of catalysts, but the lipases that are mostly used in the enzymatic reaction are expensive; thus the high cost makes the enzymatic reaction less effective than chemical reactions, and the reaction rate is slow and the productivity is low.

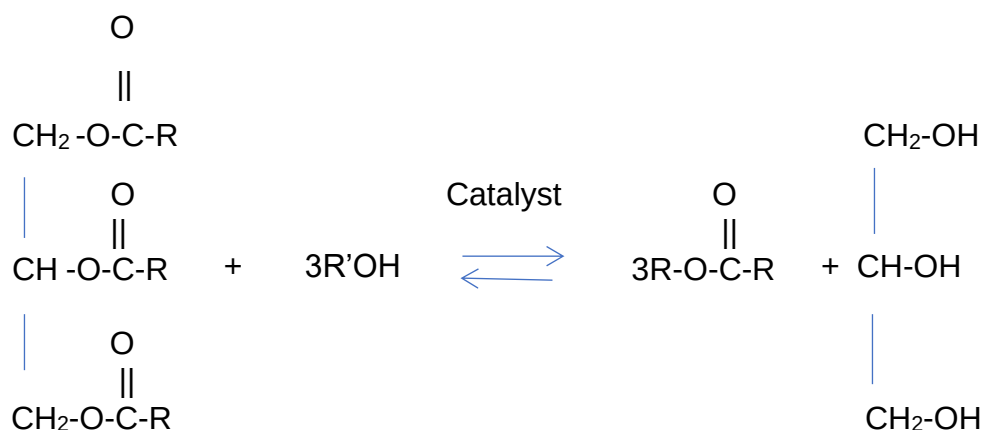


Figure 2.2 Transesterification of triglyceride with methanol in presence of NaOH

2.2.2 Biodiesel production

The solution was divided into two different layers, crude biodiesel and glycerol, following the transesterification procedure (Figure 2). This was caused by the fact that the two layers had different center of gravity. The solution in the conical flask was then moved into a beaker, which has a greater surface area, allowing the methanol to evaporate more quickly (Lin *et.al.*, 2009).

2.3 Biodiesel analysis and characterization

The primary goal of a biodiesel analysis using a gas chromatography-mass spectrometer (GC-MS) is to find the methyl esters contained in the generated biodiesel. In the Tribology Laboratories of the Mechanical Engineering Department inside the College of Engineering, University of Malaya, biodiesel characterization was completed. The test techniques used to determine the viscosity of biodiesel were American Society for Testing and Materials (ASTM D445, ASTM D664, ASTM D4739), acid value number, total base number, and multi-element, respectively.

For alkaline transesterification, 1% catalyst concentration is the ideal level. Revealed that up to a catalyst concentration of 1%, as catalyst concentration rises, so does

biodiesel yield. The molar ratio of oil to methanol must be 1:6 in order to produce the highest amount of biodiesel(Bhatti *et.al.*, 2008).

Theoretically, the reactions of methanol with triglycerides can produce methyl esters at a ratio of 1:3 oil to methanol. The response, however, might be going forward or backward. Numerous investigations have demonstrated that a ratio of 1:6 is adequate for the high output of methyl esters. Maximum oil: methanol proportion of 1:6 was chosen in this experiment in order to make the manufacture of biofuel more economically feasible, and it led to the experiment's highest conversion rate (Guan *et.al.*, 2008; Hossain & Boyce 2009).

Table 2.1 Optimum conditions for biodiesel production

Parameters	Value
Temperature	55°C
Retention time	2 h
Catalyst concentration	1% (w/v)
Alcohol oil ratio	6:1
Stirring speed	250 rpm

2.4 Important properties of the waste fish fat

In the current approach, catalytic cracking is used to create biofuels using fish oil industrial effluents. About 54% of the fish output is converted into waste, such as offal, bones, skin/scales, etc. Heads, bones, tails, and other debris are used to create fish oil.

These wastes are composed of 42% fish oil and 54% water (15% of the total bulk). The fish was processed through a number of steps to generate edible fish oil, beginning with fully heating it in boiling water, pressing it, and centrifuging the final product to remove the crude oil, water, and other contaminants. The crude oil underwent filtering and winterization to remove any naturally occurring waxes or fats and make it limpid.

Waste fish fat is the term for the remaining fish oil (WFF). The WFF, residue from this treatment amounts to 4,000 tonnes per year and is entirely made up of triglycerides. The SIRH group, a French company that specializes in vegetable, animal, and marine oils, provided the feedstock (waste fish fat) utilised in this study (Blin *et.al.*, 2007). This trash, which really is brown in colour and was utilised without any additional purification, is the byproduct of treating marine oil. Gas chromatography research Gas Chromatography With Flame Ionization (GC/FID) has been used to examine the usual fatty acid content, and the results are provided (Blin *et.al.*, 2007)

Table 2.2 Important properties of the waste fish fat

Properties	Waste fish fat
Visual aspect	Liquid at 60°C ,brown color,typical smell
Water content (%)	<0.05%
Flash point (°C)	318
High heating value (kJ/kg)	39,000
Kinematic viscosity (mm ² /s)	27
Density (Kg/m ³)	893
Myseric	1.05
Palmitoleic	5.00
Palmitic	16.00
Stearic	10.50
Oleic	45.60
Linoleic	20.60

2.5 Properties of biodiesel and diesel

Table 2.3 Properties of biodiesel and diesel

Properties	Unit	Standard test method	Biodiesel	Diesel fuel
Flash point	°C	ASTM D93-94	57	56
HHV	MJ/kg	ASTM D2015-85	45,10	45,71
Dynamic viscosity at 20°C	Ns/m ²	ASTM D7042	2.32	2.52
Density at 20°C	Kg/m ³	ASTM D4052-91	825	830
Kinematic viscosity at 20°C	Mm ² /s	ASTM D445	1.7	2
Cetane number		ASTM D613	57	52
Cloud point	°C	ASTM D2500-91	9	-
Pour point	°C	ASTM D97-93	-5	-
Cold filter plugging point	°C	ASTM D6371	14	-

2.6 World biodiesel production and its composition

The Austria is world's largest producer of biodiesel while having the highest production costs. This represents the greatest proportion of diesel vehicles in Europe, which in 2018 accounted for 35.9% of new passenger vehicle sales and comprised 41.9% of a vehicle fleet (Meher *et.al.*, 2006). The member nations, however, have quite different percentages; for instance, in Spain, it was 60.0%, France, 51.9%, Italy, 44.4%, and Germany, 32.2% (Meher *et.al.*, 2006). In the other key producing nations, biodiesel is mostly utilised in buses and other light, medium, and heavy commercial vehicles. It is also blended with petroleum in accordance with the various country- specific blending laws. Diesel passenger cars play a very small part in the USA, but Brazil has a substantial number of flexible-fuel vehicles.

The output of biodiesel is anticipated to fall by 2.53% during the following ten years, although the market's structure is not anticipated to alter dramatically .

In 2029, the TOP5 producers will remain the same. The shares of the EU, the USA, and Indonesia will gradually decline. In contrast, Brazil and Argentina's shares are anticipated to rise.

In addition to being utilised in commercial cars, biodiesel is also added to petroleum. Its ownership stake might range from 1 (B1) to 100%. (B100). Blending requirements are a significant and consistent component of the biodiesel demand. Mandates for biodiesel mixing differ from country to country(Feroldi *et. al.*, 2013).

3 Aim and Scope

AIM

To produce biodiesel from fish oil

SCOPE

- The scope of biodiesel from fish oil is still relatively small, but its potential is increasing. Fish oil can provide an alternative source of biodiesel feedstock, with the potential to reduce our reliance on fossil fuels.
- It can help reduce carbon emissions, while providing a renewable and sustainable energy source.
- It has been used successfully in some countries, and is being explored as a viable option for other countries. In addition, fish oil can be used to help reduce the amount of plastic waste that is generated and also to reduce the amount of oil that is used for energy production.
- To produce a sustainable, environmentally friendly fuel that can be used in place of traditional fossil fuels.
- It has the potential to reduce greenhouse gas emissions and promote energy independence.

4 Materials and methods

4.1 Oil Extraction

Several studies have been developed around the extraction and quality analysis of oil obtained from different fish species, as well as by-products of their processing, in which different techniques are used, such as supercritical fluids, wet pressing, extraction using solvents, and fish silage employing enzymes present in fish or from other sources .

The extraction of fish oil by wet pressing is the most commonly used method for production on an industrial scale, and is basically carried out in four stages: fish cooking, pressing, decantation and centrifugation .

4.2 Raw Materials

The fish processing waste used in this current study was collected from a local fish market. The less valuable edible parts of fish like heads, tails, fins, organs were taken as fish waste and used for the production of biodiesel.

4.3 Wet pressing

Fish waste was collected from local fish market in sollinganallur. Put the fish waste in becker . Add 1 liter of water to coveer and cook on pressure over medium heat for 15 to 30 minutes. After 30 minutes strain using a fine metal strainer when cool enough pour in the glass jar.after it set,the oil starts to flot on top of water transfer the oil to centrifuge tube and keep for centrifuge for 30 min in 4000 rpm then the oil will be rised and can be separated in a clean container then can be given for further fatty acid analyas.



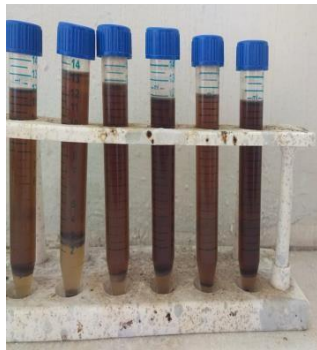
Fish waste



Put in to the becker



Steam over the heat



Fish waste oil



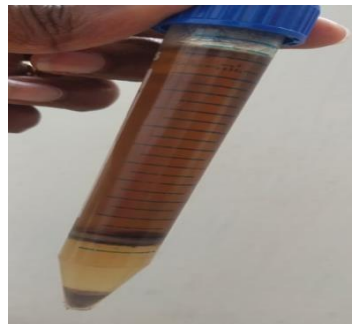
Strain using metal strainer



Oil seperated on top



Centrifuge for 30 min in 4000 rpm



Oil and water will seperated

Figure 4.1 : Fish waste oil extration process



Figure 4.2 : FISH OIL FROM FISH WASTE

4.4 Transesterification

Transesterification is an organic reaction in which the R group of an alcohol is exchanged with an R' group of an ester. This is generally done via the introduction of an acid or base catalyst to the reaction mixture. However, it can also be done using certain enzyme catalysts (such as lipases). An illustration detailing the exchange of an R' group belonging to the alcohol with the R'' group of an ester in a transesterification reaction.

When catalyzed by an acid catalyst, this reaction proceeds via the conversion of the carbonyl group through the donation of a proton to it. On the other hand, base catalysts take a proton away from the alcohol group, resulting in the formation of a highly nucleophilic alkoxide ion.

It can be noted that methyl & ethyl esters can be used to form esters with relatively large alkoxy groups via the process of transesterification. This is usually done by heating the ester (methyl or ethyl) with the acid/base catalyst and the alcohol having a large alkoxy group, and subsequently evaporating off the smaller alcohol in order to drive the equilibrium reaction in the required direction.

Transesterification is nothing but exchanging of organic group R of an ester with organic group. This process is very important in production of biodiesel. This process

triglyceride obtain from fish oil is react with methanol and this reaction gives glycerol and methyl ester. There are three basic routes to biodiesel production from oil and fats.

1. Base catalyzed tranesterification of the oil.
2. Direct acid catalyzed tranesterification of the oil.
3. Conversion of the oil to its fatty acids and then to biodiesel.

Mostly used base catalyzed method biodiesel is produced using base catalyzed tranesterification as it is the most economical process requiring only low temperature and pressure and producing a 98% conversion yield.

4.4.1 Characteristics

Biodiesel characteristics as a fuel vary depending on its composition, and the fuel used to be stringently monitored to avoid adverse impacts on the environment and engines. A very important consideration in the efficiency of combustion is the ignition delay in the combustion, which is influenced by the ratio of compression adopted, which in turn is related to the kind and quality of fuel used. The physicochemical properties of the biodiesel may vary depending on the source from which the mixture of fatty acids was obtained, from the transesterification and separation efficiency process. Factors such as hydrocarbon chain length, branching, and degree of saturation influence their composition; hence, quality control is important to guarantee combustion efficiency and lower atmospheric emissions. The properties of the biodiesel give an indication of whether it would be suitable or not for the performance, life and emission of the engine. So, the main properties of biodiesel such as the acid number, calorific value, viscosity, density, flash point, fire point, cloud point, pour point, ash content and carbon residue content.

4.5 Materiels

Waste Fish Oil (WFO) sample used in this study. The chemicals were used without any prior purification: Sodium hydroxide ($\geq 97\%$), ethanol ($\geq 99.9\%$) .

4.5.1 Methods

Pour 105 milliliters methanol into the glass blender pitcher. Turn the blender on its lowest setting and slowly add 3.5 grams sodium hydroxide. This reaction produces sodium methoxide, which must be used right away or else it loses its effectiveness. Mix the methanol and sodium hydroxide until the sodium hydroxide has completely dissolved. Heat the 350 ml of oil until it reached 60°C. Turn off heat. Add the sodium hydroxide methanol mixture in to the oil. Continue blending this mixture (on low speed) for 20 to 30 minutes. After stirring let the mixture leave for 24 hours. You will see the liquid start to separate out into layers. After 24 hours decant to separate the biodiesel from glycerol. The bottom layer will be glycerin. The top layer is biodiesel. Add the distilled water in the biodiesel. mix it well and pour it in to separating funnel. It will separate in to biodiesel from impurities. Repeat this process three to four times to remove excess contaminants and leftover production chemicals from biodiesel. Finally, filter the biodiesel by using filter paper. Transfer the biodiesel into new container.



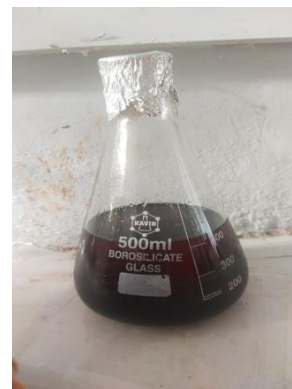
Ethyl alcohol mixture



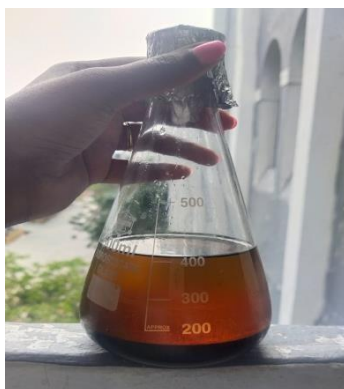
Fish waste oil



Add the Ethyl alcohol mixture in
to Fish waste oil



After stirring the mixture



After 24 hours



Glycerol and biodiesel
were separated





Separated biodiesel



Added distilled water in biodiesel



Biodiesel and impurities were separated



Filter the biodiesel by using
filter paper



Again washing

Figure 4.3 : Tranesterification process

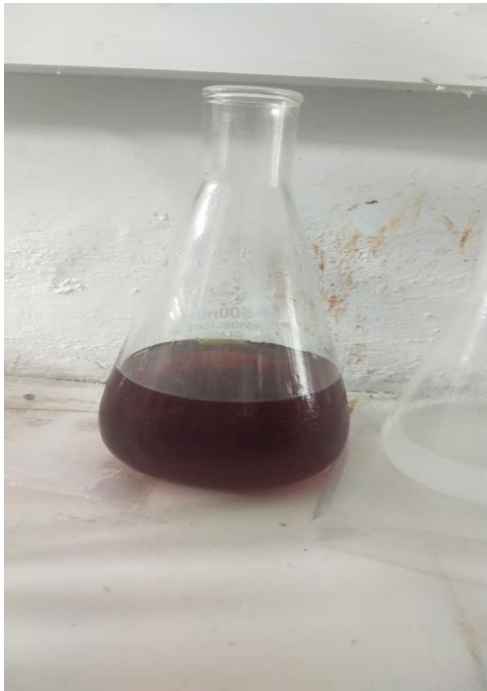


FIGURE 4.4 : FISH WASTE OIL



BIODIESEL FROM FIFH WASTE OIL

4.6 Properties of biodiesel

TABLE 4.1 : PROPERTIES OF BIODIESEL

PARAMETER	UNITS	METHODS	APPARATUS REQUIRED	REACTION TIMETAKEN	BIODIESEL
Kinematic Viscosity	CST	ASTM	Canon- Fenske viscometer	122 sec	5.04 cSt
Calorific value	Cal/g	ASTM	Bomb calorimeter	22 min	9466.49 Cal/g
Flash point	(deg C)	ASTM	Pinsky- martens closed-cup	15 min	152
Fire point	(deg C)	ASTM	Pinsky- martens closed-cup	15 min	160

4.7 Engine test

The different blend levels adopted for the Engine testing study are Diesel 100% (D100), Biodiesel 20% and diesel 80% (B20), Biodiesel 40% and diesel 60% (B40), Biodiesel 60% and diesel 40% (B60), Biodiesel 80% and diesel 20% (B80) and Biodiesel 100% (B100).

4.7.1 Diesel Engine

An internal combustion (IC) engine, the diesel engine ignites the fuel after it has been introduced into the combustion chamber at a high temp that petrol reaches when it is considerably compressed. Unlike spark-ignition engines, like gasoline engines or gas

engines, which ignite an air-fuel mixture using a spark plug. A diesel engine has the greatest thermal effectiveness of any imaginable internal or external combustion engine due to its enormous growing proportion and inherent lean burn, which encourages heat dissipation through the excess air. Diesel motors with two and four strokes are both made. In this experiment, a four-stroke diesel engine is being used. The piston completes four different strokes while the crankshaft revolves in a four-stroke engine, a kind of internal combustion (IC) engine. A piston's whole motion along the cylinder, whether in one direction or the other, is known stroke. The four different strokes are referred to as:

- Intake: The intake stroke of a diesel engine begins with the piston moving downward, which creates a vacuum in the cylinder. This vacuum draws in air through the intake valve.
- Compression: Once the air is drawn into the cylinder, the piston moves upward, compressing the air. This compression raises the temperature of the air to a point where it can ignite the fuel.
- Combustion: Fuel is delivered into the cylinder just as the engine's piston reaches the peak of its stroke. Gases quickly expand as a result of the fuel being ignited by the heat produced by the compressed air. By pushing the piston downward, this expansion generates power.
- Exhaust: As the piston moves downward, it pushes the exhaust gases out of the cylinder through the exhaust valve. The cycle then repeats itself, with the piston moving upward to begin the intake stroke again.

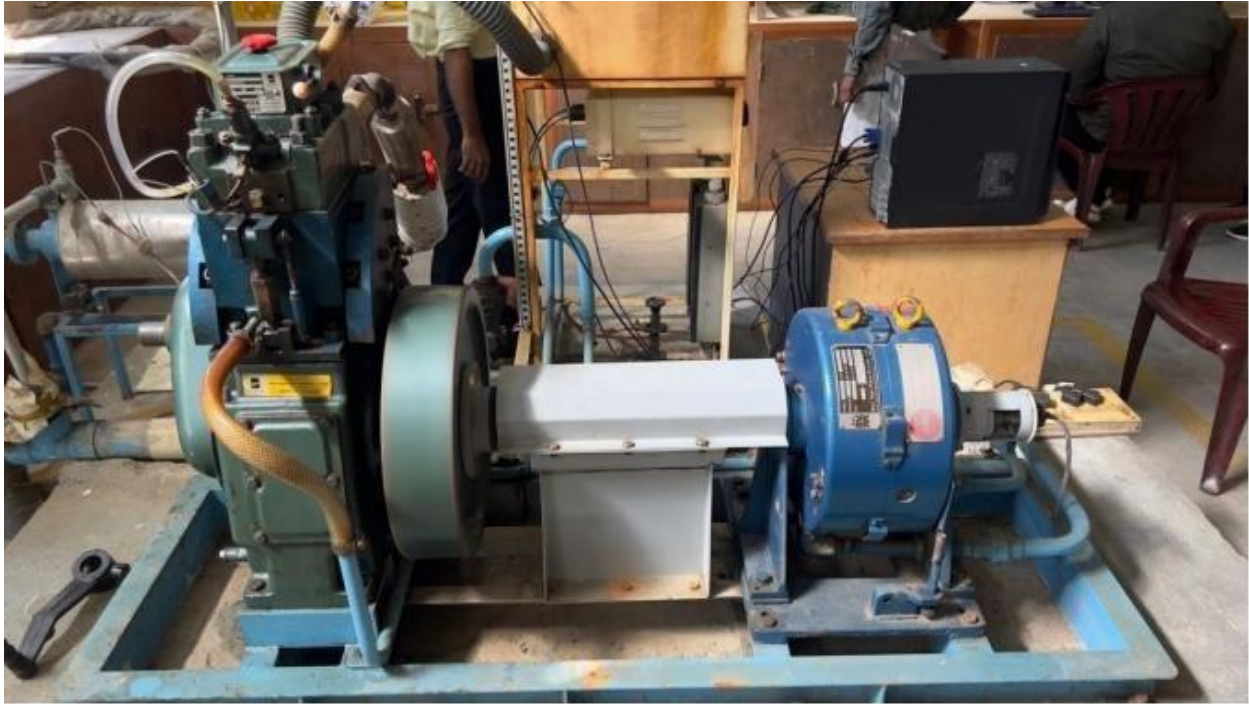


FIGURE 4.5 : Engine setup

Description: From fig 4.5 we evaluate that, An eddy current dynamometer is connected to a single- cylinder, four-stroke diesel engine with an electronic start and a variable compression ratio for loading. The compression ratio can be changed utilising a specially designed tilted cylinder block arrangement without shutting down the engine or changing the geometry of the combustion chamber. The system is equipped with the instruments needed to measure combustion pressure and crank angle. The signals in question are connected to the comput for PPV diagrams via the engine indicator. There is also space for the interface of temperature, fuel flow, airflow, and load monitoring.



FIGURE 4.6 : Engine Testing

5 Result and Discussion

5.1 Result

5.1.1 Confirmation Test for Bio-diesel

The confirmation test was carried out to determine the degree to which the oil (triglyceride) is converted into biodiesel (fatty acid methyl ester). The degree of conversion is a significant aspect in assessing the quality of biodiesel. The test is generally carried out in any ratio of 9 parts methanol to 1 part biodiesel (i.e. 25 ml of biodiesel was mixed with 225 ml methanol in a volume ratio in a test tube). It can be observed in the next 30 minutes that no oily material settles at the bottom of test tube showing formation of highly converted biodiesel. Three batches of experiment were conducted with the above procedure and all the time clear solution was obtained.

5.1.2 Test for Checking the Purity of Bio-Diesel

One part of biodiesel is combined with one part of water (50/50 proportion) and shaken thoroughly. Then the resulting mixture separates very fast and the biodiesel layer appears clearly and brightly on the top whereas the water phase appears clearly at the bottom.

5.1.3 Testing the Properties of Biodiesel and Comparison with the Petro-Diesel

The properties of biodiesel produced was evaluated by testing various parameters such as pour point, cloud point, sulfur content, acid number and kinematic viscosity as per the ASTM standards. The values were promising when compared with values of petrodiesel.

5.1.4 Gas Chromatography-Flame Ionization Detection (GC-FID)

Gas Chromatography-Flame Ionization Detection (GC-FID) is an analytical technique that is used to separate and analyze mixtures consisting of volatile components. GC-

FID is particularly useful in detecting and quantifying organic compounds, such as fatty acids in food and resin acids in water.

In FID, analytes combust in a hydrogen-air flame as they exit the column, producing carbon ions that induce a current in nearby electrodes. The current is directly proportional to the carbon mass, thus, the concentration of the compound can be determined.

The normal working range is between 0.1 and 100000 ppm for FID and 0.2–2000 ppm for PID. PID/FIDs are commonly used for detecting volatile organic compounds (VOCs) such as benzene/toluene/xylene, vinyl chloride, and hexane, and provide quick response for this growing concern.

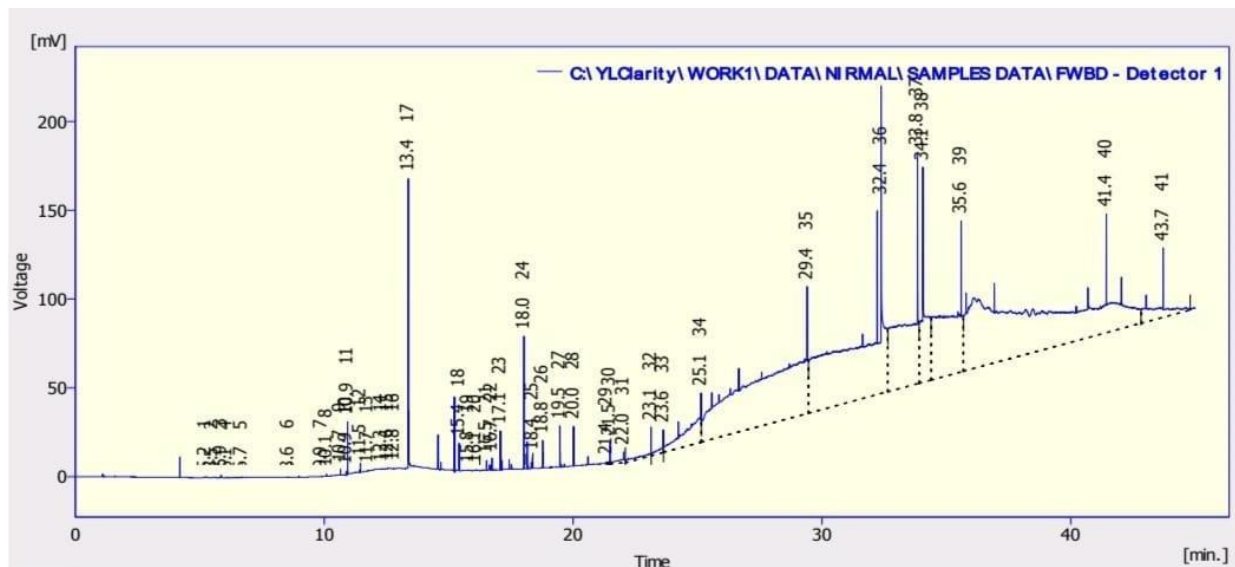


FIGURE 5.1 : GC/FID (Gas Chromatography-Flame Ionization Detection)

TABLE 5.1 : Gas Chromatography-Flame Ionization Detection Tabulation

	Reten.Time (min)	Area (mV.s)	Height (mV)	Area (%)	Height (%)
1	5.223	4.023	0.596	0.0	0.1
2	5.513	2.623	0.298	0.0	0.0
3	5.853	1.922	1.416	0.0	0.1
4	6.073	0.805	0.298	0.0	0.0
5	6.677	4.798	0.522	0.0	0.0
6	8.553	16.436	0.316	0.1	0.0
7	9.880	6.430	0.381	0.0	0.0
8	10.090	2.831	1.346	0.0	0.1
9	10.653	23.156	3.956	0.1	0.3
10	10.883	1.661	2.642	0.0	0.2
11	10.937	15.035	30.473	0.0	2.6
12	11.453	50.999	6.859	0.2	0.6
13	11.733	40.606	2.776	0.1	0.2
14	12.287	105.619	3.453	0.3	0.3
15	12.560	67.309	3.632	0.2	0.3
16	12.797	90.435	3.520	0.3	0.3
17	13.373	449.106	166.262	1.5	14.0
18	15.420	10.885	15.727	0.0	1.3
19	15.783	11.444	0.713	0.0	0.1

20	16.083	6.132	0.634	0.0	0.1
21	16.527	6.847	5.813	0.0	0.5
22	16.740	7.294	7.081	0.0	0.6
23	17.077	14.216	22.209	0.0	1.9
24	18.020	25.466	74.921	0.1	6.3
25	18.373	4.098	6.359	0.0	0.5
26	18.777	6.631	15.493	0.0	1.3
27	19.467	11.250	23.258	0.0	2.0
28	20.020	25.332	22.498	0.1	1.9
29	21.353	19.670	0.897	0.1	0.1
30	21.483	11.385	11.928	0.0	1.0
31	22.030	52.825	6.178	0.2	0.5
32	23.133	79.378	16.119	0.3	1.4
33	23.623	60.722	12.704	0.2	1.1
34	25.140	702.322	27.692	2.3	2.3
35	29.403	6359.279	71.591	21.1	6.0
36	32.380	5924.672	173.205	19.6	14.6
37	33.843	2667.174	130.104	8.8	11.0
38	34.053	1064.017	121.099	3.5	10.2
39	35.600	2608.880	84.817	8.6	7.2
40	41.433	9106.494	66.660	30.2	5.6
41	43.713	530.034	39.114	1.8	3.3

	Total	30200.243	1185.560	100.0	100.0
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5.1.5 Engine test results

The smoke emission test revealed that **B40** (biodiesel blend with 40% biodiesel and 60% diesel) had the least black smoke compared to the conventional diesel. Diesel engine performance test indicated that the specific fuel consumption of biodiesel blend was increased sufficiently when the blending ratio was optimized.

TABLE 5.2 : Engine test result blending 40%

BLEND	CO	HC	CO2	O2	NOX
S1	0.009	2	0.3	20.3	38
	0.01	4	0.7	19.9	92
	0.015	7	0.9	19.7	176
	0.017	9	1.1	19.1	246
	0.021	11	1.3	19.1	417

5.1.6 Hydrocarbon Emission

Table 5.3 Hydrocarbon emission

	0	0.875	1.75	2.62	3.5
S1	2	4	7	9	11
Diesel	2	6	10	15	19

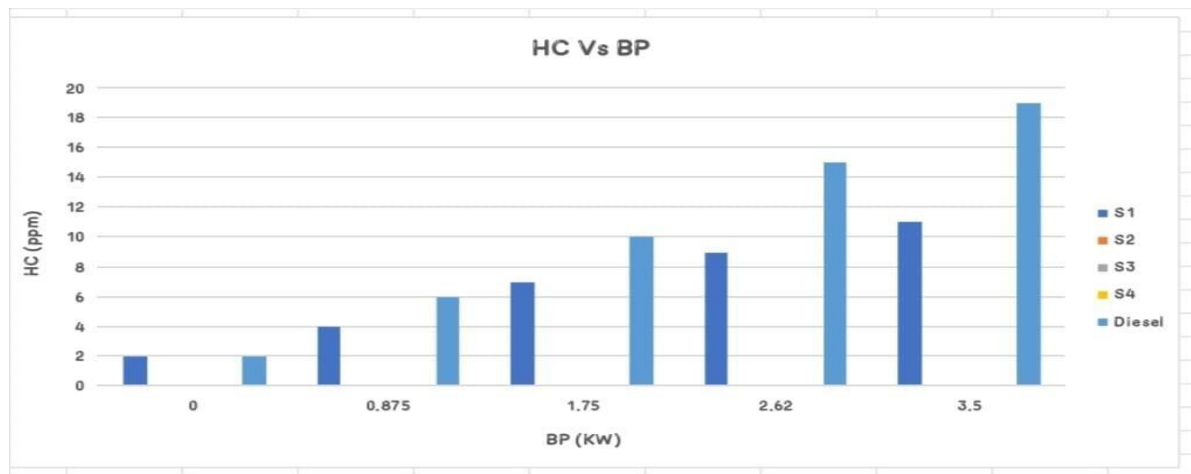


Figure 5.2 Hydrocarbon emission Vs Brake power

5.1.7 Carbon Monoxide Emission

Table 5.4 CO emission

	0	0.875	1.75	2.62	3.5
S1	0.009	0.01	0.015	0.017	0.021
Diesel	0.008	0.013	0.018	0.023	0.029

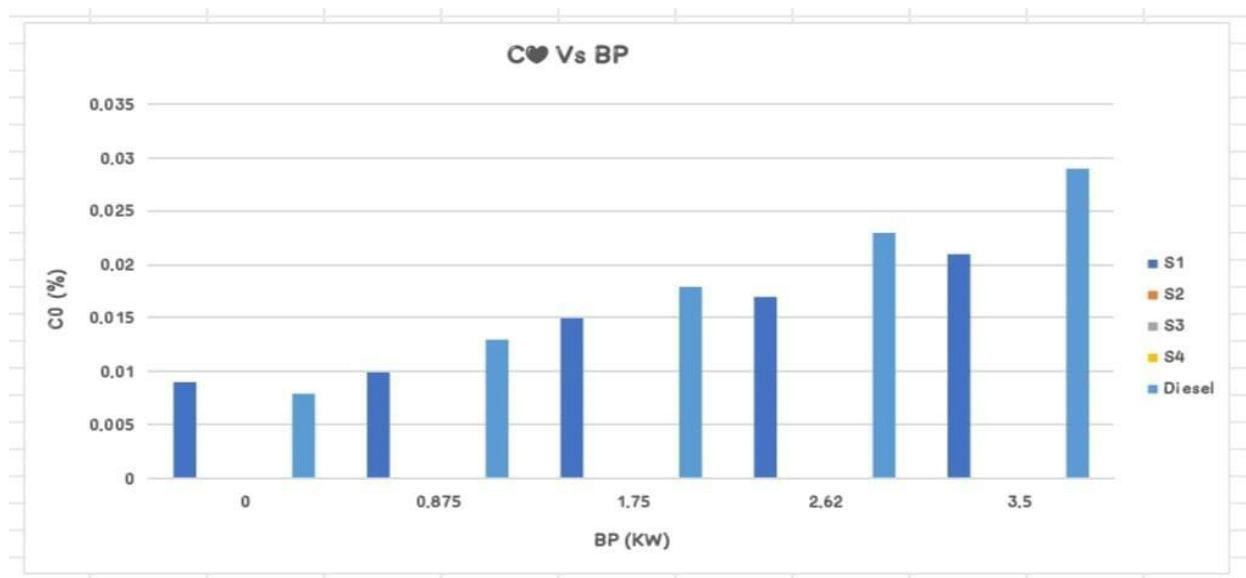


Figure 5.3 CO emission Vs Brake power

5.1.8 NOx Emission

Table 5.5 NOx Emission

	0	0.875	1.75	2.62	3.5
S1	38	92	176	246	417
Diesel	56	156	289	485	750

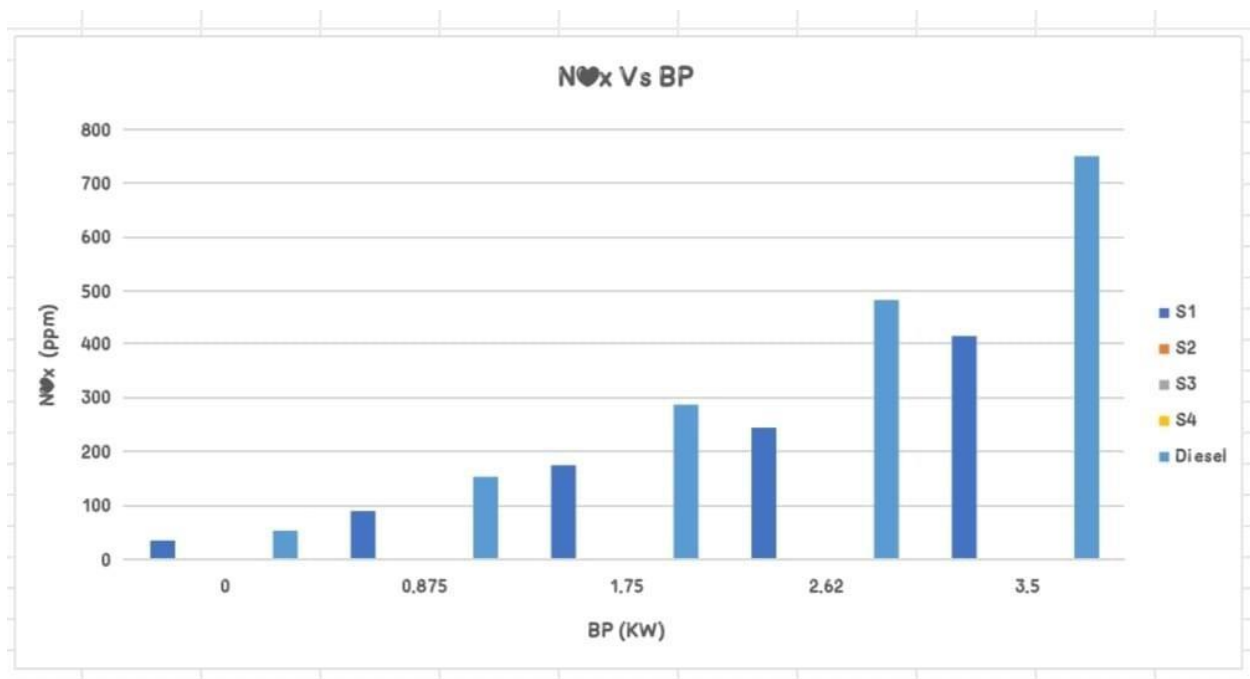


Figure 5.4 NOx emission Vs Brake power

5.1.9 CO2 emission

Table 5.6 CO2 emission

	0	0.875	1.75	2.62	3.5
S1	0.3	0.7	0.9	1.1	1.3
Diesel	1.6	1.96	2.54	2.89	2.98

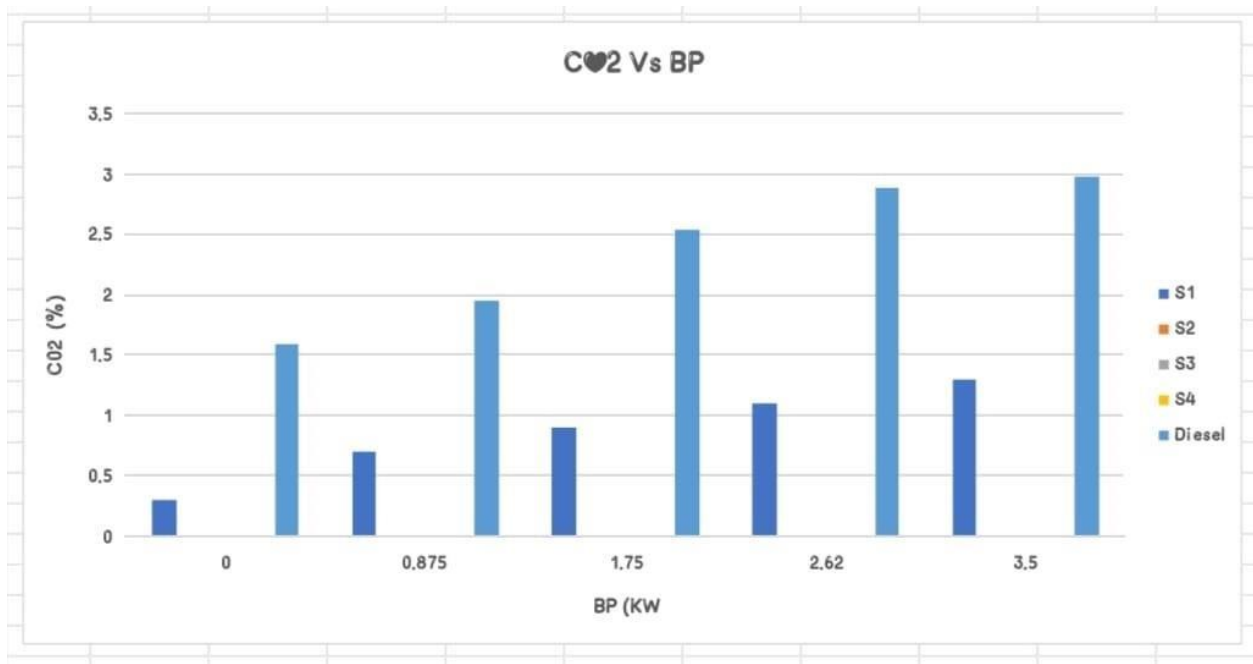


Figure 5.5 CO2 emission Vs Brake power

5.1.10 O2 Emission

Table 5.7 O2 Emission

	0	0.875	1.75	2.62	3.5
S1	20.3	19.9	19.9	19.4	19.1
Diesel	18	19	15	12	11

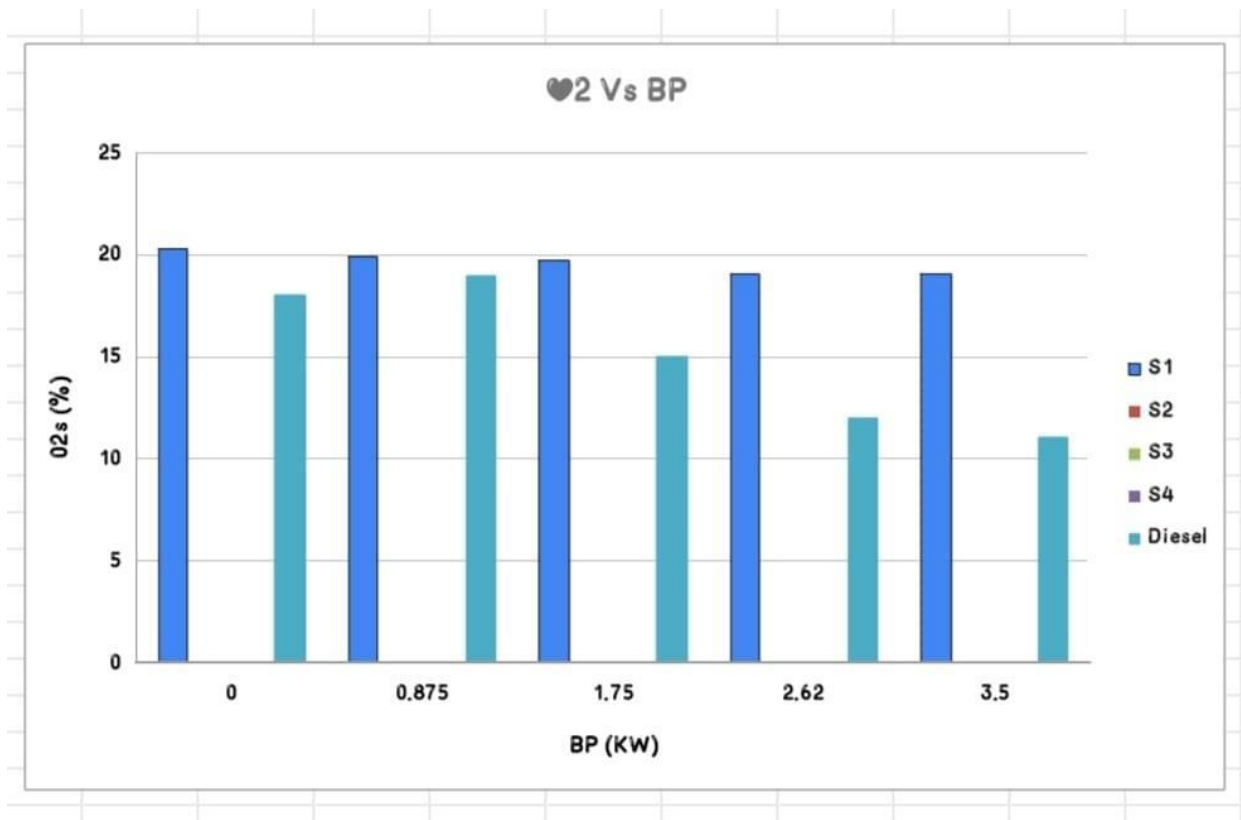


Figure 5.6 O₂ Emission vs Brake power

5.1.11 Cost analysis

A economic analysis was performed to compare the costs of waste fish oil biodiesel with that of salmon oil and soybean oil biodiesel . Supposing that the only difference between waste fish, salmon and soybean oil biodiesel plants hardware would be the costs of raw materials used for biodiesel production. At a cost of 0.69 US \$/l for waste fish oil biodiesel compared to 1.065, 0.527, and 0.91 US \$/l for salmon biodiesel, soybean biodiesel and diesel fuel respectively, it is easy to see why waste fish oil biodiesel blend make good economic sense. Future efforts will focus on assessing.

5.2 Discussion

Fish oil production is important from two perspectives of human and animal consumption. The presence of this food in livestock feed, and in particular aquatic, is important for supplying the energy of the feed as well as essential fatty acids and is also considered in human consumption for providing essential fatty acids such as EPA and DHA. Therefore, the production of fish oil for two aims, yield and the quality of the product, was studied.

5.2.1 Yield

The results of oil yield coefficient in WP and EE showed that this value was higher in EE method and this difference was significant. The results of oil yield coefficient in WP and EE showed that the extracted oil content in the EE method was higher than WP method. In EE method, the protein matrix is hydrolyzed by the action of added protease to the mass of waste, then attached oils to the protein networks are purified after centrifugation (Liaset et al 2003). In the WP method, the mass is first baked at high temperature and then extracted by mechanical pressure and these two parameters result in the extraction of more oil from the bake mass. Heat contributes to the denaturation of the protein matrixes of the tissue that the oil strongly bonds to them. Following this process, solid particles and liquids can be extracted mechanically. Also, heat causes the opening of oil globules and fat cells, resulting in the release and fluidity of the oil, which can increase the yield (Chantachum et al 2000). The obtained results in this study showed that protease enzyme hydrolysis plays a more effective and efficient role in the separation of oil globules from tuna's protein network in comparison with high temperature and mechanical pressure. Therefore, its yield was significantly higher than WP method yield. The results of oil extraction from fish by-products by 4 methods of WP, supercritical fluid extraction (SFE), EE and cold extraction (CE) showed that the efficiency of the SFE method was higher than the other methods and EE was higher than the two others. In the study of Rubio-Rodriguez et al (2012) there was a significant difference between the yield of EE and WP methods, which is in agreement with the results of the present study.

5.2.3 Neutral lipids

The results of analysis of neutral lipids in this study showed a significant difference in the levels of WE, TAG and FFA in extracted oils from tuna waste by WP and EE methods. Low levels of WE and high TAG levels can indicate low levels of intracellular fat and high levels of bonded extracellular fat to proteins in the raw material. Due to weak binding of the extracellular oils with protein matrices, the amount of oil extraction is increased and, consequently, the amount of triacylglycerol was increased and the wax esters were decreased (Gupta & Shim 2007). The appropriate rate of yield in these methods, as compared to the amount of oil in the raw material, can also show weak binding between oils and protein matrices in tuna waste. Also, high levels of TAG can indicate that PUFAs were high in oil (Liaset et al 2003). On the other hand, hydrolysis of TAG causes the formation of FFA. Therefore, the higher TAG and PUFA levels produce also more FFA (Linder et al 2005). In the study of the effect of time and temperature of cooking of tuna by-products in WP method on quantitative and qualitative parameters of extracted oil showed that with increasing TAG, levels of FFA also increased. In Chantachum et al (2000) study, the levels of TAG and FFA in the treatment of cooking at 95°C for 30 minutes were significantly higher than other treatments.

In another study (Fiori et al 2012), the results of qualitative analysis of extracted oils from different rainbow trout parts by supercritical carbon dioxide showed that there was a significant difference between the levels of TAG and FFA in different parts. In this study, the amount of FFA of obtained oils from the head and spine was significantly higher than those in extractive oils from the intestines and viscera. Also, treatments that they had higher TAG had also higher FFA levels.

5.2.4 Fatty acids profile determination

In our study, there was no significant difference between the levels of fatty acids. Rubio-Rodriguez et al (2008) evaluated oil extraction from *Merluccius capensis* by SFE and Soxhlet with hexane, and stated that there was no significant difference between levels of fatty acids. Therefore, the results of this study are in agreement with our results.

5.2.5 Acid value determination

Acidity value is one of the important parameters in the quality of oil, which is influenced by the amount of FFA and other non-lipid acids, such as acetic acid. This indicates that the acidity of the oil can be varied by factors such as oil compounds and extraction methods (Gbogouri et al 2006). In general, oils containing higher amounts of TAG and PUFA have higher levels of FFA, which can reduce acidity (Hajeb et al 2014). In the present study, the levels of TAG and FFA in EE treatment were slightly higher than WP. Therefore, due to the higher acidity value in EE treatments, it can be concluded that FFA probably have an effect on acidity, which has led to a higher acidity value in EE treatment than WP. On the other hand, the acidity value in WP treatment was significantly lower than the recommended acidity value for fish oil, and in contrast, acidity value of EE treatment had not significantly different with recommended acidity value. It was probably influenced by the higher levels of FFAs in this treatment. The obtained data and no higher acidity value than the recommended level in the two treatments can indicate the state of keeping the raw materials was good and the used methods for oil extraction in present study were suitable.

6 Summary and conclusion

The conclusion of my project is eco-friendly, clean burning alternative fuel. It contains no petroleum, but can be blended with conventional diesel fuel. This fuel can be used in any diesel engine without any modification. Biodiesel is degradable, non-toxic and free of sulphur and lead. Biodiesel offers a wide range of benefits that makes it a highly viable alternative fuel source for the foreseeable future. The fuel's quality rests in large part on the purity and cleanliness of the final product. Achievement of high quality biodiesel fuel could provide the following benefits: reduction in elastomeric seal failures, decrease in fuel injector blockages and corrosion due to absence of glycerol, catalysts and soaps, reduces degradation of engine oil thereby providing high engine performance, better lubricant properties and better quality exhaust emission.

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