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Effect of Difference Type of Food Used to Produce Waste Cooking Oil for Alternative Fuel

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ABSTRACT

Due to the increase demand in world's energy resources, research in alternative fuel is growing significantly to supplement the non-renewable petroleum-based fuel. Among promising candidate of alternative fuel is waste cooking oil (WCO), because it is a by -product that can be recycled. The simplest way that was successfully used WCO as alternative fuel for diesel engine is blended it with diesel fuel. However, the reported results of engine performance and emissions trend were inconsistent among literatures. This study expected that one of the reasons to that inconsistent results is the different type of food used to produces WCO. So that, this study investigates that different to find whether this hypothesis is true or not. Three type of WCO that being used to fry sweet potato, tapioca and banana, respectively were used in this study. The WCO is filtered properly before it was blend with diesel fuel at 20 percent WCO and 80 percent diesel fuel (W20) of volumetric volume. The density, viscosity and calorific value of the fuel samples were measured and compared to investigate the difference between them. Based on this study, no significant different among those food types is acknowledge, probably they all are from plants-based food.

Keywords: *Alternative Energy; Diesel Engine; Waste Cooking Oil; Fuel Blend.*

Introduction

Currently, the demand or energy is increasing drastically due modern lifestyle. Therefore, the world could not depend on one source of the non-renewable

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petroleum-based fuel anymore. Alternative fuel needs to be searched in order to at least supplement the petroleum-based fuel if not replaced it at near future [1].

This study found that waste cooking oil (WCO) has a very good potential to be a source of alternative fuel for diesel engine [2]. This is due to it comes from vegetable resources that can always be reproduced as well as it is a by-product of frying other food. Also, utilizing WCO as the source of alternative fuel could promotes the recycling attitude among communities as well as avoiding illegal disposing of WCO.

However, the main drawback of WCO is it has higher viscosity and density than diesel fuel that make it less prone to combust as diesel fuel [3]. The simplest and fastest way to utilise the WCO as alternative diesel fuel is blended it with lower viscosity fuel. This method has been successfully used in many studies. Among successfully reported literature were Yilmaz et al in their study about blending diesel, biodiesel, higher alcohol with vegetable oil quaternary and tested it in diesel engine [4]; Örs, İlker in his study about the cetane number of the new alternative fuel when biodiesel from WCO was blended with bioethanol [3] and another example is Al-Dawody et al studied about WCO biodiesel blended with diesel fuel that has been tested in the diesel engine [5].

Based on these three literatures, this study found inconsistent result were reported among them. For an example, the brake specific fuel consumption (bsfc) reported by Al-Dawody et al that their new alternative fuel was less consume by the engine than diesel fuel where this result is contradicted with what has been reported by Yilmaz et al and Örs, İlker. This is the main concern in this study and trying to investigate the cause of this problem.

As for the initial study to investigate this difference, this study starts with investigating its sources. Based on that, three sample of WCO from different type of food that being used to produce it were collected from Kilang Kerepek Ros. This company produces variety of chips that only use the cooking oil from palm oil to fried only one specific food. Therefore, it is easy for this study to use it since the WCO was use for one type of food only. The three samples of WCO are cooking oil from palm oil used to fried sweat potato, tapioca and banana.

Upon collecting the WCO samples, filtering process was performed to clean up the WCO before it is blend with diesel fuel at 20 percent WCO and 80 percent diesel fuel from its volume, respectively. This study called this new fuel as W20. This is to mimic the successful 20 percent biodiesel mixed with 80 percent diesel that being called B20 that already in worldwide market.

When the fuel sample were ready, the physical properties of them were measured. For this study, the physical properties were limited to the density, viscosity and calorific value only. This is due to that these three physical properties are the most important properties in compression ignition engine. If these properties do not show any significant results, then there is no reason to further a study to the other physical properties such as boiling point, cetane number etc.

Finally, the results of those physical properties were compared among those three fuel samples as well as their respected WCO sources and referred diesel fuel. The following section explain in details the methodology and results for this study.

Methodology

In this study, the methodology can be divided into to main part. The first one is the fuel sample preparation and the second one is the physical properties of the fuel samples.

Fuel samples preparation

As mentioned in the introduction, the WCO were collected from Kilang Kerepek Ros, Banting, Malaysia. Three type of WCO were collected and they are WCO from frying sweat potato chips recorded as WP; WCO that being used to fried tapioca chips is recorded as WT and finally this study has WB that is the WCO from cooking the banana chips.

The all fuel samples were then undergoing sedimentation process. In this process, the fuel samples that has been stored in transparent container respectively, was leave in the storage room for two weeks. The idea was to make the impurities in the WCO samples deposited at the bottom of the container and lighter impurities will be floating on the top of the WCO samples. The transparent container is used as it is easy to observed this process.

After that, the WCO samples were transferred into another container by leaving the deposition impurities at the bottom of the transparent container. Then, the WCO fuel samples were filtered by using cotton mesh to further filtered any remaining impurities inside the WCO samples. This filtering process were repeated several times until impurities is no longer seen on the cotton mesh filter. Then the WCO were considered as clean and ready to be blend.

As for the diesel fuel, this study gets the Euro 2M diesel fuel from the nearby local petrol station.

The blending method between WCO and diesel for this study was the splash mixture method. That mean, both fuels were just put in the same container and the mixture was just shake it by using hand power without the help of any machine or electronic binding method. As mentioned earlier, this study prepare three fuel blend samples and they are WP20, WT20 and WB20. In total, this study has seven fuel samples including diesel labelled as D100 and three WCO sample namely WP00, WT00 and WB00.

Basically, this study using the simplest method to prepared the fuel samples. This is to ensure the reproduction of the fuel samples as it might be getting commercialised is doable with the cheapest possible cost of it.

Physical properties

In this study, three physical properties need to be measured. They are density, viscosity and the calorific value of all seven fuel samples.

The density of the fuel samples was measure by using basic equation which is the mass of the fuel samples divided with its volume [6]. The mass of the fuel samples was taken by using the analytical balance at the Propulsion Laboratory at the Faculty of Mechanical. The mass the respected fuel samples were weight by using the analytical balance machine.

The kinematic viscosity of fuel samples was measured by using Cannon-Fenske Routine viscometer at the Tribology Laboratory at the Faculty of Mechanical. The kinematic viscosity were measured at 40°C as per referred references and accordance to ASTM D445 [7, 8]. It is important to prepared the method according to the referred references because the results are then comparable with other related research work.

The calorific values of every sample were measured by using a bomb calorimeter according to ASTM D240 [8]. This process was conducted at the Instrumentation Laboratory at the Faculty of Chemical Engineering.

All of the methods used in this study were properly referred to the related references so that the results from this study can be referred for future researches.

Results and discussion

In this study, five results were observed and analyse. The are the deposition of the WCO samples, filtering process, density, viscosity and calorific values of all fuel samples. The details of the result s are presented in the following section.

Deposition

The result of deposition for the WCO from frying the tapioca chips is illustrated in Figure 1. From that figure, at the first day of the WCO being collected from Kilang Kerepek Ros, the colour of the WCO is quite darker. After being left for two weeks, the colour becomes gradient as seen on Figure 1 from the bottom to the top of the transparent container.

After two week of storage times, then the impurities were deposited on the bottom of the container. In this result, no solid fat is observed in the fuel sample. This is expected that the WCO is not from frying protein-based food as chicken or meat product.

Although, Figure 1 is only illustrated the deposition for the tapioca based WCO, this study is confirmed that the other two WCO samples which are tapioca and banana also have similar behaviour.

Figure 1: Sample photograph of the deposition method.

Filtering

For the filtering process, this study used white cotton mesh to filter any other impurities in the WCO samples that has been deposited for two weeks as explain in the methodology. The result of filtering process is illustrated in Figure 2. In that figure, the impurities were clearly seen after the first time performing the filtering process. In this study, minimum of five times of filtering using cotton mesh is required in order to ensure all the impurities were clearly remove from the WCO samples.

This result implies that there are so many impurities in the WCO samples that need to be clean, even though after deposition process. However, the main finding from this result is there are so many impurities in the WCO sample and it need to be clean up properly otherwise it will give a problem to the engine later. All three samples have similar characteristics.

Figure 2: Sample photograph of the impurities after first time filtering the WCO.

Density

The result of density for all seven fuel samples is illustrated in Figure 3. As mentioned in the introduction, the WCO for all samples were ways higher than diesel fuel. Based on that figure, the highest recorded density is with WCO from sweat potato chips, followed by WCO from tapioca chips and the lowest density among WCO samples is the WCO from banana chips.

As for the objective of blending method which is to reduce the density of the WCO, then this study is said that it is successfully reduced it. However, the reduction of WT20 is not linearly as expected from it based WCO samples.

The different of the density between fuel blended samples is approximately 38 kg/m^3 and this value give five percent to the lowest density of WB20. Further study needs to be conducted to investigate this result.

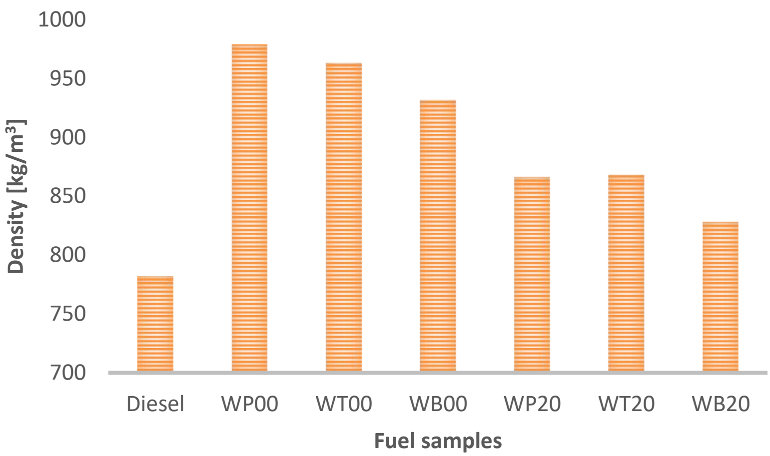

Figure 3: The trend of density for all fuel samples.

Viscosity

Figure 4 is illustrated the result of the viscosity for all samples that being measured at 40°C. Again, as highlighted in the introduction that the problem of WCO that limit it from directly used as an alternative diesel fuel is its higher viscosity as compared to the diesel fuel. In general, the viscosity of WCO samples are approximately 10 times higher than diesel fuel. Based on this result, the highest viscosity is recorded with WCO from sweat potato chips, followed by WCO from tapioca chips and the lowest viscosity among WCO samples is from banana chips.

Basically, the trend for the WCO sample between density and viscosity are identical. Theoretically, this is true since higher density will have higher molecular weight then it will much heavier to move.

However, the trend of viscosity for the fuel blend is not accordance to the trend of viscosity for the WCO samples. This study found that the lowest viscosity among fuel blend is with tapioca chips followed by potato chips with a very closed margin. The highest viscosity for the fuel blend is with banana chips where it quite higher margin than the other two fuel blend samples.

This is an interesting finding that need a further investigation whether different type of the food used in the palm oil-based cooking oil will affect the molecular structure of the WCO that eventually affect the blending fuel.

However, the difference of viscosities among the fuel blended samples is approximately 0.5 mm^2/s only and approximately 8.6 percent from the lowest viscosity of WT20.

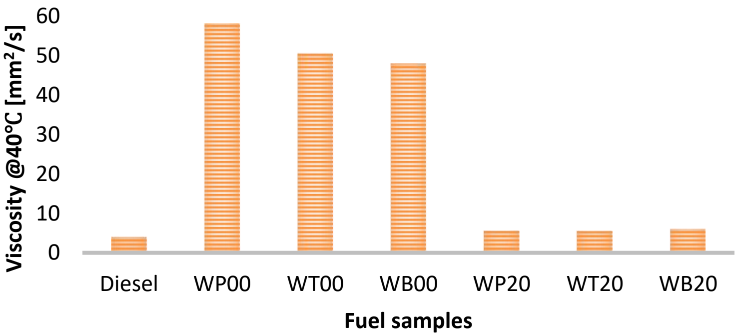

Figure 4: The result of viscosity at 40°C for all samples.

Calorific value

The result of the calorific value in this study is illustrated in Figure 5. As expected, diesel fuel has highest calorific value than all WCO samples. The highest calorific value among WCO samples is with tapioca chips while WCO for sweat potato chips recorded the lowest calorific value and WCO with banana chips has the result in between the other two WCO samples. So, for the calorific value of the WCO samples, the inclination trend is from sweat potato, banana and tapioca.

As for the blended fuel, it was successfully increase calorific value of the WCO samples. From this result, the inclination trend is from sweat potato, tapioca and banana. Theoretically, the trend of WCO samples and the fuel blend must be similar since they are blend with similar diesel fuel. However, this is an interesting result that need to be further investigated.

Based on this result, the difference of calorific value between fuel blend is approximately 0.36 MJ/kg with give less than one percent from the lowest value of calorific value at WP20.

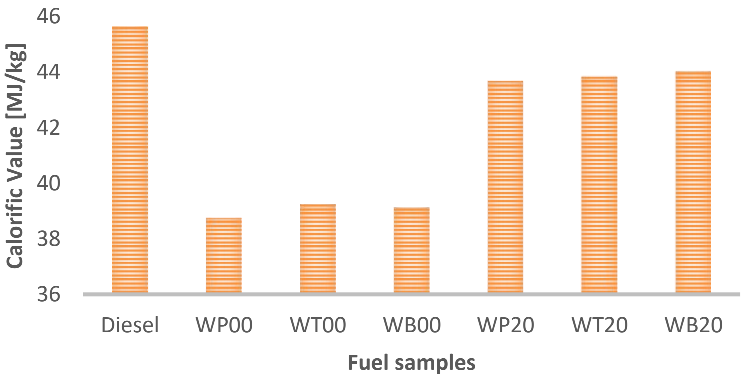

Figure 5: The results of calorific value for all samples.

Effect of different type of food used to produce WCO

As the objective of this study which is to investigate whether the different type of food used to produce WCO will affect the quality of WCO to be used as the source of an alternative fuel, this study found that, the result is insignificant.

This is due to the maximum different percentage among fuel blend sample is at the value of 8.6 percent for the viscosity. Note that, the value of the viscosity is basically smaller in magnitude, the 8.6 percent for the 0.5 mm^2/s can be considered insignificant enough. Also, the result of density of give the different approximately five percent and the worse is the calorific value where the different is not event one percent.

Conclusion and Recommendation

Alternative fuel is required to supplement the dependency on the non-renewable petroleum-based fuel due to the fact that the demand on the energy is kept increasing with the modern human lifestyle. WCO is identified by this study that has higher potential to be used as sources of the alternative fuels, specifically for diesel fuel.

Unfortunately, the density and viscosity of the WCO were poorer than diesel fuel and the simplest method to use WCO is by blending it with the diesel fuel.

However, the WCO can be produced from cooking oil that being used to fried variety of the food. Therefore, this study investigates whether WCO that being used to fry sweat potato chips, tapioca chips and banana chips will give any significant different to the fuel blend.

The results from this study can be concluded as insignificant since the different just between eight percent without considering the experimental error analysis. So, this study acknowledges that the WCO produces from frying plant-based food has insignificant different and they can be mixed together. No separation is needed. This is the main contribution to the body of knowledge from this study.

As for the recommendation, this study suggested that comparative study should be made between WCO produced from plant-based food and meat-based food. This is because in the meat, there is a fat that also can be a source of the alternative fuel. When cooking oil cook fat, probably reaction between them will affect the quality of the WCO to be the source of an alternative fuel.

Moreover, the results of density, viscosity as well as the calorific value have inconsistence trend. This condition probably due to the microstructure of the WCO and diesel itself. Thus, thus study recommended to investigate the molecular chain of those WCO i.e. from variety of the food used to produces it.

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