Feasibility of waste cooking oil as biodiesel feedstock

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Abstract. Waste Cooking Oil (WCO) has potential as biodiesel feedstock since it contains triglycerides. However, it contains many impurities and requires several purifications. Thus, this study aims to evaluate the feasibility of WCO as a biodiesel feedstock in the term of physicochemical properties such as free fatty acid content (%FFA) as palmitic acid, moisture content, and peroxide number. Samples are collected from fast-food fried chicken restaurants in Padang, West Sumatera, Indonesia. WCO is processed by filtering, degumming, centrifugation, neutralization, and adsorption. FFA content, moisture content, and peroxide number are examined based on ISO 660, ISO 665, and ISO 3960, respectively. The finding shows that WCO has 2.01% FFA, 0.65% moisture content, and 1.02 mg O2/100g peroxide number. These findings show that WCO is feasible as biodiesel feedstock after several purifications. The results of this study are expected as the basic information in biodiesel production by using waste cooking oil as biodiesel feedstock.

1. Introduction

Oil-based fuel scarcity is common not only in Padang but throughout Indonesia. The provision of alternative fuel feedstock has been done through the utilization of biodiesel that is officially sold at various gas stations. The government's commitment in encouraging the utilization of biodiesel is implemented by increasing the level of biodiesel mixture from Biodiesel 20 percent (B20) to Biodiesel 30 percent (B30). In fact, President Joko Widodo has inaugurated the B30 program at Pertamina MT Haryono Gas Station, South Jakarta on December 23, 2019. Biodiesel B40 is also ready to be tested in March 2020 and is planned to come into effect in 2021 [1].

However, the biodiesel from cooking oil is based on palm oil which will be addressed with the issue of food security. Thus, it is necessary to find alternative feedstocks other than palm oil such as algae, waste or non-edible oil. One of the wastes that can be utilized is waste cooking oil from fried chicken restaurant that is abundant in Padang, West Sumatera, Indonesia.

Based on data from the Padang City Cultural and Tourism Office, there are currently 512 culinary/restaurant industries both fast food and regular restaurants in operation [2]. These restaurants produce Waste Cooking Oil in a large scale. As a waste, used cooking oil is dangerous if recycled as recycled cooking oil (RCO) because it can cause Parkinson's, coronary heart, stroke and cancer risk. Surprisingly, there are 18 to 20% RCO (3.56 million tons) circulated on market [3].

WCO has the potential to be used as feedstock for the biodiesel production. However, used cooking oil has a low quality [4]. The process of frying chicken continuously and repeatedly at high
temperatures (160- 180°C) accompanied by contact with air and water in the frying process results in a complex degradation reaction in the oil. This causes WCO contains many impurities such as solid waste, colloid waste, gum, high content of Free Fatty Acids (FFAs) which is more than 15% and blackish color [5, 6]. The low quality makes used WCO does not qualify as biodiesel feedstock with a maximum FFA content of 3% [6].

Thus, this study aims to evaluate feasibility of waste cooking oil as biodiesel feedstock after carried out by several treatment. The significant of this study is a diversification of biodiesel feedstock, one of efforts in conducting waste management from fastfood friend chicken restaurants, and avoiding transformation of WCO into RCO that can harm health. Further, this study is expected to increase the added value of WCO.

2. Method

2.1 Samples
For the experiments, Waste Cooking Oil purchased from several fastfood friend chicken restaurants in Padang, West Sumatera, Indonesia.

2.2 Purification stages
WCO were purified by several stages such as preparation, centrifugation, neutralization and adsorption. The preparation of WCO/samples consist of three processes, namely sedimentation, filtering and degumming. This stage is a preliminary treatment stage that aims to eliminate insoluble and colloidal suspension in sample (gum) by sedimentation, filtering, and degumming methods using phosphoric acid (1% v/v of WCO) as well as heating to eliminate moisture content.

Centrifugation is carried out to remove residue impurities in the form of a colloidal suspension in oil. Centrifugation is carried out by using a centrifuge. Meanwhile, the neutralization process is the process of separating Free Fatty Acids (FFA) from the oil by reacting them with alkali to form soap. In this study, KOH is used as alkali in order to produce liquid soap. It does not clog the outlet pipe. In addition, the utilization of KOH can be neutralized with phosphorus acid and produces potassium phosphorus that can be used as fertilizer. In the neutralization process, 1% w/v KOH is added to oil. The neutralization process also can reduce oil color substances [8]. It reduces quantity of required adsorbents in the adsorption process.

2.3 Analysis of physicochemical properties
Samples were examined the physicochemical properties such as FFA content as Palmitic acid, moisture content, and peroxide number. Samples were analysis twice. First, before purification process. Second, after purification process. Data before, after and unused cooking oil are compared to examine effectiveness of purification process and feasibility of WCO as biodiesel feedstock.

Methods in examining FFA content as palmitic acid, moisture content, and peroxide number are based on ISO 660, ISO 665, and ISO 3960, respectively as presented in Table 1.

| Physicochemical properties | Method          |
|----------------------------|-----------------|
| Free Fatty Acid content    | ISO 660         |
| (% FFA as Palmitic acid)   | ISO 665 and 662 |
| Moisture content (%)       |                 |
3. Result and Discussion
Result of physicochemical properties of oil before purification process is presented in Table 2.

| Physicochemical properties               | Value     |
|------------------------------------------|-----------|
| Free Fatty Acid content (%) FFA as Palmitic acid | 14.2      |
| Moisture content (%)                     | 2.31      |

Table 2 shows that FFA content of WCO, moisture content, and peroxide number before purification process are 14.2%, 2.31%, and 9.12 mg O2/100g, respectively. Those values are far exceed the value of free fatty acids and peroxide number in unused cooking oil which is 1.04% and 0.91%, respectively. Waste Cooking Oil before purification process and after purification are presented in Figure 1.

Waste Cooking Oil before purification is cloudy with blackish color due to high impurities such as gum, colloid waste, solid waste [6]. After filtration, sedimentation, degumming, centrifugation, neutralization, and adsorption, samples are turn to be clear with yellowish color as presented in Figure 2. Figure 2 shows purifications effective to convert dark with blackish color oil to clear with yellowish color oil. Purification also reduce free fatty acid content, moisture content, and peroxide number of oil. Those physicochemical properties of oil is presented in Table 3.
Table 3. Physicochemical properties of oil after purification process

| Physicochemical properties         | WCO after purifications | Unused cooking oil |
|------------------------------------|-------------------------|--------------------|
| Free Fatty Acid content (\% FFA as Palmitic acid) | 2.01                     | 1.04               |
| Moisture content (%)               | 0.65                     | 0.1                |
| Peroxide number (mg O2/100g)      | 1.02                     | 0.91               |

Free fatty acid content is allowed maximum 3\% and maximum moisture content is 1\% in order feasible as biodiesel feedstock [6]. Table 2 shows WCO after purifications has 2.01\% of FFA and 0.65\% of moisture content. Thus, WCO after purification is feasible as biodiesel feedstock. Meanwhile WCO before purification is not feasible as biodiesel feedstock.

4. Conclusion
Waste Cooking Oil from fastfood chicken restaurant has high impurities such as solid waste, colloid waste, gum, high free fatty acid content and also high moisture content. However, it is feasible as biodiesel feedstock after purification processes. Those purification processes are filtration, sedimentation, degumming, centrifugation, neutralization, and adsorption. This study are expected as the basic information in biodiesel production by using waste cooking oil as biodiesel feedstock.

Acknowledgments
The project is financed by Universitas Negeri Padang DIPA-023.17.2.677514/2020. The authors would like to thank the university authorities for the financial support.

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