Waste Peel of Durian as Solid Catalysts for Biodiesel Production

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Abstract. In this study, peel durian ash was used as a solid catalyst to convert rubber seed oil into biodiesel production via transesterification reaction. The catalyst was fabricated by simple burning and calcined at 600°C for 8 h. The morphology of particles was confirmed by Scanning Electron Microscopy (SEM). The Energy-dispersive X-ray Analysis (EDX) was used to obtain the atomic composition and percentage of the catalyst. The reaction was carried out at 65°C for 1 h. Whereas, the catalyst loading were varied of 1.0%, 2.5%, 5.0%, 10% and 15% wt.%. From EDX data was confirmed that the ash catalyst composes of the potassium oxide (K₂O) as the dominant compound. The performance of the catalyst was evaluated from a transesterification reaction for biodiesel production. The highest biodiesel yield of 96.5% was obtained in the reaction using a catalyst of 10 wt.%. The density obtained was 0.865 gr/cm³ confirming the produced biodiesel complies with the SNI standard.

1. Introduction
The widespread using of fossil fuels in power plants, transport vehicles, generators, and mining equipment has required higher energy consumption [1]. The demand energy in the transportation sector has hiked with the growth of the population and it is expected to keep on increasing. This has led to a rapid depletion in the world's reserves of fossil fuels. The environmental pollution generated by fossil fuels is currently increasing [2-3]. So that we need to look for other energy sources as alternative fuel which possess all the properties such as renewability, accessibility, sustainable nature, and clean fuel that can meet all the challenges caused by fossil fuels, one of it is biodiesel [4-7].

Biodiesel right now has been used in most countries in the world. Triglycerides that generally exist in vegetable oil (edible or non-edible) or animal fats are reacted with methanol besides either alkali or acid catalyst for industrial-scale manufacturing of biodiesel. The biodiesel can be produced from various natural sources including waste cooking oil, jatropha oil, palm oil, neem oil, soybean oil, rapeseed oil and other vegetable oils. The economics of biodiesel production is highly sensitive feedstock and it comprises a very substantial portion of overall production cost. Hence, the use of non-edible oil sources or waste products of the edible oil industry as biodiesel feedstock to adjust the

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international standards is a recently focused area of research. In this research, the rubber seed oil is used as a raw material for biodiesel production because easy to cultivate [8-17].

To accelerate the transesterification reaction of vegetable oils into biodiesel, various catalysts have been used. The catalyst could be significantly affected the reaction rate and also may favor the formation of the product. There are three types of catalysts that are often used, namely homogeneous, heterogeneous and biocatalyst. The use of heterogeneous catalysts is more preferred than a homogeneous catalyst. The homogeneous catalyst still has a limitation on the separation process that leads to an increase in the total cost of biodiesel production. The heterogeneous catalysts offers more advantages, such as easily separation, recyclable, high glycerol purity without corrosion in the reactor. Several heterogeneous catalysts have been studied for the conversion of vegetable oils into biodiesel, such as SrO, CaO, TiO$_2$-based, K$_2$O, showing relatively high activity [18-22].

Generally, the exploration of solid catalysts based on non-renewable sources. Durian wastes as a renewable source can be used as a solid catalyst due to it contains K$_2$O compound. When the durian peel was burned at a moderate temperature, it would produce an ash residue. The inorganics parts of the ash residue are K$_2$O composition as the dominant component. The present work aimed at exploring the possibility of using durian peel as a source of K$_2$O as a catalyst for biodiesel production. The ash catalyst was characterized by SEM and EDX. The effect of catalyst loading to oil ratio was also evaluated.

2. Methodology

2.1. Material
Durian peel is obtained from waste durian, in Banda Aceh City, Indonesia. Methanol was provided by Merck (Germany), and rubber seed oil was purchased from the market. The rubber seed was obtained from a rubber farm in East Aceh, Indonesia. The oil was extracted by pressing the rubber seed using a mechanic press.

2.2. Preparation of Catalyst
Waste durian peel was dried in open area. After drying, durian peel was cut and crushed using a mechanical crusher. The durian peel was put in stainless steel plate and burned until forming ash. The ash of durian peel was calcined at 600 °C for 8 hours. Then the catalyst was cooled at room temperature.

2.3. Catalyst Characterization
Analysis of catalysts was carried out to determine its morphology and chemical composition. The catalysts were analyzed by scanning electron microscopy (SEM). The catalyst element were characterized by energy dispersive X-ray (EDX).

2.4. Transesterification Reaction
The biodiesel production was carried out via transesterification reaction of rubber seed oil, ash catalyst, and methanol. In each experiment the catalyst were varied of 1.0%, 2.5%, 5.0%, 10%, and 15 wt.% to oil. This reaction was conducted in a three-neck round-bottom flask batch reactor equipped with a heater, magnetic stirrer and a water-cooled condense [23]. The rubber seed oil and methanol put into a three-neck flask. Whereas the catalyst was varied of 1.0%, 2.5%, 5.0%, 10%, and 15 wt.% to rubber seed oil. The reaction was kept at a temperature of 65°C for 1 h. The generated biodiesel was separated from the catalyst residue and glycerol using separating funnel and filter paper. After being separated, the biodiesel was then dry-washed in an oven at 80°C for 12 h. The methanol to oil molar ratio was 8:1. The yield of biodiesel was determined using Eq. (1):

\[
\% \text{ yield} = \frac{\text{weight of biodiesel produced}}{\text{weight of oil used}} \times 100\% \quad (1)
\]
3. Results and discussion

3.1. Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray (EDX) Analysis
The morphology of the durian peel ash catalyst was carried out to determine by SEM analysis, as shown in Figure 1. As can be seen from SEM analysis, the surface morphology of the ash durian peel is inhomogeneous particle size. The shape of the particles of around 300 nm - 2µm. This irregular shape of the ash particle might be due to an agglomeration when burning the durian peel.

![Figure 1. Morphology of durian peel ash](image)

To identify the compounds in the ash catalyst, EDX was employed to confirm the atomic composition and atomic percentage of the catalyst. The results of the EDX analysis are presented in Figure 2.

![Figure 2. EDX analysis of durian peel ash](image)

The spectrums of the EDX were composed of potassium, magnesium, calcium, silica, aluminium, carbon, oxygen, and phosphor, as can be seen from Fig. 1. It appears that the highest peak of the spectrum is potassium. The data analysis reported that the weight percent of potassium is 27.25%.
3.2. Influences of Catalyst Loading
Catalyst is one factor greatly affects the effectiveness of biodiesel production [24]. In this experiment, the ratio of the catalyst to the rubber seed oil was varied of 1.0%, 2.5%, 5.0%, 10.0 and 15.0 wt.%. The effect of the weight ratio of the catalyst to the yield of biodiesel is shown in Figure 3.

As shown in Fig. 3, the yield of biodiesel tends to increase with an increase in the loading of catalyst. As catalyst loading increased from 1.0 % to 10%, the yield biodiesel also increased from 81.21% to 96.5% %. With further increase in the catalyst loading, above 10 wt%, the biodiesel yield decreased due to emulsification. With an increase in catalyst loading to 15.0 wt.%, the biodiesel yield slightly decreased to 93.8%. The excess catalyst could increase the solubility of glycerol, lead to reduced separation of biodiesel and glycerol and decreased biodiesel yield [25].

3.3. Biodiesel Properties
The properties of biodiesel have been carried out to determine the physical-chemical characteristics of the process using a durian peel catalyst is shown in Table 1.

| Parameter                | Unit       | Result            | SNI       |
|--------------------------|------------|-------------------|-----------|
| Kinematic viscosity      | mm²/s (cp)| 4.42 – 5.90      | 2.3 – 6.0 |
| Density                  | kg/m³      | 865 - 890         | 850 - 890 |

The properties of biodiesel from ash peel durian catalysts such as kinematic viscosity and density were also analyzed. The kinematic viscosity of biodiesel is ranging from 4.42-5.9 mm²/s (cp), while, the biodiesel density of biodiesel from this study of 865-890 kg/m³ which were in accordance with SNI standards. Thus, the properties of biodiesel produced in this study using heterogeneous catalysts of durian peels ash are in accordance with Indonesian National Standards. The high fuel properties cause mass injection to be higher in the engine. Because of this, its energy content in the combustion chamber and engine performance are greatly influenced by fuel properties [26-27].

4. Conclusion
The heterogeneous catalyst from durian peel ash has been prepared by a simple combustion process. The catalyst has been applied for the transesterification reaction of rubber seed oil. From EDX data was confirmed that the ash catalyst composes of the potassium oxide (K₂O) as the dominant
compound. The prepared sample has been successfully produced biodiesel with a high yield of 96.5% using 10% catalyst at 65°C for 1 h with methanol to oil ratio of 8:1. Durian peel ash contains potassium oxide which owns good ability and stability makes it has the potential to be utilized as a material for catalyst production.

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6. References
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