RESEARCH ARTICLE

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The Potential of KemiriSunan as Feedstock for the Production of Biodiesel

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KemiriSunan (*Reutealistrisperma* (*Blanco*) *Airy Shaw*) seed is a material that has a great potential to be used as a biodieselfeedstock. The core seeds contain high level of free fatty acid/crude oil. This paper investigates the potential of KemiriSunan in Indonesia. Comparisons of the productivity of plants producing biodiesel and processing methods for producing biodiesel from KemiriSunan seeds are analyzed. The economic prospect for developing KemiriSunan as biodiesel is also addressed. KemiriSunan's productivity is much higher when compared to other biodiesel feedstock. The option available for development of biofuels from non-food source in Indonesia is KemiriSunan and followed by *Calophylluminophyllum*. The esterification and trans-esterification methods used for biodiesel production yield biodiesel that is in some parameters in accordance with the biodiesel standard according to SNI-2006 standard:density at 40 °C: 881 kg/m^3; kinematic viscosity at 40°: 4.4 cSt; cetane number: 53.9; flash point: 129.5 °C; cloud point: 12 °C; calorific value: 39.7758 MJ/kg; and iodine number: 95.24 g iodine/100 g. The economic analysis showed that NPV Rp. 521,724,254, IRR 21.78% BCR 1.3, PBP 9.2 years.

Keywords: Biodiesel, KemiriSunan, Biofuel, Tansesterification, Esterification.

1. INTRODUCTION

Burning of fossil fuel emits some substances that cause negative impacts to the environment. Fossil fuel causes deterioration of climate conditions, concerns over environmental and health problems, and energy crisis.[1] Biodiesel is a promising option of alternative fuels for diesel engine. Biodiesel has some advantages compared to petroleum diesel fuel. Biodiesel is biodegradable, not harmful to human health, renewable, non-flammable, readily available and also eco-friendly. The most important advantages of biodiesel are higher flash point, improved cetane number and reduced exhaust emissions. Also, biodiesel is free from sulfur or aromatic compounds and reduces air pollution like carbon monoxides, hydrocarbons and particulate matter.[2]

The Indonesian Government Decree No. 79, 2014 on National Energy Policy mandates that the use of biodiesel does not interfere with food security.[3] It encourages the development of non-food-based biodiesel. KemiriSunan (*Reutealistrisperma* (Blanco) Airy Shaw), a non edible source, is a promising alternative for biodiesel. The biggest potential of KemiriSunan is in its seeds and shell, where the seeds contain fatty acid that can be processed into biodiesel, the shell and oil cake can be converted for various purposes such as briquettes, bio-pesticides and organic fertilizer. Since the development of KemiriSunan biodiesel has not been optimal yet in Indonesia, it is therefore this paper will analyze its potential as feedstock for the production of biodiesel.

2. KemiriSunan (*ReutealisTrisperma* (Blanco) Airy Shaw)

KemiriSunan (*ReutealisTrisperma* (Blanco) Airy Shaw) is a shady medium-sized tree with deep roots and belongs to annual plant. It is suitable for rehabilitation of degraded land into productive land as it can be a conservation plant. KemiriSunan will be available for harvest for about 4–8 years since the planting. Another advantages of KemiriSunan Tree: the growth is relatively fast; the plant has deep roots that work to increase the absorption of ground water and prevent it from sliding; It is excellent as cover crop (conservation plant) in order to prevent erosion and suitable for reforesting degraded land including the former mining area; KemiriSunan is more easily grown on marginal land and has high productivity; KemiriSunan can reach the age of 50 years.[4]

Physical and Chemical characteristic of crude oil KemiriSunan: Acid value 13.26 mg KOH/g, Free Fatty Acid 6.63%, Density 985.49 kg/m^3, Kinematic Viscosity 26.57 mm^2/s (cSt), Crude oil sightings is yellow brown.[5] Oil composition

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comprises 10% of palmitic acid, stearic acid 9%, oleic acid 12%, linoleic acid 19%, and acid a-elaeostearic 51%. The content of acid a-elaeostearic explains the presence of toxins in the oil.[6] Thus KemiriSunan can't be consumed.

KemiriSunan tree is widely distributed in various cities in Indonesia, for instances, Bekasi 30,000 trees, Kuningan 10,000 trees, Majalengka 10,000 trees, JatiGede 10,000 trees, Bandung 3,000 trees, Ngawi, 40,000 trees, Lamongan 80,000 trees, Nusa Penida-Bali 15,000 tree, Lombok 14,500 trees, and Timor 20,000 trees.

KemiriSunan's productivity is much higher when compared to other biodiesel feedstock. The productivity of KemiriSunan is approximately 10,000 liters/hectare, far exceeding palm whose productivity is approximately 6,000 liters/hectare. The next order is *Calophylluminophyllum* which is half as KemiriSunan as at approximately 5,000 liters/hectare. Jatropha produces only about 2,000 liters/hectare.[4,7,8] With these figures, the option available for development of biofuels from non-food source is KemiriSunan and followed by *Calophylluminophyllum*.

2.1. Biodiesel

Biodiesel is a non-petroleum based diesel fuel which consists of mono alkyl esters of long chain fatty acid derived from vegetable oils, used cooking oil or animal fat through various chemical process known as esterification and trans-esterification process in which the crude oil is reacted with methanol in the present of catalyst to yieldglycerin and biodiesel.[9–11]

Biodiesel is easily adaptable to a variety of uses because it can be used in the neat form (called B100) or blended with petroleum diesel fuel in a variety of different concentration level for use in compression ignition (diesel) engines.[12] Its physical and chemical properties as it relates to operation of diesel engines are similar to petroleum-based diesel fuel, thus biodiesel can be used on machines without any modification to the engine.[13] Biodiesel has several advantages in which it can reduce emissions of toxic gases, such as carbon monoxide, hydrocarbon, carbon dioxide, and sulfur oxide, reduce smoke opacity and carcinogenic compounds, and increase engine lubrication. However, nitrous oxide emission from biodiesel is slightly higher than petroleum-based diesel fuel.[13]

The esterification reaction converts the free fatty acids (FFA) present in low quality vegetable oils into esters. The most commonly used alcohol for this process is methanol because of its low cost and its chemical and physical advantages (the reaction is called methanolyisis). A further advantage of methanolysis of triglycerides is that during the reaction, glycerol and biodiesel/fatty acid methyl ester (FAME) are produced as the main products.

KemiriSunanseed oil content reaches up to 49–59% 52% so-called *Trisperma* Crude Oil and after the trans-esterification process it reaches 88–91%[8]. A study of two steps of reaction, esterification by using H_2SO_4 catalyst and transesterification by using NaOH catalyst showed that the biodiesel yield increased with catalyst concentration of 0.5–1.0 %wt. On the other hand, concentration of 1.5–2.0 %wt making the biodiesel yield decreased.[14]

The most common disadvantages of biodiesel are their high density and viscosity and low volatility.[15] The fuel density has a great influence on the atomization process. The kinematic viscosity is the other key factor to take into account in order to achieve optimal fuel atomization. This leads to poor combustion in diesel engines including formation of deposits and injector cocking due to poorer atomization upon injection into the combustion chamber. Density also has more impact at low load/low speed than at high load and speed operation point.[2] Viscosity of fuel also affects fuel system lubrication, fuel system leakage, the line pressure, leakage, and friction of the plunger in the injection pumps. The chemical modifications to overcome these problems have been tried by transesterification reaction.[16] However, the esterification and trans-esterification reaction of KemiriSunan crude oil have not totally solved the high viscosity problem.[17,18] Nevertheless, a two-stage transesterification process reaction seems to be the most effective process in decreasing the kinematic viscosity of biodiesel.[8] This process in principle is reprocessing methyl ester (biodiesel) obtained in the first step of transesterification to the 2nd stage of transestrificataion. The result showed that the process was able to gain better properties of biodiesel as indicated by parameters biodiesel according to SNI 04-718 (2006) standard:[19] density at 40 °C: 881 kg/m^3; kinematic viscosity at 40°: 4.4 cSt; cetane number: 53.9; flash point: 129.5 °C; cloud point: 12 °C; calorific value: 39.7758 MJ/kg; and iodine number: 95.24 g iodine/100 g.

3. THE ECONOMIC PROSPECTS OF KEMIRISUNAN

KemiriSunancrop was planted in Sumur Village, Musuk, Boyolali, Central Java Province where it has become a model village to plant KemiriSunan. The project was initiated by Ministry of Energy and Mineral Resources of Republic of Indonesia in March 2014. KemiriSunan trees are planted on area of 13 hectares (2000 trees) in sub-optimal land and vacant lot.

In order to figure out its prospect, financial analysis was conducted on the project. The analysis is based on: Net Present Value (NPV), Interest Rate of Return (IRR), Net Benefit Cost Ratio (BCR), Pay Back Period (PBP). The cost calculated includes, development of KemiriSunan plantation and the cost of biodiesel KemiriSunan processing.

Revenue from the development of the KemiriSunan crop is derived from the sale of dry seeds and biodiesel which the amount of income varies depending on the amount of seed production. KemiriSunan starts to bear fruit at the age of four years and the production increases in the following years. It assumes that the initial product begins from 15 kg dry seed/tree in year 5 to 150 kg dry seed/tree in year 10. The selling price of KemiriSunan dry seedis Rp. 1,500/kg while the price of biodiesel is based on the biofuel price index of *Mean of Platts Singapore* (MOPS).

The economic analysis showed that NPV Rp. 521,724,254, IRR 21.78% BCR 1.3, PBP 9.2 years. It means that the development of KemiriSunan plantation and biodiesel processing are economically feasible. Similar result has been concluded of the economic analysis of KemiriSunan development either in small scale plantation or large scale plantation, which large scale plantation is more profitable because of its economic of scale.[20] Nevertheless, biodiesel processing is sensitive to the rising costs of materials and a decrease in the selling price of the products.

4. CONCLUSION

KemiriSunanbears to be considered as the potential feedstock of biodiesel in Indonesia. Not only the use of KemiriSunan as raw material of biodiesel does not interfere with food security since it is non-food source, but also it has the highest productivity per hectare among other biodiesel sources. KemiriSunan trees spread in many areas in Indonesia and can be used for land conservation. Processing biodiesel from KemiriSunan seeds by esterification and transesterification methods produces biodiesel that is in accordance with the biodiesel standard according to SNI-2006 standard. Density at 40 °C: 881 kg/m^3; kinematic viscosity at 40°: 4.4 cSt; cetane number: 53.9; flash point: 129.5 °C; cloud point: 12 °C; calorific value: 39.7758 MJ/kg; and iodine number: 95.24 g iodine/100 g. The economic potential in the development of KemiriSunan as biodiesel is promising, NPV Rp. 521,724,254, IRR 21.78% BCR 1.3, PBP 9.2 years, with economic viabilities both in a large and small scale. A further study on KemiriSunan biodiesel in terms of property characteristics, optimum processing methods and performance in diesel engines need to be carried out.

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