COMPREHENSIVE STUDY OF BIOETHANOL FROM CASSAVA AS A SUBTITUTE FOR FUEL OIL

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Abstract

Fuel oil (BBM) consumption in Indonesia has increased from year to year, but the availability of fuel oil will gradually become scarce. Bioethanol can be used as a substitute for fuel oil (BBM) depending on its purity level. Bioethanol is a liquid resulting from the fermentation process of sugar from carbohydrates which has good prospects as a liquid fuel with raw materials that are renewable, environmentally friendly and very profitable economically. Bioethanol can be used as a gasoline mixture for vehicle fuel and can be used as cooking fuel in households. The use of bioethanol can reduce CO gas emissions significantly. Bioethanol can be used directly as fuel oil or mixed into premium as an additive in a certain ratio (Gasohol or Gasoline alcohol). If mixed into gasoline, bioethanol can increase the octane number significantly. Bioethanol is known as an environmentally friendly fuel, because it is free from pollutant emissions. Bioethanol can be made from plant raw materials that contain starch such as cassava, sweet potato, corn, sago and molasses. One of the materials that can be used to make fuel from ethanol is the cassava plant. Cassava is a tuber that contains carbohydrates that come from the roots of the cassava plant. Cassava is very easy to plant and maintenance is not difficult. Cassava is usually used as a substitute for rice, but can also be used as an alternative to fuel oil. This research is qualitative research with a descriptive approach. Researchers use research data in the form of secondary data obtained from a number of credible sources such as scientific articles, books and a number of other sources that are credible and commonly used in research. These data were analyzed using analytical tools with stages of data collection, data selection, data reduction and drawing conclusions.

Keywords: *Fuel Oil, Bioethanol, Cassava*

1. INTRODUCTION

Indonesia is the 13th fuel consuming country in the world. Domestic oil consumption reached 1.58 million barrels or 1.6% of total global oil consumption. According to the Energy Institute report, world oil consumption has tended to increase in the last decade. It was recorded that the average growth rate of world oil consumption during 2012-2022 was 0.9% per year (Mutiara, 2023). Fuel oil (BBM) consumption has increased from year to year, this is inversely proportional to its availability. If consumed continuously, without the discovery of new oil reserves, oil will run out within the next few years. One effort that can be made to reduce people's consumption of fuel oil (BBM) is by utilizing renewable alternative fuels and energy conservation (Saragih, *et. al.*, 2024).

Fuel oil is one of the influencing factors because in the distribution process, transportation uses fuel oil as a driving force. Due to the high demand for fuel oil and the high price of fuel oil, people are also trying to find alternative substitutes. This effort produced good results, namely the creation of bioethanol fuel from cassava plants (linkum.km, 2023).

As a substitute for fuel oil, ethanol can be used, namely ethyl alcohol, which has similar properties to gasoline fuel. While gasoline fuel is currently the main need in the world of transportation and automotive, with the extinction of fossil fuels in the future, many vehicles will no longer be able to be used, so with the presence of ethanol this can be an alternative energy that can be renewed. Alternative fuels such as ethanol are renewable fuels produced from the fermentation of plants containing carbohydrates (Mutaqqin, 2020).

Ethanol (C_2H_5OH) is a chemical compound in liquid form, clear, colorless, has a distinctive aroma, has a liquid phase at room temperature, and is flammable. Ethanol has characteristics similar to gasoline because it is composed of straight chain hydrocarbon molecules. Bioethanol is ethanol (C_2H_5OH) which can be made from substrates containing carbohydrates (sugar derivatives, starch and cellulose). One of the raw materials often used to make bioethanol is raw materials containing starch (Lovisia, 2022). Bioethanol is a liquid resulting from the fermentation process of sugar from carbohydrates which has good prospects as a liquid fuel with raw materials that are renewable, environmentally friendly and very profitable economically. Bioethanol can be used as a gasoline mixture for vehicle fuel and can be used as cooking fuel in households (Sofiah, *et. al.*, 2019).

Bioethanol can be made from abundant biological resources in Indonesia. Bioethanol is made from sugary or starchy ingredients such as cassava or cassava, sugar cane, sap, sorghum, palm sap, sweet potato, and others. Almost all the plants mentioned above are familiar plants, because they are easy to find and some of these plants are used as food (Widyastuti, 2019). Currently, fuel energy sources from natural sources have been widely developed. One of these energy sources is bioethanol. Bioethanol has been developed in various parts of the world and currently Brazil and the United States are the largest bioethanol producing countries in the world. Brazil produces bioethanol from sugar cane with total production in 2004 of around 15 million m^3. Meanwhile, the United States produces bioethanol from corn with a production of 14 million m^3 in the same year. Meanwhile, Spain is the largest country in Europe that produces bioethanol (Arlianti, 2018).

Cassava is a plant that has been known for a long time by Indonesian farmers, even though it is not native to Indonesia. According to Wikipedia (2023) Cassava was first imported by the Dutch colonial government in the early 19th century from Latin America. Because it has been known to Indonesian farmers for a long time, developing cassava to be processed into bioethanol raw material is not too difficult. Currently, cassava is widely exported to the United States and Europe in the form of tapioca. In these countries, cassava is used as raw material for the alcohol manufacturing industry. Tapioca flour is also used in the glue, chemical and textile industries. Indonesia ranks fifth as the largest cassava producer in the world. Indonesia is recorded as being able to produce 18.3 million cassava in 2020 (Rizaty, 2022).

In Indonesia, cassava plants are usually only used as animal feed and traditional food after rice and corn. Because of this, the price of cassava is very volatile and does not provide adequate profits for farmers. It is hoped that the development of bioethanol can be a renewable energy source solution and can increase the income of cassava farmers. With this step, cassava prices will stabilize, thereby providing sufficient profits for farmers. The problem of the future renewable energy crisis will be resolved and lead Indonesia to become an energy independent country (Yakinudin, 2012).

2. METHODS

Researchers believe that the use of bioethanol can reduce CO gas emissions significantly and bioethanol from cassava plants can be used as a substitute for fuel oil in Indonesia, so it can be a solution to replace fossil fuel oil which will gradually run out. Therefore, this research aims to utilize bioethanol from cassava plants as a substitute for fuel oil. This research is a qualitative

research with a descriptive approach, namely describing the benefits of bioethanol from cassava plants as an alternative to fuel oil. The data used in this research is secondary data that researchers obtained from books, credible websites, scientific articles, books, and other things that are usually used as reference data from researchers (Sugiyono, 2011). The data sources were analyzed using the stages of data collection, data selection, data reduction, and drawing conclusions (Rijali, 2018).

3. DISCUSSION

Bioethanol is ethanol made by fermenting biomass containing starch, sugar and cellulose plants. Biomass that contains starch for example cassava, sweet potato, corn kernels, sago sorghum seeds and potatoes. The most prospective sources of raw materials in Indonesia are cassava (cassava), sweet potatoes, molasses, sago, coconut sap, palm sap, palm palm sap, sorghum and seaweed. Cassava or cassava (*Mannihot esculenta*) originates from Brazil, South America, spread to Asia in the early 17th century, brought by Spanish traders from Mexico to the Philippines. Then it spread to Southeast Asia, including Indonesia. Cassava is a staple food in several African countries. Apart from being a food ingredient, cassava can also be used as an industrial raw material and animal feed. Sweet potatoes contain around 60% water, 25-35% starch, as well as protein, minerals, fiber, calcium and phosphate. Cassava is a higher energy source than rice, corn, sweet potatoes and sorghum (Loupatty, 2014).

It is very possible for cassava to be developed on a large scale in Indonesia to support bioethanol production. Cassava supports bioethanol production. Cassava has a carbohydrate content of around 32-35% and a starch content of around 83.8% after being processed into flour (Hambali, *et. al.*, 2008), according to Yaqin (2014) the calorific value of cassava is 250 x 103. Cassava can grow in less fertile soil, which has high resistance to disease and can be adjusted to harvest time, with a harvest age of 8 months. Cassava can produce 30-60 tons per hectare.

Indonesia is a country with abundant natural resources and has extensive opportunities for the development of bioethanol as a substitute for fossil energy, whose reserves are starting to decrease over time. The government has strengthened the development of bioethanol by making Presidential Regulation of the Republic of Indonesia Number 5 of 2006 which was followed by Minister of Energy and Mineral Resources regulation Number 12 of 2015 concerning National Energy Policy to develop alternative energy sources as a substitute for fuel oil sourced from fossil energy (Wiratmaja, *et. al.*, 2020). Meanwhile, according to Novendri (2018), ethanol is an easily soluble liquid produced from glucose fermentation and to increase its purity it is usually followed by a distillation process. Ethanol is short for ethyl alcohol with the chemical formula (C_2H_5OH), a density of 0.7939 g/mL, and a boiling point of 78,320°C at a pressure of 766 mmHg, and has a heat of combustion of 7093.72 kcal.

The use of ethanol as a fuel began to be researched and implemented in the United States and Brazil since the fossil fuel crisis occurred in both countries in the 1970s. Brazil is listed as one of the countries that is very serious about implementing ethanol fuel for motor vehicle use with the level of ethanol fuel usage currently reaching 40% nationally. In the United States, relatively cheap fuel, E85, which contains 85% ethanol is increasingly popular among the world community (Susanto, *et. al.*, 2015). According to Purwati (2016) Ethanol can be used in pure form or as a mixture for gasoline or hydrogen fuel. The interaction of ethanol with hydrogen can be used as an energy source for fuel cells or in conventional internal combustion engines.

The most widely used bioethanol production is the production obtained through the fermentation method, where this process will produce alcohol with fairly low levels. To increase the ethanol content to reach Fuel Grade Ethanol (FGE) with a content of 99.5%, further processes are needed in the form of distillation and dehydration. There are several advantages of bioethanol which are considered quite significant, namely that it is able to increase the

performance of vehicle engines. This can be seen in the use of biogasoline with a mixture ratio of gasoline and bioethanol with a composition of (90:10) which provides higher torque and power values as well as lower specific fuel consumption compared to the use of pure gasoline, especially at high engine speeds (Wiratmaja, 2010a).

This is because bioethanol has a research octane number (RON) value of 116-129, which is relatively higher than premium gasoline which has an octane value of RON 88. With a high RON value, bioethanol which can function as an additive is able to work well in increase the octane value (octane booster) of low octane fuel so that it has a positive impact on engine efficiency and power, especially for vehicle engines with high compression ratios and avoids detonation during the combustion process in the engine (Wiratmaja, *et.al.*, 2020) .

Table 1 Sources and Health Standards of Vehicle Exhaust Gas Emissions (Ismiyati, *et. al.*, 2014).

Polluter	Information
Carbon Monoxide (CO)	Health standard: 10 mg/m^3 (9 ppm)
Sulfur Oxide (S0x)	Health standard: 80 kg/m^3 (0.03 ppm)
Particulate Matter	Health standards: 50 ug/m^3 for 1 year; 150 ug/m^3
Nitrogen Oxides (N0x)	Health standards: 100 pg/m^3 (0.05 ppm) for 1 hour
Ozone (0_3)	Health standards: 235 ug/m^3 (0.12ppm) for 1 hour

From table 1 you can see the threshold for vehicle exhaust emission levels. From the incomplete combustion process, exhaust emissions are produced in the form of HC (Hydrocarbon), CO (Carbon Monooxide), CO_2 (Carbon Dioxide), O_2 (Oxygen) and NOx (Nitrogen Oxide) compounds. From the results of exhaust gas emission testing, a conclusion was drawn that variations in engine speed, where the higher the engine speed, will produce higher HC emissions and reduce CO and CO_2 emissions. The greater the concentration of bioethanol used will result in higher HC emissions and decreasing CO and CO_2 emissions (Octaviani, *et. al.*, 2010).

Table 2 Comparison of Physical Properties Between Ethanol and Gasoline (Wiratmaja, 2010b)

Property	Ethanol	Gasoline
Chemical formula Composition	C_2H_5OH	C_4 sd C_{10}
% weight	52.2	85 – 88
Carbon Hydrogen Oxygen		
Octane Number	13.1	12-15
Research Octane	34.7	0
Motor Octane	108	90-100
Density (lb/gal)	92	81-90
Boiling temp. (◦ F)	6.61	6.0 – 6.5
Freezing Point (º F)	172	80 – 437
Flash Point (º F)	-173.22	-40
Auto Ignition Temp. (º F)	55	-45
Heating value	793	495
Higher (Btu/gal)	84 100	124 800
Lower (Btu/gal)	76 000	115 000
Spesific heat Btu/lb ºF	0.57	0.48
Stoichiometric air/fuel, weight	9	14.7

From table 2 it can be seen that there is a comparison of the physical properties of bioethanol to gasoline, that bioethanol has physical properties that are close to the physical properties of gasoline or can be said to be in the interval of the physical properties of gasoline so that the use of bioethanol as the main fuel must receive study and attention. What is more serious about the government as policy maker is that the use of bioethanol is not just as an additive or as a mixture of gasoline fuel, but has the ability to be the main fuel for vehicles in the future (Wiratmaja, *et. al.,* 2020).

According to Yakinudin (2012), there are several internal characteristics of ethanol that cause the use of ethanol in engines to be better than gasoline. Ethanol has a research octane number of 108.6 and a motor octane number of 89.7. These figures (especially research octane) exceed the maximum value that gasoline can achieve even after adding certain additives. For the record, the gasoline sold by Pertamina has a research octane number of 88 and generally motor octane is lower than research octane. For a mixture ratio of ethanol and gasoline reaching 60:40%, an efficiency increase of up to 10% was recorded.

Ethanol has one OH molecule in its molecular composition. The oxygen bound in the ethanol molecule helps improve combustion between the air and fuel mixture in the cylinder. Coupled with a wide flammability range, namely 4.3-19 vol% (compared to gasoline which has a flammability range of 1.4-7.6 vol %), combustion of a mixture of air and ethanol fuel is better. This is believed to be a factor causing the relatively low CO emissions compared to burning air and gasoline, which is around 4%. Ethanol also has a high heat of vaporization, namely 842 kJ/kg (Giancoli, 1998). This high heat of vaporization causes the energy used to vaporize ethanol to be greater than gasoline. A further consequence of this is that the peak temperature in the cylinder will be lower when burning ethanol compared to gasoline.

The disadvantages of bioethanol when compared to gasoline are that at low temperatures, engines with bioethanol fuel will have more difficulty starting and the fact that bioethanol reacts with metals such as magnesium and aluminum so that it can damage vehicle components made from these metals. (Setiawati, *et. al.,* 2013).

This is because bioethanol is a fuel that oxidizes very easily, making it possible for steam and water droplets to form in tanks and fuel pipes in vehicles. The steam and water droplets can cause corrosion in the tank and fuel lines so that the use of ethanol will accelerate corrosion in the tank and fuel lines. As a preventive measure, studies and modifications can be carried out on vehicle materials, especially fuel lines and fuel tanks, where previously used materials are replaced with materials that are more resistant to corrosion (Fahmi, *et. al.,* 2015).

Then, the obstacle from an economic perspective is that in the bioethanol distillation process, efforts to obtain a higher level of purity are complicated and require high costs, so marketing bioethanol at a low price is quite difficult, so it is certain that there will be a fairly high disparity in the price of bioethanol and gasoline, making bioethanol become less desirable for further development because they are considered less economical. In terms of providing raw materials for making bioethanol, sourced from sugar-containing plants such as sugar cane and cassava, it is also vulnerable to becoming an obstacle to the development of bioethanol itself. This is because sugar cane and cassava are one of the main food products, so that increasing the use of bioethanol as an alternative energy source will automatically increase demand for raw materials so it is feared that there will be competition between the availability of raw materials for food, feed and energy sources, which will have an impact. on human survival (Siagian, *et. al.,* 2023)

According to Wiratmaja *et. al.* (2011) Efforts to replace all of the world's current fuel needs with ethanol require very large areas of agricultural land to avoid the intermittent nature of alternative fuels, thus opening up opportunities for large-scale deforestation. Seeing the fact that currently various countries in the world are showing indications of a crisis in the food and energy

sectors, it is very necessary to immediately look for safer sources of raw materials for making bioethanol.

Of the several shortcomings of bioethanol, a solution must be immediately found so that the use of bioethanol as a fuel does not just stop at its application as an alternative fuel and as an additive to gasoline fuel but is able to stand alone as an alternative fuel for now and become the main fuel in the future. with the exhaustion of fuel reserves based on fossil energy. One solution that can be used to overcome the availability of bioethanol raw materials is through efforts to make second generation bioethanol through the use of lignocellulosic materials which contain simple sugar structures that can be converted into ethanol, which is still abundant, cheap and still not widely used on a large scale. (Siagian, *et. al.*, 2023).

4. CONCLUSION

Based on the explanation above, several points can be concluded regarding the benefits of Bioethanol from cassava plants as an alternative to fuel oil as follows:

1. The use of bioethanol as the main fuel to replace gasoline fuel sourced from fossil energy in the future has quite a big opportunity because the physical properties of bioethanol are close to the physical properties of gasoline fuel.
2. The government's role is to ensure continuity in the availability of raw materials and efforts to reduce the selling price of bioethanol on the market, which must be completed as soon as possible and in a race against time as non-renewable fossil energy reserves run out.

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