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The Potential of Developing Siwalan Palm Sugar (*Borassus flabellifer* Linn.) as One of the Bioethanol Sources to Overcome Energy Crisis Problem in Indonesia

Nisa Bila Sabrina Haisya [1], Bagus Dwi Utama [2], Riki Cahyo Edy [3], and Hevi Metalika Aprilia [4]

[1] Student at Faculty of Veterinary, Bogor Agricultural University
[2] Student at Faculty of Agricultural Technology, Bogor Agricultural University
[3] Student at Faculty of Economy and Management, Bogor Agricultural University
[4] Student at Faculty of Forestry, Bogor Agricultural University

Abstract. The energy demand in Indonesia increases due to a significant growth in population, this fact has diminished the fossil fuel storage as our main non renewable energy source. Recently, there are a lot of researches on renewable energy; one of the most prominent is the development of bioethanol as a result of fermentation of sugar or starch containing materials. Palm sugar as one of the natural sugar sources can be obtained from most of palm trees such as coconut, aren, nipah, and siwalan. This paper explored the potential of Siwalan palm sugar development to be converted into bioethanol as renewable energy source through fermentation and purification processes. Siwalan palm sugar contains 8.658 ml ethanol out of 100 ml palm sugar liquid processed using fermentation and distillation. Bioethanol can further utilized as fuel when it is mixed with gasoline that called gasohol. In the future, it is expected that gasohol can replace gasoline consumption as an alternative energy that can be competitive in term of price in Indonesia.

Keywords: alternative energy, siwalan palm sugar, bioethanol, gasohol, energy demand

1. Introduction

The fuel reserves have been decreasing in these recent years due to a rapid population growth. This phenomenon forces human to utilize fuel to its fullest extent for the sake of their economic and social benefit. Indonesia is now classified as net energy importing country, since the energy production in Indonesia cannot afford to meet the domestic demand. Based on Indonesian outlook book, it is predicted that the energy demand will increase 3.6% in 2030 and bricket will become main energy source for Indonesia with 517 million tons of productivity. Based on data and existing calculation, in 2030, the reserve ratio of bricket is still able to fulfill the demand up to 20 years (2050). However, if we scrutinize the current tendency, it is forecasted that the dependency on fuel will get higher, on the other hand the fuel reserve is very limited, and therefore the possibility of scarcity is definite. Nonetheless, the science and technological advancement can also be applied to manage our abundant natural resources to cater the need of renewable energy; one of feasible way to be taken is by utilizing Siwalan palm sugar as the staple to be converted into bioethanol. Bioethanol can be seen as prospective alternative to replace or alleviate fossil fuel consumption, since bioethanol can function as fuel in forms or pure bioethanol or mixture of bioethanol and gasoline. This paper aims to elaborate the potential of Siwalan palm sugar development as the staple for bioethanol as prevention towards future energy crisis.

Indonesian government pays very serious attention to the development of biofuel through President Instruction number 1 year 2006 on the development of biofuel as alternative energy. Bioethanol (C_2H_5OH) is

[1]Nisa Bila Sabrina Haisya. Tel.: +6281369409704
Email address: sabrinahaisya@yahoo.co.kr

defined as liquid fraction that is obtained from sugar fermentation (carbohydrate) using microorganism and performs a series of characteristic that resembles to gasoline. As a replacement of premium, bioetahnol can be turned into alternative gasohol which is the mixture between bioethanol and gasoline. The utilization of gasohol in Indonesia can foster some aspects such as, (1) enrich the basis of liquid fuel sources, (2) lessen the fuel import volume, (3) strengthen fuel security of supply, (4) increase job opportunities among people, (5) alleviate the revenue gap between central and other areas, (6) support the national competency on agroindustrial technology sector, (7) avoid the negative impact of global warming and air pollution (through environmental friendly fuel), and (8) initiate the export activities for new commodity.

In order to generate bioethanol development, sugar containing staples such as cassava, sweet potato, sago, sorghum, aren palm sugar, nipah palm sugar, and siwalan palm sugar are needed. Siwalan palm sugar can be considered as a prominent option, siwalan palm sugar has been popular for its utilization as alcoholic beverage named *tuak* (local language), besides siwalan palm sugar is also commercially converted in red sugar and refined sugar. Siwalan palm sugar is derived from siwalan plant (*Borassus flabellifer* Linn.), one of palm families that is widely cultivated and available in South and South East Asia. The *Borassus flabellifer* Linn. plant and fruit is known as Tala in Odia, Tnaot in Khmer, Thot Not in Vietnamese, Tari in Hindi, Tal in Bengali, Tale Hannu or Tateningu in Kannada, Nungu in Tamil, Pana Nangu in Malayalam, Thaati Munjalu in Telugu, Munjal in Urdu, Lontar in Indonesian, Siwalan in Javanese, Ta'al in Madurese, Ton Taan in Thai, Akadiru by the East Timorese, Tao in Divehi, Tadfali in Gujarati, Targula in Konkani, TadGola in Marathi and sometimes Ice-apple in British English. In Indonesia, siwalan is also recognized in different names based on its area for instance lonta (Min), ental (Sunda, Jawa, dan Bali), taal (Md),dun tal (Sas),jun tal (Sumbawa),tala (Sulsel),lontara (Toraja),lontoir (Ambon), manggita, manggitu (Sumba) and tua (Timor) (Irine RC et al, 2006). Siwalan tree perform an amazing adaptation capability especially in dry area and also assessed fertile land. This plant can grow well in low altitude area, coastal area, and mountainous area that ranged from 0-800 m above sea level with rainfall rate around 500-5000 mm/year (CSA Tuban Regency, 2007). Siwalan can be classified as follow:

Kingdom	: Plantae
Division	: Angiospermae
Class	: Monocotyledoneae
Ordo	: Arecales
Family	: Arecaceae (sin. Palmae)
Genus	: Borassus
Species	: *Borassus flabellifer* Linn.

(Source: Widjanarko, 2008)

(a) (b)

Figure 1. Siwalan fruit (a) and siwalan palm sugar which tapped (b)

Siwalan Palm sugar is a sweet liquid portion contained in the flower; it can be obtained by cutting the petal and suck the liquid part. Siwalan palm sugar is widely available in Tuban (East Java), the local people used it as staple to make beverage named l*egen* and *tuak*. Palm sugars that are taken from palm sources such as *Arenga pinnata*, *Borassus flabellifer* Linn., *Cocos nucifera*, and *Nypa fruticans* contain around 10-20% of sugar. Basically, palm sugar is a sugar cane that can be stored by the plant to linger their lives, thus the production of palm sugar can be naturally kept constant.

The development of gasohol, which is a mixture between gasoline and bioethanol, to be introduced as an alternative energy is a brilliant idea to overcome the energy crisis in Indonesia. Beside the staple availability which is abundant, the conversion process is also simple, and beyond that, the fuel can also be considered as more environmental friendly based on several researches. In 2006, a research conducted by Ministry of Agriculture (Department of Research and Technological Development) on car, revealed that the carbon emission released by Gasohol E-10 which is a mixture between gasoline and 10% ethanol is lower than normal gasoline. Gasohol E-10 and E-25 can be applied to normal machines that usually rely on gasoline, while gasohol E-100 can be applied to modified machines. A test that was carried out to assess the

performance of siwalan based biofuel showed that in terms of power and torsion, ethanol 10% is identical or slightly better than normal gasoline. Ethanol contains 35% oxygen; it makes the burning efficiency higher. The development of siwalan palm sugar is also expected to shift the people bad habit in utilizing siwalan palm sugar as alcoholic beverages (*tuak*), through this development people are encouraged to optimize their siwalan palm sugar to make biofuel that will bring a lot bigger economic benefit to their society, instead of consuming the palm sugar in form of alcoholic beverage.

2. Materials and Methods

The materials which used in bioethanol processing is sugar palm siwalan which obtained by means intercepted through palm trees twice a day (morning and afternoon). The equipment used is fermentor and destilator. The writing methods is based on literature reviews and discussions related to some authorities. Bioethanol processing from siwalan palm sugar is done through three stages, namely (1) preparation of staples, (2) fermentation, and (3) purification. Siwalan sugar palm which have been tapped from the plant will natural fermentation process carried out at room temperature for seven days, followed by purification through azeotropic distillation process repeated three times in the 78°-100°C temperature range until the palm sugar dries. Bioethanol from the result of drying has a purity up to 99,5% (Erliza Hambali, 2007).

3. Discussion

Nowadays, Indonesia is experiencing an energy crisis characterized by energy reserves will decline. The discovery of bioethanol as a renewable fuel made the incentive to do research and develop it in their respective countries, include Indonesia. Bioethanol produced from several plants such as tubers (yams, cassava), grains (corn), plant stems (sago, sorghum, sugarcane, banana weevil), rind (peel), grass (grass hay), and palm sugar (nipa, sugar palm, coconut, and siwalan).

Selection of palm sugar as a source of bioethanol can overcome the energy crisis from several perspectives. First, research and development of bioethanol in Indonesia use a lot of food such as corn, cassava, sweet potato, sugar cane, sago palm, and palm while now Indonesia is being intensified the local food diversification program to tackle the food crisis. Palm sugar is also a food staple with the final product in the form of brown sugar and vinegar, but it is not as main commodity.

Second, the process of making bioethanol in the palm sugar is easier and does not require a long time. The staples are treated in the form of solids size reduction by grinding the ingredients and cooking phase includes liquification and saccharification processes. Processing of solid ingredients will produce by-products of CO_2 and sludge which generally still contain sugar levels up to 18% (Erliza Hambali, 2007). Palm sugar does not need to enter the stage of preparation because it is a liquid sugar that will not produce bioethanol produced sludge so that more optimal than solid ingredients.

Third, the primary production machines of bioethanol in palm sugar that is distilator and fermentors whereas in solid ingredients requires an additional milling and cooking equipment so the production costs of bioethanol on the palm sugar is cheaper than solid ingredients.

Fourth, data from the Plantation Office Tuban (1990) in Rofiqi's research (1992) mentions that based advantageous of palm production in Tuban regency is divided into 20.0% for the consumption of sugar, 64.5% for consumption *legen* or *tuak* (palm wine), and 15.5% for fruit consumption. The amount of percent of people consume the intoxicating wine will raises the social and cultural issues such as high crime rates and declining productivity of public employment. However, if the wine used as bioethanol will be many benefits, including employment opportunities will increase and the added value from production of bioethanol will increase people's income than the production of brown sugar and wine that is slowly taking the drinking wine culture is reduced, decreasing the crime rate, and more prosperous society .

Fifth, from an environmental standpoint, siwalan palm sugar more environmentally friendly. For large-scale bioethanol production would require a lot of staples as well. An area planted with one type of plant - assuming bioethanol production with only one type of plant, such as sugarcane, cassava, sweet potato, corn, sorghum - and lasts a long time will lead to degradation of agricultural land so that over time will decrease crop productivity . Unlike the palm sugar, palm tree spacing in the range between 6-8 meters, the lifetime of

more than 12 years, and the siwalan plant that can coexist with other plants to have benefits to the soil, that soil is not polluted with chemical fertilizers as in other monoculture farming.

The development potential of palm into bioethanol is an appropriate innovation, because the staples, namely palm sugar, is quite adequate. In Table 1 can be listened to a nutrient composition of some plant palm sugar, and in Table 2 can be observed siwalan area planted and productivity in Indonesia year 2007.

Table 1. Substance Composition of Some Plant Nutrition in its Palm Sugar.

Plant Type	Nurtient Composition Substance of Sugar(%)				
	Water	Sugar	Protein	Fat	Ash
Sugar palm 1	88,85	10,02	0,23	0,02	0,03
Sugar palm 2	87,66	12,04	0,36	0,02	0,21
Lontar (Siwalan)	87,78	10,96	0,28	0,02	0,10
Nipah	86,30	12,23	0,21	0,02	0,43
Coconut 1	87,78	10,88	0,21	0,17	0,37
Coconut 2	88,40	10,27	0,41	0,17	0,38

Source : Anonim 1981 in Halim (2008)

Table 2. Extent of Cultivation and Productivity in Several Regional Centers Siwalan in Indonesia 2007.

Region	Planting area (ha)	Production (ton)	Productivity (kg.ha)
Situbondo	16	48	3.684
Bangkalan	669	214,98	48.212
Tuban	1.183	5.447,059	6.275

Source: Central Statistical Agencies (CSA) and Regional Development Planning Agency (RDPA) of Tuban Regency, Central Statistical Agencies (CSA) Bangkalan Regency, and Central Statistical Agencies (CSA) Situbondo Regency

Table 1 shows that the siwalan palm sugar would make alternative energy sources of bioethanol as a complete composition, which is composed of sugars, proteins, fats, and water as an excellent nutrient for microbial growth. In particular microbe Fermentative yeasts require optimal sugar levels by 10% for the fermentation process.

The process bioethanol begins by tapping processing siwalan palm sugar of palm trees by slicing the tip of palm tree flowers. Incision goal is to obtain a sugar palm liquid to be sampled in processing. Siwalan palm sugar which had taken then cooled for about nine hours in order to disable the microbes before the fermentation process. Fermentation is done with using the yeast *Saccharomyces cerevisiae* because it can produce ethanol more in high quantities. Type of anaerobic metabolism produces a small amount of energy, carbon dioxide, water and other organic metabolic end products, such as lactic acid, acetic acid, and ethanol (Buckle et.al, 1985). Glucose contained in the sugar support the active growth fermentative organisms. Siwalan palm sugar that has been fermented is called *tuak* (Rukmana, 1998). The fermentation process was continued by letting the wine at room temperature for about 1 week to alcohol go the higher levels. *Tuak* became main commodities of urban society to get drunk even it has been the culture of Tuban society. But beside the intoxicating trait, *tuak* can be utilized as a renewable alternative energy sources or biofuels. Separation between the liquid and the residue of siwalan palm sugar need distillation method (evaporation) in the flask destilator begins with 78°-100°C temperature or until the juice runs out (Sholikhah, 2010).

The results of other studies using gas chromatography (GC) states that the ethanol content of 100 ml of siwalan palm sugar that has been done evaporation of 8.658 at the 130^{th} hours or 6 days of storage (Sholikhah, 2010). In these circumstances the alcohol will decrease, and this suggests that the formation of ethanol relative velocity equal to the rate of degradation to acetic acid (Mulja, Purwanto, and Marthania, 2008). Value is what causes the ethanol content of siwalan palm sugar can be used as an alternative energy in Indonesia. Palm trees (palm) is the potential in some areas in Indonesia. Productivity palm in Indonesia is quite sufficient to help reduce the energy crisis in Indonesia. Besides palm flower sugar that can produce 3-5

liters per day, and can be harvested two times a day through a wiretap, and reported that of 10 liters of siwalan palm sugar can produce 2 liters of ethanol (Antaranews, 2009).

Results tapping on average per day to a palm tree sugar as much as 4 liters. If converted to the above results, it can be said that siwalan palm sugar to 4 liters will produce 0.8 liters of ethanol per day per tree. Processing staples for bioethanol will be obtained the equivalent of 8.8 tonnes or 11,000 liters of Fuel Grade Ethanol per hectare per year (Halim, 2008). Moreover, commodity prices in Tuban siwalan palm sugar is quite cheap. By the centers spread of siwalan palm sugar in East Java, bioethanol which have been produced can help to overcome the energy sources in the area, East Java. Long-term sustainability of bioethanol production will reduce the energy crisis in Indonesia.

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