Bio-alcohol Production from Anaerobic Digestion of Banana Peels

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Abstract

Bio-alcohol production from banana peels through the process of anaerobic digestion are one of many alternatives in producing renewable energy and at the same time reducing environmental effects. Bio-alcohol can be obtained by subjugating biomass through a series of pre-treatment processes to obtain the maximum amount of bio-alcohol. This experiment discuss the potential of biomass product as an alternative energy sources while at the same time producing clean and sustainable energy. Throughout the experiment, parameters such as temperature, pH and concentration of bio-alcohol that are produced are monitored. The composition of bio-alcohol was analyzed using the UV-Vis Spectrophotometry. The banana peels were separated to categories depending on the pre-treatment methods that were applied. The experiment was conducted under mesophilic conditions and at a pH range of 6.5 until 7.9 within 28 days of retention time. The highest result recorded in the experiment is when the banana peels undergo alkaline pre-treatment whereby bio-ethanol produced is 60.70 % and the second one being those that went through acidic pretreatment at 54.90% of bio-ethanol. The correlation of temperature, pH and retention time were important factors in an anaerobic process to ensure the conditions for the microorganisms to grow.

Keywords: anaerobic digestion; banana peel bio-diesel; ethanol; microorganisms; organic waste; renewable; energy;

1. Introduction

Energy is defined as the ability of a person or an object to do work and other various activities (Irps. 2010). Currently fossil fuels are the main suppliers of energy worldwide. The use of fossil fuel in everyday life has cause major environmental issues such as global warming, various types of pollution and the depletion of fossil fuel reserves. This is one of the biggest obstacles faced by oil and gas companies worldwide (Mushtaq et al. 2013) . This has aroused some concerns governing the further use of fossil fuels in everyday life. Renewable energy is now being fully researched in order to find out a suitable replacement for fossil fuels.

There are two types of energy. Those are renewable and non-renewable energy. Renewable energy is defined as resources that do not diminish and have a supply whereby that supply is abundant and almost impossible to diminish while non-renewable energy is finite and can diminish over a period of time. (Cesaro and Belgiorno 2015; Irps 2010). Examples of non-renewable energy is coal, petroleum and natural gasses. For centuries man has used these non-renewable energies as a means to generate power for everyday life. This however is shown to be disadvantageous as the world consumption of fossil fuels is increasing. Figure 2 shows the energy consumption in Malaysia during 1990-2008. As of 2017, the world energy consumption has increased with renewables playing a very minor part in energy generation (BP 2017) as shown in Figure 2.

Bio-alcohol is a form of resource of renewable energy and can be derived from various methods. Ethanol and methanol are an example of bio-alcohol. Usually to obtain methanol and ethanol a chemical synthesis from petrochemical substances is required (Bhatia and Paliwal 2010). However since the depletion of fossil fuels at a rapid pace it is not fully advised and instead the production of ethanol and methanol can be extracted from a more greener and cost effective way. This method is called anaerobic digestion of biomass to produce bio-alcohol. Using bio-alcohol as a replacement for fossil fuels shows that despite its origin from biomass it can still provide an energy supply security which means that it has an uninterrupted availability of energy sources at a reasonable price (Cesaro and Belgiorno 2015; Danmaliki et al. 2016). Using bio-alcohol in engines does not harm the environment compare with the fossil fuels used today (Kumar et al. 2009). During the combustion of bio-alcohol, it does not contribute to the increase of CO_2 in the atmosphere therefore it slightly reduces the effect of global warming (Albarelli et al. 2011).Bio alcohols such as methanol and ethanol are also types of bio fuels that have been researched by many as a renewable energy source.

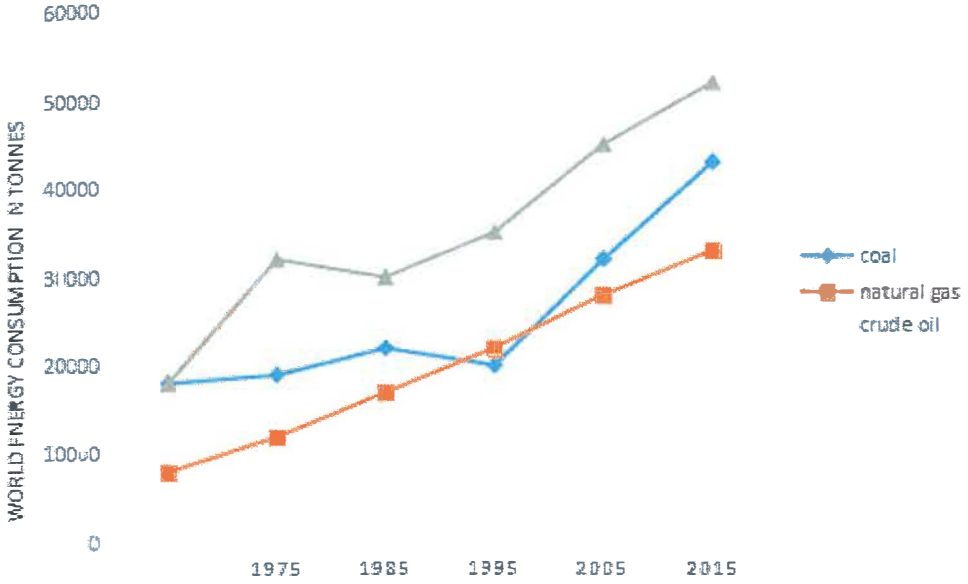

Figure 1 World energy consumption as of 2015 (BP 2017)

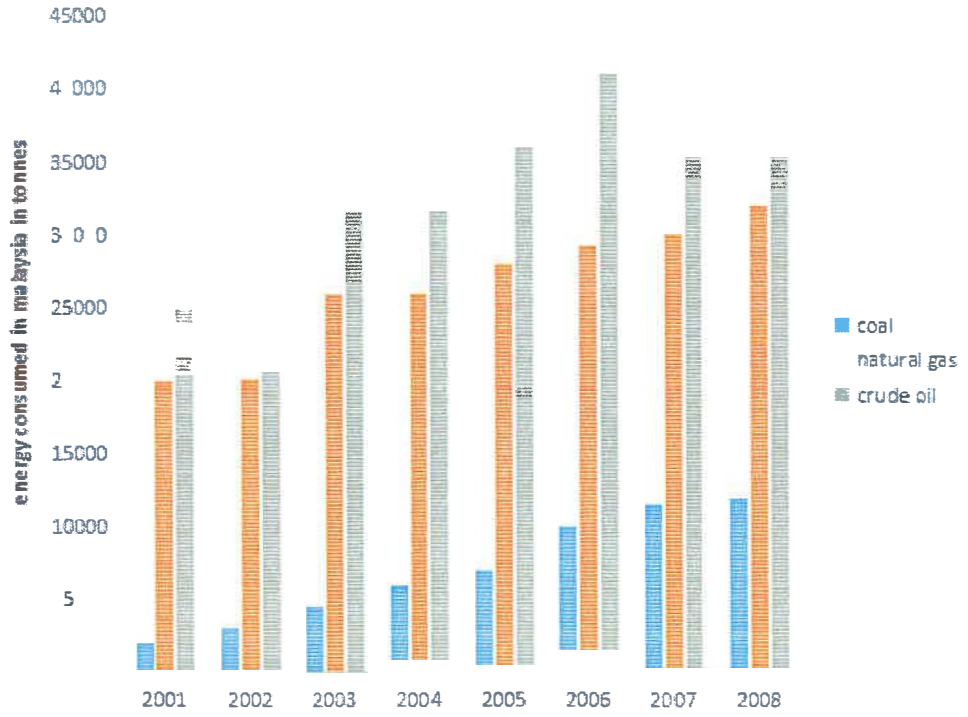

Figure 2 shows the energy consumption of Malaysia as of 2008 (Ong, Mahlia, and Masjuki 2011)

Ethanol also called ethyl alcohol is a colourless, flammable, volatile liquid with a molecular formula of C_2H_6O. It has a molar mass of 46.07 g/mole, a density of 0.789 g/cm^3, a melting point of −114 °C, and a boiling point of 78.37 °C. It is widely used as a solvent, a fuel, and as a raw material for the production of other useful chemicals that have wide applications in the industry (Danmaliki et al. 2016). Many types of biomass can be used to produce biofuels, including agricultural residues, woods, fibre residues, grasses, as well as food crops (Gebresemati, M; Gebregergs 2014). These biomass contain materials that are labelled as lignocellulosic. Lignocellulosic are found in most biomass substances. These raw materials are sufficiently abundant and generate very low net greenhouse emissions(Kumar et al. 2009).

Banana peels are used as a biomass for production of bio-alcohol. This is carried out to find ways to minimize the cost of ethanol production from the conventional methods. Bananas are amillaceuos and lignocellulosic therefore they must be hydrolyzed first in order to be converted to carbohydrates which will then be converted to ethanol inside the digester through anaerobic digestion. Banana production as of these past years has increased with almost 99 million tons annually (Food and Agriculture Organization of the United Nations Market and Policy Analyses of Raw Materials, 2014). Currently, Malaysia is a minor supplier of bananas with 500 MT, worth US$500 million in exports worldwide (Jamaluddin, 2000.). This shows the abundance of bananas in a country such as Malaysia.

uch a shown in Figure 3. The steps in producing these bio-fuels compromise of using different steps. First, the pr duction of ethanol from sugar, starch and finally lignocellulosic biomass (Danmaliki et al. 2016; Gebresemati, M; Gebre ergs 2014).

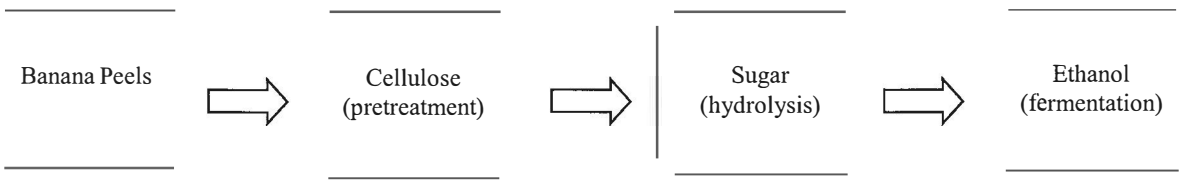

Figure 3. Shows the steps involved in the conversion of lignocellulosic biomass to ethanol (Danmaliki et al. 2016).

In some studies it is shown that the pre-treatment process is not carried out. Therefore it takes time to carry out the experiment. The reason why pre-treatment is carried out is because is to destroy lignocellulosic shell protecting cellulose in the plants. These methods used during pretreatment includes chemical pretreatments by the use of materials such as H_2SO_4 (sulphuric acid), HCl (hydrochloric acid), ammonia, or NaOH (sodium hydroxide). Physical pretreatment involving the use of steam explosion or liquid hot water. Biological pretreatment that involves the use of microorganisms such as white rot fungi, brown rot, Bacillus, Trichoderma, Aspergillus (Danmaliki et al. 2016). The objectives of this study was to find out if there are ways to produce renewable alternative energy and use banana peels as a biomass medium for bio-alcohol production.

2. Methodology

2.1 Material

The materials needed to carry out this research was banana peels procured from local fruit vendor in Pasir Gudang, distilled water, municipal waste water, sodium hydroxide and hydrochloric acid and sulfuric acid.

2.2 Equipment

Among the equipment needed was a knife, a blender, an oven, pH meter, a centrifuge and UV-Vis Spectrophotometer (SHIMADZU UV 1800 PC). The digester tanks were set up as shown in Figure 4.

Figure 4: Setup of anaerobic digesters 1 until 4

2.3 Procedures

2.3.1 Pretreatment

Pretreatment is carried out so that the lignocellulosic components in the biomass in this case banana peels is broken or weaken down so that the process of obtaining ethanol through anaerobic digestion can be less time consuming. The pretreatment methods were carried out similar to the pretreatment method done by (Danmaliki et al. 2016). Pretreatment consists of three types of pretreatment 1) alkaline pretreatment 2) water pretreatment 3) acid pretreatment. Alkaline pretreatment requires the biomass to be soaked in a NaOH solution with 0.5 mol concentration. The biomass was soaked in the solution and was placed in the oven and heated to 120 °C for three hours. Water pretreatment requires the biomass to be cooked at 120 °C while soaked in tap water for three hours. The acid pretreatment was carried out by 40g of banana sample with a 200 ml of 0.5 mol of hydrochloric acid kept at 120 °C. The biomass were the filtrated and washed to neutralize each of the pH values and then dried at 45 °C.

2.4.2 Hydrolysis

The banana peels were collected from local suppliers and was divided into four separate groups. The groups of banana peels were classified as NaOH pre-treated, HCl pre-treated, water pre-treated and controlled variable. The substrate was placed in the digesters which were labelled 1,2,3,4. Digester 1 being the controlled variable with distilled water and fresh banana peels as the controlled variables. Digesters numbers 2-4 will be placed with different banana peels those being pre-treated banana peels with different pre-treating process. Table 1 shows the amount and type of solution used and the corresponding type of bananas and weight used.

Table 1. The water and biomass ratio were determine as 1:1 and 1:2 for every type of pretreated banana peels

Digester	Volume and Type of Solution	Type of Banana peel And Weight used
	200ml Distilled water	200g Fresh banana peel
2	200ml Waste water	200g Pretreated banana peels(alkaline)
3	200ml Waste water	200g Pretreated banana peels(acidic)
4	200ml Waste water	200g Pretreated banana peels(water)

The experiment was carried out through a period of 4 weeks equivalent to 28 days in which for every five or four days samples from all seven digesters will be taken for analysis using a UV-Vis Spectrophotometer (SHIMADZU UV 1800 PC). The data that was analyzed is pH value of each digester and the temperature of each digester with three day intervals. To obtain the bio-fuel samples from all four digesters were taken and centrifuged. The liquid phase of the centrifuged sample was taken and was filtered using a syringe filter. For the samples that had a higher total suspended solid than liquid ratio the sample were filtrated using filter papers.

3. Result and discussion

3.1 *Determination of the effects of temperature against ethanol concentration*

Temperature is one of the important variables that have the ability to affect the performance of anaerobic digestion in term of bio-alcohol and to be exact to produce bio-ethanol (Anitha et al. 2015). The temperature can be classified or divided into three ranges to provide optimum condition to produce bio-ethanol which are psychrophilic, mesophilic and thermophilic. Based on, the range temperature for mesophilic was between 20 °C to 40 °C and the optimum temperature for mesophilic can be considered from 30 °C to 35 °C. The thermophilic however have a range temperature from 50 °C to 65 °C and considered to be an optimum temperature at 55 °C to 60 °C. Meanwhile, psychrophilic can be maintained at 12 °C to 16 °C. The condition of temperature used for the setup of this experiment was mesophilic condition and maintained the range of temperature between 20 °C to 45 °C. Mesophilic condition are used as it was optimal to produce large number of ethanol forming microorganism as researched by (Pisutpaisal, Boonyawanich, and Saowaluck 2014) . The reason why mesophilic conditions was used was because it was the same conditions used by (Nathoa, Sirisukpoca, and Pisutpaisal 2014; Odedina et al. 2017)

Based on Figure 5, the temperature range was between 24 °C to 27 °C. The lowest temperature recorded for the experiment is in week one which is 24 °C as the palm oil mill effluent which is a majority substance in the digestion tank was kept in a refrigerator. This explains the temperature recorded for week one is the same for all type of pre-treated banana peels. The highest temperature for the experiment is at 27 °C which is from the banana peels which had been treated by hydrochloric acid. The line representing the pre-treated banana peels by water is overlapped with untreated banana peels. Besides that, the sodium hydroxide treated banana peels temperature increase over weeks. As the temperature increases the concentration of bioethanol in Figure 5 and 7 increases