Production of Bioethanol Using Rotten Fruit

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Bioethanol, which one of the renewable biomass fuel is used as petrol substitution is mostly used in the world since it reduces the usage of crude oil and reduces the environmental pollution at the same time. This study is conducted to identify the most suitable rotten fruits that can be used in producing bioethanol. The rotten fruits are mixed with yeast, *S. cerevisiae* at two different temperatures, 30°C and 35°C, which are then fermented for 8 days. From this study, mixed fruits have the highest percentage of bioethanol at the temperature 30°C with the reading of 7.5899 % (v/v).

1. Introduction

"Fuel of the future" is the term used by Henry Ford to describe ethanol (Küüt, Ritslaid, & Olt, 2011). It is only a matter of time until our main source of energy such as fossil fuels, which is non-renewable to be depleted. The current main feedstock for bioethanol are sugarcane and corn, but unfortunately, it is not enough to fulfill the demand of bioethanol (Vohra et al., 2014).

Nowadays, bioethanol has been domestically produced from cellulosic and starch and sugar based feedstock. Using dry or wet mill processing due to lower capital costs mainly uses the starch or sugar-based ethanol in the United States. From the dry-milling process, ethanol is produced by from fermentation of flour from grinded corn (Bothast & Schlicher, 2005). Along the ethanol, distiller's grains and carbon dioxide is produced. Meanwhile, ethanol corn sweeteners and by-products such as corn oil and starch are produced from a wet-milling process.

In the production of ethanol using cellulosic biomass, biochemical and thermochemical are used. Cellulosic biomass includes grass, wood, and agricultural residues. To produce ethanol from a biochemical process, hemicellulose sugars are released by pre-treating it and breaking the cellulose down into sugars by hydrolysis. The sugars are then fermented into ethanol. Meanwhile, in the thermochemical conversion process, chemicals and heat are added to the biomass feedstock to produce syngas which is then mixed with a catalyst and thus ethanol is produced with other by-products. The cellulosic biomass is more preferred as a feedstock compared to starch and sugar-based feedstock since it is an environmentally sustainable process in which agricultural wastes and residues are taken care off (Tesfaw and Assefa, 2014).

Different area uses a different type of feedstock to produce ethanol based on the availability of the raw material. In Ghana, their potential feedstock to produce ethanol has been identified with cassava, yam, and maize in order to reduce their dependence on crude oil. 50% of cassava domestic supply is consumed as food and they have decided that it is the most suitable feedstock for producing bioethanol (Osei et al., 2013). Meanwhile, in Brazil, 79% of ethanol is produced from fresh sugarcane juice and the remaining is from cane molasses (Wilkie et al., 2000). In India, sugarcane juices are also used as the main feedstock for the production of ethanol (Musatto et al., 2010)

To replace the current main source of fuel, the cost of bioethanol production should be lower than the gasoline prices. To lower the cost of bioethanol production, the feedstock cost plays an important role (Chandet et al., 2007). The feedstock depends on the availability. For example the usage of the cheap raw material, which is cassava that is produced in more than 80 countries, making it one of the favourable bioethanol feedstock considering its cost and availability (Lin, Y., & Tanaka,S. 2006)

At the industrial level, production of ethanol from cellulosic feedstock is still not widely used due to high processing cost (Tesfaw & Assefa, 2014). The high cost came from the steam energy consumption in the distillation of fermentation. Still, production of bioethanol at plant scale is a huge challenge (Chandet et al., 2007). Many countries have developed the bioethanol technology as a concern towards the environment and the plummeting of fossil fuels source (Hira et al, 2009).

This study is conducted to identify which type of fruit is the most suitable feedstock in Malaysia since we have an abundant source of raw material and a well-developed technology to produce it commercially. The fruits that were used are banana, papaya, and pineapple. These fruits were chosen as a subject for this study because of the availability of it, which is all year long. The availability of feedstock can help fulfill the demand for ethanol hence, reducing the dependability of crude oil as the main feedstock. Ever since the oil crises back in 1970, production of ethanol as a substitute for fuel have increased rapidly from less than billion litres in 1975 to over 39 billion litres in 2006 and the market keeps on growing since (Tesfaw and Assefa, 2014). For example, Iogen Corporation, based in Canada, produces bio-ethanol by using wheat straw and corn stover at a commercial level. Meanwhile, in India, the feedstock comes in large scale, but the lack of technology such as production plant causing it to not produce bioethanol at commercial scale.

2. Methodology

2.1. Raw materials

The rotten fruits which are bananas, papayas and pineapples are taken from the market in Taman Bukit Dahlia, Pasir Gudang. The fruits are then stored in a closed container.

2.2. Experimental Procedure

The rotten bananas, rotten papayas, and rotten pineapples are peeled using a knife and washed thoroughly with water. These fruits are then blended after cutting them into small pieces. The mashed rotten fruits are put into eight sets of 250ml Erlenmeyer flask with each of them containing 100ml of mashed rotten fruits. 25ml of distilled water is then added into each of the conical flasks and is uniformly stirred. The samples are then left in an incubator for 8 days at the temperature of 30°C and 35°C. For the fermentation process, yeast *(Saccharomyces cerevisiae)* is used to convert carbohydrates into bioethanol. Yeast has the capability of hydrolyzing sucrose into glucose and fructose and can produce ethanol in high concentration.

2.3. Analysis of bioethanol

The bioethanol analysis is done by an interval of one day for each reading in the period of 8 days for each temperature which are (30 °C and 35 °C): each temperature requires 8 days of fermentation). The bio-ethanol is extracted from the sample (100 ml of banana, papaya, pineapple and mixtures of the 3 types and 10 gram of yeast and 25 ml of water). To determine the concentration of ethanol in the product of evaporation from the sample using a rotary evaporator, Refractive index indicator is used for each sample (fermented fruits). The data is taken several times to make sure the readings are accurate and reliable.

3. Results and Discussion

3.1 Fermentation at temperature of 30 °C

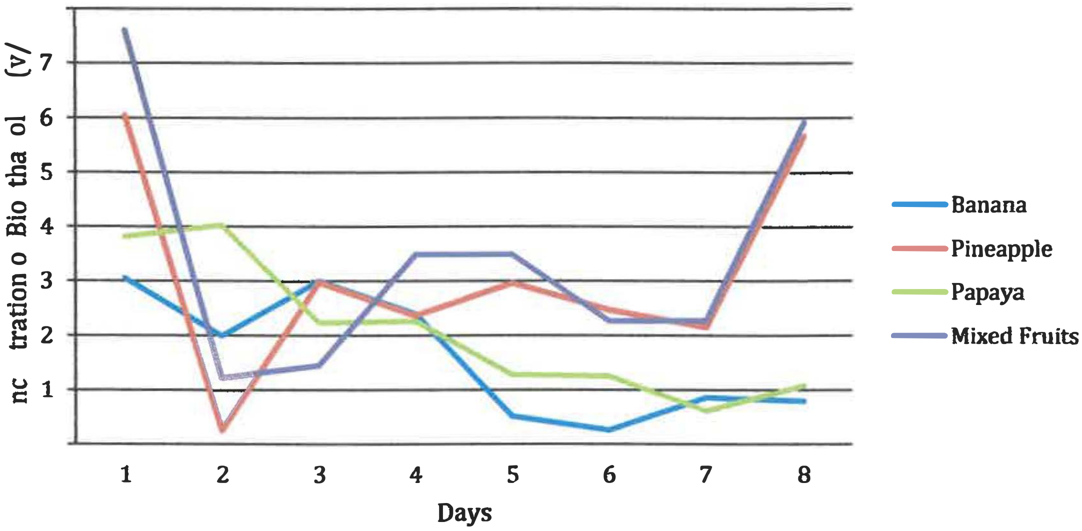

Fig 1 Concentration of bioethanol % (v/v) of banana, pineapple, papaya, and mixed fruit at temperature of 30 °C

The figure illustrates the concentration of bioethanol in banana, pineapple, papaya and also mixed fruits produced in 8 days of fermentation process at the temperature of 30°C. From the figure, it can be seen that all of the samples have a high concentration of bioethanol on the first day. This is because the presence of yeast helps in promoting the formation of bioethanol (Velásquez-Arredondo, Ruiz-Colorado, & De Oliveira, 2010). From the figure shown, the concentration of bioethanol in mixed fruits and pineapple are increasing even after 8 days. This is due to their sugar level are higher than the other fruits.

3.2 Fermentation at temperature of 35 °C

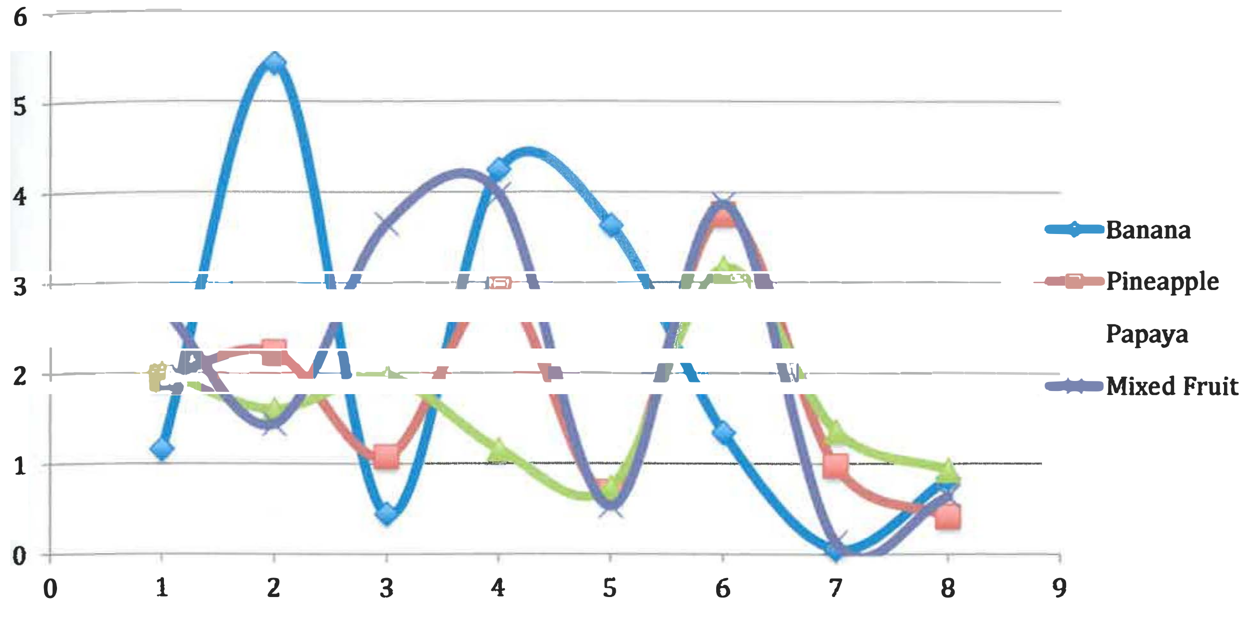

Fig 2 Concentration of bioethanol % (v/v) of banana, pineapple, papaya, and mixed fruit at temperature of 35 °C

Based on the figure, the highest concentration is represented by banana, where it reaches 5.424 % (v/v) of bioethanol concentration. This is due to the temperature, where at between 30°C and 45°C, ethanol production and the specific growth rate in the experiment conducted by the researcher is at maximum (Lin and Tanaka, 2006). Meanwhile, papaya does not show any significant increase value of ethanol concentration unlike banana and mixed fruit. This is because papaya's sugar level is rather low compared to the other fruits. After ripening, the percentage of sugar in papaya varies between 10 to 13% after ripening due to an abundant amount of sucrose, fructose and glucose (Gonçalves et al., 2011). From the graph, it is clearly shown that on day 7, the percentage of bioethanol from all fruit depleted rapidly as *S. cerevisiaie* cells die (Yamaoka et al., 2014).

3.3 Comparison of concentration of bioethanol from fermentation of banana at 30 °C and 35 °C

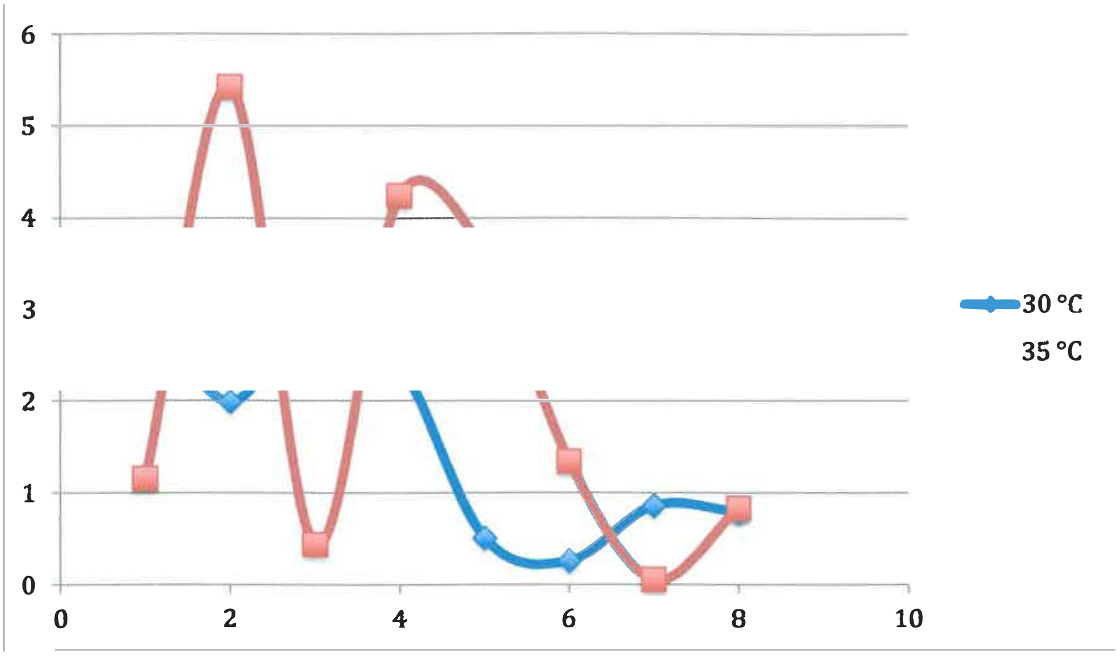

Fig 3 Concentration of bioethanol % (v/v) of banana at temperature of 30 °C and 35 °C

Fig. 3 shows the comparison between the concentration of bioethanol between fermentation of banana at different temperatures which are 30 °C and 35 °C. From the graph, there is a sudden drop in the concentration of bioethanol on day 3 of temperature 35 °C. This happens due to stuck fermentation where the sugar utilization in that certain flask is at a very low rate (Bataillon et al., 1996) and low yeast viability (Blateyron and Sablayrolles, 2000). Stuck fermentation means the available sugar did not transform into alcohol by the yeast cells but stops at an incomplete stage (B. Lee et al., 2005). Overall, the bioethanol concentration for the temperature of 35 °C is higher than that of 30 °C. This is due to the fermentation process at temperature 30 °C started faster where the sugars available is already being consumed from fermentation, causing the reduced amount of available sugar (Poblet et al., 2003) for further fermentation to produce more bioethanol.