BIOETHANOL QUALITY IMPROVEMENT OF COFFEE FRUIT LEATHER

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ABSTRACT

Recently, Indonesia's dependence on petroleum is to be reduced and even eliminated. To overcome the problem of finding the needed alternative materials that can produce ethanol, in this case as a substitute material or a transport fuel mix, boosting the octane number, and gasoline ethanol (gasohol) can be conducted. In the red coffee processing (cooking) that will produce 65% and 35% of coffee beans, coffee leather waste is a source of organic material with fairly high cellulose content of 46.82%, 3.01% of pectin and 7.68% of lignin. In this case, its existence is abundant in Indonesia and optimally utilized. During the coffee fruit peeling, the peel waste is only used as a mixture of animal feed or simply left to rot. The purpose of this study was to produce and improve the quality of the fruit skin of bioethanol from coffee cellulose. However, to improve the quality of bioethanol, the production of the lignin content in the skin of the coffee fruit should be eliminated or reduced. Hydrolysis process using organosolve method is expected to improve the quality of bioethanol produced. In particular, the use of enzyme *Saccharomyces* and *Zymmomonas* will change the resulting sugar into bioethanol. On one hand, by using batch distillation process for 8 hours with *Saccharomyces*, bioethanol obtains high purity which is 39.79%; on the other hand, by using the same batch distillation process with *Zymmomonas,* the bioethanol obtains 38.78%.

Keywords: delignification, organosolve method, Saccharomyces C, Zymomonas M, bach distillation.

INTRODUCTION

Bioethanol has a great potential as an alternative fuel in various energy sectors, especially in the transport sector. In 2007, the United States of America became the largest bioethanol producer in the world with a capacity of fuel alcohol production of 51.5 billion liters from 180 plantations with bio-refinery (Walker, 2010).

The production and the use of bio-ethanol has attracted more and more attention as a strategy for reducing greenhouse gas (GHG) emissions and improving global energy security. In general, the commercial production of bio-ethanol is mainly dependent on the fermentation of sucrose from sugar cane and molasses, or glucose from starch-based crops such as corn, wheat and cassava (Davis, RogerSB, Pearcec, & Peirisa, 2006). Brazil together with the US uses ethanol approximately 60.0% of the ethanol world production by utilizing sugar cane and corn (Chandel et al., 2007). However, using food crops to ethanol production could increase food safety concerns (MR Schmer, 2008). Bioethanol is obtained from biomass and bioenergy crops which have been declared as one viable alternative to gasoline (Demirbas, 2011).

Lignocellulosic biomass is one of the main potential sources for the production of bioethanol global economy. Agricultural, forest (soft wood and hard wood) and industrial wastes are some major lignocellulosic biomass (Limayem et al., 2012). Balat et al. (2008) studied the production of bioethanol from lignocellulosic biomass by using several subsequent processes such as pretreatment, hydrolysis, fermentation and recovery of ethanol, thus it obtained ethanol to the levels below 16%, then, with a further distillation process, it will obtain 95-96% ethanol content.

Saravana et al. (2014) conducted a study about the production of bioethanol from sago pith waste (SPW) by using microwave hydrothermal catalytic hydrolysis with carbon dioxide, resulting in higher energy savings compared to previous techniques without the enzyme, acid or alkaline catalyst, in which the process derived ethanol with the content of 15.6 %.

The technology for lignocellulosic ethanol production mainly relies on pre-treatment, chemical or enzymatic hydrolysis, fermentation, and product separation or distillation. With proper pretreatment strategy on hydrolysis enzyme, it can increase the efficiency of lignocellulosic biomass and lignin to inhibit the saccharification process. Various pre-treatment approaches have been used in the past such as acid or alkaline pretreatment, pretreatment hydrogen peroxide, steam explosion, hot liquid, ammonia fiber expansion pretreatment (Teymouri et al., 2005), sodium chlorite pretreatment (Kumar et al., 2009) and biological pretreatment. The purpose of using dilute acid pretreatment is to remove the hemicellulose and sugar recovery component. Among all the methods of pretreatment, acid pretreatment method of biomass with dilute sulfuric acid has long been recognized as an important step to eliminate the hemi-cellulosic fraction of lignocellulosic substrates to conserve the biological conversion of cellulosic biomass into ethanol (Kuhad et al., 2010). Reaction formation of glucose from cellulose can generally be written as follows:

$$(C_6H_{10}O_5)_n + n\,H_2O \longrightarrow nC_6H_{12}O_6$$

Cellulose Glucosa

The fermentation process is affected by microorganism, and it requires good nutrition to get a good fermentation. Proper nutrition for microorganisms is nitrogen which can be obtained from the addition of NH_3, ammonium salts, peptone, amino acids and urea, liquid Nitrogen needed approximately to 400-1000g/1000L, Phosphate needed approximately to 400g/1000L (Kuhad et al., 2010).

In the fermentation process, glucose is converted to ethanol with the following reaction:

$$\underset{\text{Glucosa}}{C_6H_{12}O_6} \xrightarrow{\text{SC / } Zymmomonas} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

According to the researcher predecessor, bioethanol made of cellulose obtained results which were quite good bioethanol. The purpose of this study is to look for alternative raw materials, and to review the process of hydrolysis, fermentation, and batch distillation process to produce bioethanol with high ethanol content. Original research which is located on the second generation of alternative materials is elephant grass, by simultaneously using three processes (hydrolysis, fermentation and distillation batch) and technical bioethanol production to the levels that are 95-96% ethanol substitute material.

METHODOLOGY

From the results of laboratory analysis, it is discovered that the cellulose content of coffee skin is 46.82%, 3.01% of pectin and 7.68% of lignin. Coffee skin is dried and ground into powder. To get a high glucose, cellulose hydrolysis process is done by employing organosolve method which uses an acid solution that is environmentally friendly citric acid. Product quality bioethanol is determined from multiple parameters that affect as the concentration of acid additions, additions % ethanol, fermentation time, % mo and time addition of batch distillation. The analysis of the quality of raw materials and products bioethanol is made by laboratory analysis. Instrumentation analysis was performed by using Gas Chromatography (GC) and Spectrophotometer, in which it will particularly analyze the ethanol content.

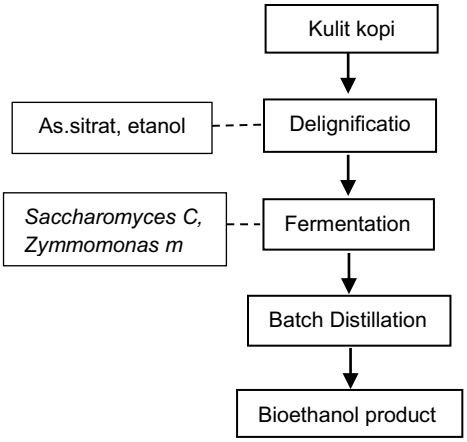

Figure-1. The flow of bioethanol production using hydrolysis, fermentation and distillation batch.

The procedure of delignification process

The condition is still being done at the temperature of 80 °C and the stirring speed of 600 rpm. Changes on conditions are made on the addition of citric acid (1:10 ; 1:12 ; 1:14 ; 1:16 ; 1:18), %addition of ethanol (10, 20, 30, 40, 50) as well as the length of stirring (1 ; 1.5 ; 2 ; 2.5 ; 3 hours). The solids are separated from the solution, and then, made into the delignification process. The solution (filtrate analyzed as pectin). Analysis is performed on the concentration of lignin separated both in the filtrate and in the sediment.

The procedure of fermentation process

The results of glucose hydrolysis process that has not qualified to do the process of adding citric acid or NaOH. Citric acid is then added to the filtrate as a result of hydrolysis in which it will be fermented until it reaches the fermentation pH approaching 4.5. Next, the starter is added to the solution, then, it is fermented in anaerobic conditions by closing the bottle tightly and watching it for a certain time. The changes of fermentation time conditions are 3, 4, 5, 6, 7 days, and Zym starter SC are 9, 10, 11 %. Then, the ethanol levels are analyzed from those data.

The procedure of distillation process

Results obtained from the fermentation are inserted into the distillation flask to obtain ethanol from glucose. Batch distillation process is run at the temperature of 78 °C. After the volume of the solution bottom stays 10% of the feed volume, batch distillation is stopped, and then analyzed for the ethanol levels.

RESULTS

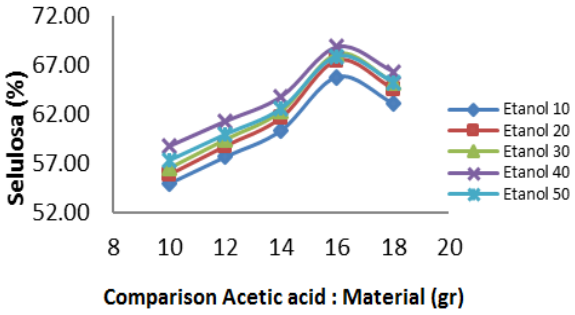

Figure-2. Cellulose content of the sludge after the delignification.

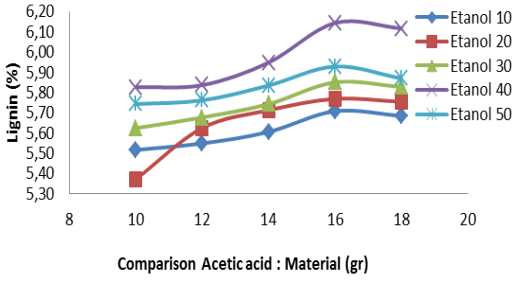

Figure-3. Lignin content is obtained after a process of delignification

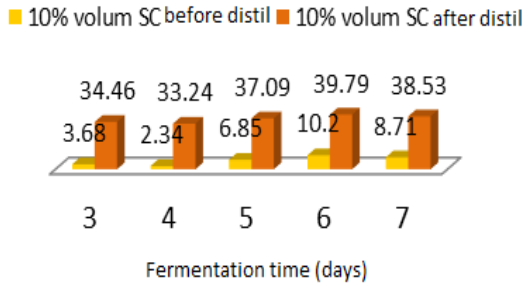

Figure-4. Levels of bioethanol using *Saccharomyces*

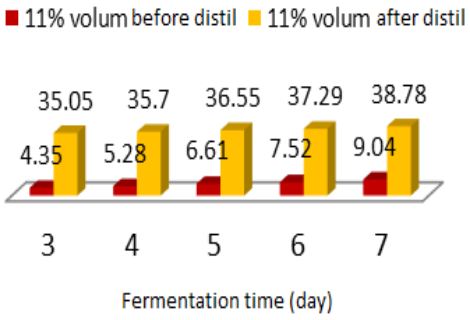

Figure-5. Levels of bioethanol using *Zymmomonas*

DISCUSSIONS

From Figure 2 and 3, the greater the solution of cellulose obtained, the greater the cooker is. However, at certain times it shows a decrease in the amount of cellulose. It happens the same to lignin. That is because the greater the concentration of the solution cooker, the greater the lignin content dissolves. Nevertheless, when the concentration is too high, it will cause damage to the cooker cellulose, and cellulose esterification reaction occurs in which in this case, reaction between the alcohol formed cellulose ether. Thus, it causes a decrease in cellulose and lignin produced

In the fermentation process (Figure 4 and 5) that uses Saccharomyces, best conditions are obtained at a concentration of 10 % with a time starter for 6-day fermentation, producing ethanol content amounted to 10.20 %. After the fermentation process is followed by batch distillation process for 8 hours, it produces ethanol with a concentration of 39.79 %. Whereas, the fermentation process using mobilis Zymmomonas obtained the best conditions at 7 days and the starter concentration of 11 %. In the beginning, the ethanol content is 9.04 %, then, after the distillation process the ethanol content amounts to 38.78 % .

CONCLUSION

Based on the research goal which is to assess the delignification process, fermentation, and batch distillation process, as well as finding alternative raw materials, the product of bioethanol coffee fruit peel can be used as an alternative raw material for the production of bioethanol. Still, it is possible to proceed the conduct of further distillation to obtain ethanol content of 96%. Thus, it is very possible for a commercial-scale pilot plan.

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