Manufacturing Bioethanol from Gadung (Dioscorea hispida) through One Stage Distillation Unit

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ABSTRACT

Gadung (Dioscorea hispida) is a tuber that is non-food because it contains cyanide (HCN). Starch content in gadung tuber is 30.9% so that it worth to manufacture bioethanol. Bioethanol is a product of hydrolysis of starch to glucose, followed by fermentation of glucose using yeast Saccharomyces cereviceae to bioethanol. In this research, bioethanol was made from gadung starch. The hydrolysis process produces 7.85-10.48% glucose and fermentation process produces 5-8.5% crude ethanol. Bioethanol produced from distillation unit was 80%, corresponding to the technical specifications desired. The Design of 1-stage distillation unit has completed, includes the shape and dimensions of the tools, i.e. the main condenser, cylinder-shaped, dimensions of diameter is 32cm and height is 45cm, feeder tank / boiler cylinder-shaped, small scale volume of 5L. At distillation column, the diameter is 9cm and length is 121cm. Column is filled with ceramic or glass type packing inside. Column is equipped with thermometer to measure the temperature of ethanol-water vapor. Two stages distillation unit into one stage can produce 82% ethanol which is fit as fuel for household stoves.

Keywords: Bioethanol; Fuel; Gadung; Starch; Distillation

I. INTRODUCTION

Fuel prices are rising and the world's oil reserves are more limited has prompted efforts to obtain alternative fuels. Various factors such as rising fuel prices, awareness of biosecurity to increase domestic revenue, awareness to reduce greenhouse gas emissions, and the potential to enhance the development of regional influence increased interest for biofuel production.

Bioethanol is an alternative fuel that is environmentally friendly because it is the nature of the fuel oxygenate, are compounds that contain oxygen. Oxygen content makes it a perfect fuel combustion so as to minimize toxic exhaust gas. Exhaust emissions produced from burning bioethanol 19-25% lower compared with fossil fuels. In the gadung tuber chemical elements contained cyanide (HCN), which are toxic. Gadung starchy high enough. Starch are carbohydrates in the form of a polysaccharide polymer such as monosaccharides anhidro the general formula (C6H10O5) n. The starch content in the gadung 30.9%, so the tuber is worthy converted into bioethanol as an alternative energy source that is environmentally friendly.

Gadung tuber is kind of tubers that can be used as an alternative source of carbohydrates and is a commodity that has excellent prospects.

TABLE 1. CHEMICAL COMPOSITION OF GADUNG TUBER

Parameter	Composition
Water Content (%)	61.5
Starch (%)	30.9
Fiber (%)	1.3
Ash (%)	1.1
Crude Fiber (%)	0.93
Total Sugar (%)	2.45
Cyanide (ppm)	362

The production of bioethanol from starch contained in gadung tuber, is done through the process of converting carbohydrates into sugar (glucose). In the enzymatic hydrolysis is known there are two methods: SHF and SSF.

SSF methods need to be developed because it can shorten the process of making bioethanol. The process of simultaneous hydrolysis and fermentation (SSF) is done conventionally by heating 95-120^{o}C.

II. EXPERIMENTAL METHODS

Stages of the process of making ethanol from gadung tuber include pretreatment, hydrolysis, fermentation and purification. In the process of gelatinization and liquefaction of heat required to raise the temperature to 90°C, followed by saccharification process, requiring cooling to 60°C.

At the pretreatment stage, retrieved gadung tuber starch. The next stage is the process of hydrolysis of starch. Hydrolysis of starch can be carried out with the help of acids or enzymes at a temperature, pH, and specific reaction time. Hydrolysis was followed gluco-amylase to hydrolyze the α-1,4-glucoside bond and α-1,6-glucoside to produce glucose. Gluco-amylase is added in order to enzymatic hydrolysis process for converting starch into glucose more produced, because gluco-amylase can break the bond of starch that has not been cut by the addition α-amylase.

Then, the fermentation process lasts for 7 days by using Saccharomyces cerevisiae. Furthermore, the fermentation is done in trials of 0, 24, 48, 72 hours. However, the optimum fermentation achieved in 48 hours with an alcohol content 7-8%, with 2.5% concentration of the enzyme. In this study, simultaneous hydrolysis and fermentation (SSF) with conventional heating 95-120^{o}C.

Furthermore, the distillation process. Purification by distillation frequently encountered is the separation of ethanol-water. Ethanol purified water from a mixture of ethanol through distillation. Ethanol formed after the fermentation process is not more than 10 vol%. Fermented containing less than 10 vol% ethanol heated to remove CO_2 and fed to the next column.

Purification of the ethanol yield is generally conducted with two stage distillation method. Two stages distillation are shown in Figure 1. This tool will be engineered into one stage distillation to produce bioethanol as a household fuel (ethanol content of at least 75%).

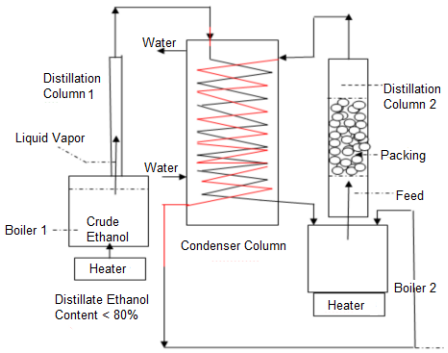


Figure 1. Schematic ethanol purification by distillation in two stages, before engineered

Results of final ethanol has the following composition azeotropic point, the average level 94%. Engineering will be done that is operating a two stages distillation engineered into a one stage by optimizing the packing in the column to get the optimum ethanol.

III. RESULT AND DISCUSSION

A. *How the effect of enzyme concentration on glucose levels?*

Hydrolysis process results are presented in Table 2:

TABLE 2. THE EFFECT OF ENZYME CONCENTRATION ON GLUCOSE LEVELS

Volume Enzyme (ml)		**Glucose Content (%)**
α-Amilase Enzyme	**Gluco - Amilase Enzyme**	
2	2	8.62
4	4	10.48
6	6	7.85

Based on table 2, the α-amylase enzyme and gluco-amylase enzyme is able to convert carbohydrates into glucose. The highest glucose level that is 10.48%, resulted from the variable α-amylase enzyme and gluco-amylase enzyme as much as 4 ml. The ability of the α-amylase enzyme and gluco-amylase to break down carbohydrates into glucose caused by α-amylase enzyme is able to break the α-1,4 randomly on the inside of both the molecule amylose and amylopectin into dextrin.

B. How yeast mass effect on levels of bioethanol and the effect of performance on the final results of ethanol of two-stage distillation?

The results of the process of fermentation and fractional distillation are presented in Table 3:

TABLE 3.THE RESULTS OF FERMENTATION AND FRACTIONAL DISTILLATION PROCESS

Mass Yeast (gram)	Bioethanol Content (%)		
	Fermentation	Distillation	
		1	2
12	8	29	92
36	10	30	93.5
60	9	30	92

The fermentation process can produce only the highest ethanol 11%. In order to achieve a viable bioethanol used as fuel for domestic stoves with a minimum content 75% is done fractional distillation. At one stage distillation process, produced bioethanol with levels 30%. For further purification is done two stages distillation using the packing material type of glass that is capable of producing bioethanol with decent levels 93.5% is used as fuel for household stoves.

C. How the results of the bioethanol production by using one stage distillation process?

In engineering two stages distillation into one stage distillation are shown in Figure 2.

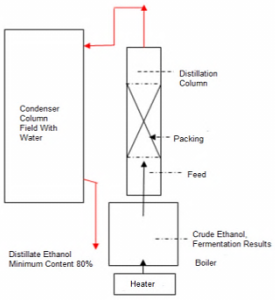
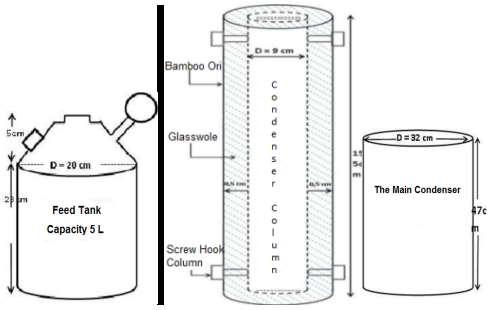


Figure 2. Results of engineering two stages distillation into one stage distillation

TABLE 4. RESULTS OF ONE STAGE DISTILLATION

Ethanol Content (%)	
Fermentation	**Distillation Of The Stage**
8	70
10	82
9	75

The result of one stage distillation produced ethanol with a minimum content 70% can be achieved by manipulating tools. The design of the one stage distillation step includes the main condenser, cylindrical, diameter 32 cm, length 45 cm, whereas for the boiler, the volume 5 liters. Dimensionless distillation column diameter of 9 cm, length 12 cm, containing gasket of ceramic material. Design one-stage distillation, including the shape and size of tool the shown in Figure 3. The materials used for distillation is a food grade stainless steel.



(a) (b) (c)

Figure 3. The Design Tools of One Stage Distillation : (a). Boiler, (b). Distillation Column and (c). Main condenser

Results of final ethanol has the following composition azeotropic point, the average level 94%. Engineering will be done that is operating a two-stages distillation engineered into one stage by optimizing the packing in the column to get the optimum ethanol.

Engineering distillation tools has many advantages, among others :

1. Eliminate 1 column distillation operation thus saving time, effort and cost.
2. Save 1 boiler as a vaporizer, thus saving fuel costs and the cost of tools.
3. Content of ethanol yield obtained almost the same when compared to the two stages distillation operation, ie at least 80%.

IV. CONCLUSION

Utilization of gadung tubers as bioethanol fuel to produce alternative energy in order to overcome the energy crisis without disturbing food sustainability. In the process of hydrolysis, the additional volume of the alpha-amylase enzyme and gluco-amylase to glucose produced. The highest levels of glucose produced by the increased volume of the alpha-amylase enzyme and gluco-amylase as much as 4 ml in 3500 ml of substrate (0.12% v / v). In the fermentation process,

the addition of yeast mass at 1.02% v / w produced crude ethanol content 10%. In engineering tools of two-stages distillation into one stage distillation process can produced the highest ethanol content 82% which is fit for use as fuel for household stoves.

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REFERENCES

[1] BRETHAUER, S. and Wyman, C. E. **(2010)**. *Review: Continuous hydrolysis and fermentation for cellulosic ethanol production*. Bioresource Technology.

[2] FOGARTY, W. M. and Kelly, C.T. **(1979*)*** *Starch degrading enzymes of microbial origin,* in: Progress in Industrial.

[3] HARGONO. **(2012)** *Pembuatan Bioetanol Fuel Grade dari Singkong Karet (Manihot glaziovii) melalui Proses Destilasi – Adsorpsi menggunakan Adsorben Zeolit*. Bandung: Prosiding Seminar Nasional Teknik Kimia , Universitas Parahyangan, ISSN: 2252-6005, Page 19-23.

[4] HARGONO. **(2015)** *Pemanfaatan Umbi Gadung Beracun (Dioscorea hispida) sebagai Bahan Baku Pembuatan Bioetanol untuk Bahan Bakar Kompor Rumah Tangga: Perancangan Distilasi Satu Tahap*, Prosiding Seminar Nasional Teknik Kimia 2015, Universitas Diponegoro Semarang, 18 Maret 2015, ISSN 1693-4393.

[5] LI, P and Zhu, M. **(2011)** *A Consolidated Bio-Processing of Ethanol from Cassava Pulp Accompanied by Hydrogen Production*. Bioresource Technology, 10471-10479.

[6] PRIHANDANA and Rama. **(2008)** *Bioetanol Ubi Kayu: Bahan Bakar Masa Depan*. Jakarta: Agromedia Pustaka.S.

[7] SUKUMARAN, R. K. **(2008)** *Cellulase Production Using Biomassa Feed Stock and Its Application In Lignocellulosa Saccharification for Bioetanol Production.* Renewable Energy. Vol 30. Page 1- 4.