Bioethanol Optimization in Hydrolysis and Fermentation Process with Surface Response Method

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***Abstract*—The starch content in the liquid waste of tapioca flour can be processed into glucose by chemical hydrolysis process with solid NaOH, and filtrate glucose obtained can be processed into technical bioethanol with fermentation process using turbo yeast. This study aims to produce maximum technical glucose and bioethanol with optimization in hydrolysis and fermentation processes using Minitab software with Surface Response. Before the hydrolysis process, tapioca flour's liquid waste underwent a pretreatment and filtration process to remove impurities. The hydrolysis process chemically uses solid NaOH with liquid waste tapioca flour as 5 liters and hydrolysis temperature ± 40°C. Variables in the form of solid NaOH 1 to 5 mg, and stirring time 15 to 60 minutes using digital magnetic stirrer type MS-20D. The fermentation process uses a volume of glucose filtrate 500 ml, fermentation temperature ± 30°C, and fermentation pH ±4.5, variable levels of turbo yeast 7 to 15 (% w/v) and fermentation time of 3 and 7 (days). The maximum levels obtained for glucose are 18%, and technical bioethanol is 21.9 %v/v, with the Response Surface method showing similarities to the second-order polynomial model.**

Keywords—bioethanol, glucose, hydrolysis, fermentation, response surface method, liquid waste of tapioca flour

I. INTRODUCTION

The first generation bioethanol raw materials such as corn and sugar cane cannot meet the global demand for ethanol production. Another alternative to agricultural waste is a 2nd generation bioethanol raw material, in the process very cost-effective, renewable, and abundant, but has challenges and limitations in biomass processes, as well as conversation of glucose and xylose requires new fermentation technology. Waste from the sago manufacturer for bioethanol production obtained glucose contains 0.47 (g ethanol per g glucose) and 15.6 ethanol per 100 grams of dry sago [2]. The starch component is very complicated in the form of the disaccharide. Before fermentation, the starch component in maltase hydrolysis with enzymes to obtain glucose [3].

Liquid waste of rice flour as a raw material of bioethanol, in the hydrolysis process, produces glucose 5-10% with bacillus, and the fermentation process produces bioethanol 11-16 % using Saccharomyces Cerevisiae [4]. To obtain the maximum ethanol fermentation process biologically, obtained ethanol levels 10-15 %v/v and bioethanol yield 36 %w/v. The raw material of generation 2 (bamboo) is carried out as a delignification process to eliminate the pentosane level to obtain bamboo filtrate, used as a raw material in the fermentation process. The experiment results were obtained in bioethanol-air-feces, then compared to the simulation of the ternary system of water-ethanol and feces (EWI), validation of the simulation results used literature data [6].

Since the raw material is cellulose-based, ethanol from red sage raw materials underwent a pretreatment process with concentrated acid (HNO3) and the delignification process to eliminate lignin levels in the raw materials fermentation process, eliminating lignocellulose fraction to obtain optimum cellulose biomass [7]. Ethanol with sago waste raw materials uses a microwave hydrothermal hydrolysis process. Another product obtained is carbon dioxide [8]. Higher energy savings compared to previous techniques without enzymes in the fermentation process, without acids or catalysts in the hydrolysis process, only adding pretreatment processes and distillation processes, obtained ethanol levels of 15.6% [9]. Optimization of the hydrolysis process uses enzymes, optimizing the Ammonia Fiber Explosion (AFEX) parameters to obtain optimum ethanol levels [10]. Bioethanol with cellulose raw materials in the process of purifying ethanol, using batch and flash distillation processes, the results obtained show almost the same bioethanol yield of about 95-96 % v/v [11].

The basic model application on fuzzy controls with closed-loop system formulas is built and hidden in discrete form, taking into account input variables and output variables, each sent by set-point and performance index errors. Formulation of quadratic optimization issues was adopted to obtain a feedback controller output that could bring about slight changes in economic index numbers and the dynamic realization of set-point compensation by the controller, replaced according to the change in lower layer conditions [12]. Theoretically, as a computer simulation, the agitator tank controller is performed with the agitator tank controller, numerical results to validate the agitator tank's performance, and obtained superior results [13].

The concentration of ethanol is noteworthy in Deionized Water and White Wine in its fermentation process. Using the WSRM method focused on increasing the Limit of Detection, the results obtained show 140 times better the Limit of Detection than the PCA method, widely used in biochemical sensing systems [14]. Clostridia solvents are used for bio-

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acetone and bio-butanol purification, bio-based impurity molecules such as chemical petro, providing additional benefits and ongoing benefits by applying clostridia fermentation to increase yields on the production of the next generation of bio-molecules [15].

The optimal results of technical glucose and bioethanol levels experiments were sought using the Response Surface Methodology (RSM) method. RSM is a combined mathematical and statistical engineering method used to model and analyze a Y response influenced by several X-free variables to optimize the response. The relationship between the Y response and the X-free variable is in (1):

$$Y = f(X_1, X_2, X_k) + \varepsilon \quad (1)$$

Description:
Y is a response variable, f (X_1, X_2, X_k) are free variables/factors, and ε is an error.

The first step of RSM is to find a relationship between the y response and the x-factor through the first-order polynomial equation and used the linear regression models, known as first-order models, as in (2):

$$Y = \beta_o + \sum_{i=1}^{k} \beta_o X_i \quad (2)$$

The first-order experiment's design suitable for the factor filter stage is the 2k factorial design (Two-Level Factorial Design). Second-order model, there is usually curvature and used polynomial models of the second-order whose squared functions are in (3):

$$Y = \beta_o + \sum_{i=1}^{k} \beta_o X_i + \sum_{i=1}^{k} \beta_u X_i^2 + \sum_{i=1,j=2}^{k-1,k} \beta_{i,j} X_i X_j + \varepsilon \quad (3)$$

Equations and optimization results are obtained using Minitab software. In this software, the optimal results will be shown using graphs and some calculation results.

The previous research produced maximum technical glucose and bioethanol with optimization in hydrolysis and fermentation using Minitab software with Surface Response. Chemical hydrolysis process using solid NaOH with MS-20D digital magnetic stirring, fermentation process using turbo yeast.

II. Methodology

Before going into the main stages of making bioethanol, hydrolysis, and fermentation, we performed pretreatment and filtration processes to eliminate impurities.

The liquid waste of tapioca undergone some pretreatment and filtration process to eliminate impurities, further hydrolysis process with a permanent change in the form of liquid waste of tapioca flour as much as 5 liters and hydrolysis temperature ± 40°C, change in the form of solid NaOH 1 to 5 mg and stir time is 15 to 60 minutes using digital magnetic stirrer type MS-20D. In the fermentation process using a fixed change in the form of a glucose filtrate volume of 500 ml, fermentation temperature ± 30°C, and fermentation pH ±4.5, the change in the form of turbo yeast content of 7 to 15 (% w/v) and fermentation time of 3 to 7 (days).

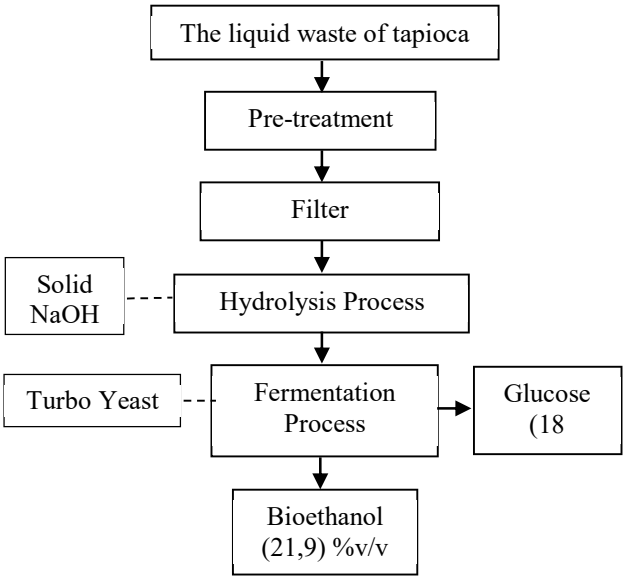

Fig. 1. Glucose and bioethanol contains flow used hydrolysis and fermentation process

III. Results and Discussion

The results yield glucose and bioethanol with 5 liters and hydrolysis temperature ± 40°C. Change in the form of solid NaOH 1 to 5 mg, and stirring time 15 to 75 minutes using digital magnetic stirrer type MS-20D solid ratio NaOH with hydrolysis process. In the fermentation process, using a fixed change in the form of the volume of glucose filtrate (500 ml), fermentation temperature ± 30°C, and fermentation pH ±4.5. Change in turbo yeast content 7 to 15 (% w/v) and fermentation time seven days as TABLE I.

TABLE I showed optimum glucose levels in the hydrolysis process with a solid NaOH ratio of 3 mg and a 45-minute digital stirring of 18 %v/v, compared to previous studies on hydrolysis biologically using bacillus obtained glucose levels of 3-9 (%v/v) [6]. After that, the glucose-containing filtrate is fermented, optimum glucose results in the hydrolysis process are used as raw materials in the fermentation process, showing optimum technical bioethanol levels of 21.9% with a fermentation time of 7 days and turbo yeast of 11 %w/v, compared to previous studies in the fermentation process using Saccharomyces Cereviceae obtained bioethanol levels of 20.88 (%v/v) [6].

In Fig. 2, the effect of MS-20D type digital magnetic stirring on glucose levels in hydrolysis processes is very significant compared to the digital stirrer. At the stirring time of 15-30 minutes obtained glucose levels of 9-16 %v/v as previously researched [6], 45 minutes stirring time brought optimum glucose levels of 18 %v/v indicated from ms-20D type digital magnetic stirring performance, after a stirring time of 60-75 minutes showed glucose levels decreased and tended to flatline by 10-14 %v/v, still resulting in higher results than previous studies [6].

TABLE I. GLUCOSE AND ETHANOL CONTAINS ON HYDROLYSIS AND FERMENTATION

Ratio NaOH	Stirring time	Glucose contain	Turbo yeast	Bioethanol contain
(mg)	(minutes)	(%v/v)	(%w/v))	(%v/v)
1	15	9.2	7	11.0
	30	12.4	9	12.3
	45	14.4	11	14.4
	60	11.6	13	11.3
	75	10.5	15	10.3
3	15	16	7	19.1
	30	17.1	9	20.2
	45	18	11	21.9
	60	16.4	13	18.5
	75	14.4	15	15.6
5	15	11.1	7	13.0
	30	12.5	9	14.7
	45	13.7	11	15.5
	60	12.4	13	13.3
	75	11.5	15	12.8

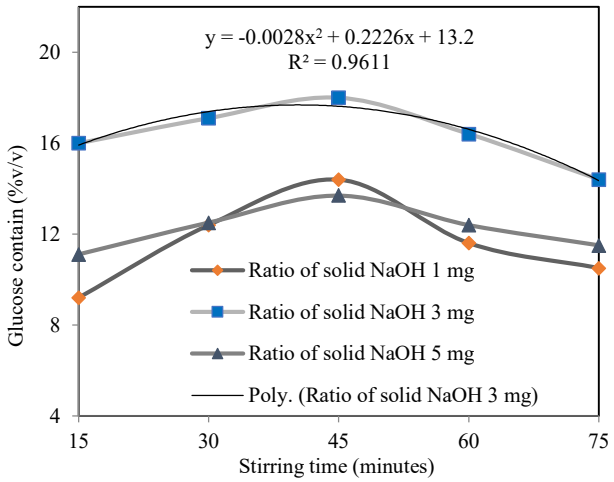

Fig. 2. Effect stirring time on the remaining glucose contain

The hydrolysis process optimization results are calculated using polynomial equations second order with the Response Surface Method. It shows the equation $y = -0.0028x^2 + 0.2226x + 13.2$ with the proximity of the result $R^2 = 0.9611$ close to the value of one.

In Fig. 3, turbo yeast on bioethanol levels in the fermentation process is higher than that in previous research. At turbo yeast 7-9 %v/v obtained bioethanol content of 11-20 %v/v, turbo yeast 11 %v/v got optimum glucose levels of 21.9 %v/v indicated from turbo yeast performance, after turbo yeast 13-15 %v/v showed glucose levels decreased and tended to flatline by 10-18 %v/v, still resulting in higher results than previous studies [6]. The result of fermentation process optimization using polynomial equations of the order of two with the Response Surface method shows the equation $y = -0.2339x^2 + 4.7114x - 2.5889$ with the proximity of the result $R^2 = 0.9157$ close to the value of one.

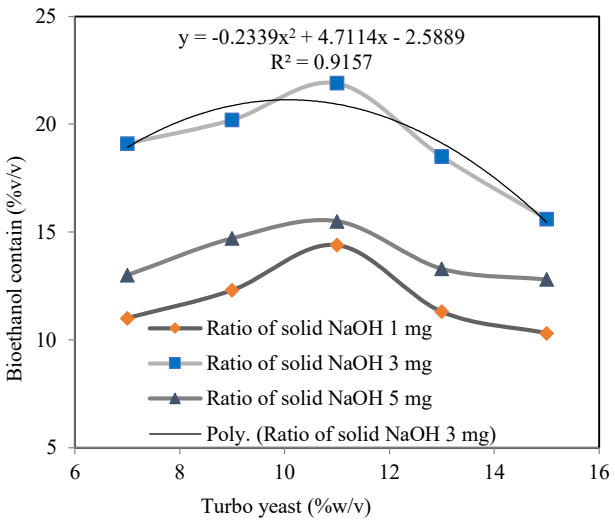

Fig. 3. Effect turbo yeast on the remaining bioethanol contain

IV. CONCLUSION

Optimum glucose levels in the hydrolysis process of 18 %v/v with polynomial equations of the order of two, $y = -0.0028x^2 + 0.2226x + 13.2$ with proximity to the result $R^2 = 0.9611$ close to the value of one. Optimum bioethanol levels in the fermentation process of 21.9 %v/v with polynomial equations of the order two $y = -0.2339x^2 + 4.7114x - 2.5889$ with the proximity of the result $R^2 = 0.9157$ close to the value of one.

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