Hydrolysis of starch from various tuber using acetic acid as an alternative sugar

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Abstract. In the beginning, tubers have only known as a source of starch. But later on, the existence of process innovation acquaints the other product from the tuber, such as liquid sugar. In this research, tubers such as *ganyong, suweg, uwi, talas, and gembili* were analyzed to know its potential as being material for a sugar alternative. The process included starch production and hydrolysis using an acid catalyst. Then sugar content and density were analysed using the Luff-Schoorl and pycnometer respectively. The results showed that the highest reducing sugar content was 2.8598% which was obtained in ganyong with 6% acetic acid catalyst. The lowest sugar content was obtained in the gembili sample (0.4816%) with the addition of an acetic acid catalyst of 2%. Besides, this research confirmed that the higher concentration of the acid catalyst, the higher the reducing content in sugar alternative from tubers.

Keywords. Hydrolysis, Luff-Schoorl, Reducing-sugar, Tubers

1 Introduction

The need for sugar in Indonesia continues to increase along with the increase in population. Based on the data, it is said that to meet domestic sugar needs, Indonesia must import approximately 1.2 million tons [1]. It can be caused by several factors, one of it that the need for sugar is still dominated by cane sugar. Meanwhile, sugarcane production is decreasing daily due to the reduction in sugarcane plantation land. Therefore, it is necessary to search for alternative raw materials like tubers. Indonesia is rich in various tubers, including ganyong (canna), suweg (Amorphophallus campanulatus), gembili (Dioscorea esculenta) [2], talas and uwi.

Tubers can be processed into raw materials to make alternative sugar, sugar syrup. The tubers' starch content is extracted and then processed through the hydrolysis stage into alternative sugars. The starch polymer will be broken down into sugar molecules with shorter chains in the hydrolysis process. The hydrolysis process can be carried out with the help of an acid catalyst. The acid catalyst commonly used is sulfuric acid, but the use of sulfuric acid is not only expensive but also difficult to apply because it is highly corrosive and requires extra handling. Sulfuric acid can be replaced by using a weaker organic acid that is safer, namely acetic acid. Acetic acid, also known as vinegar, is safer and more familiar to people.

Therefore, in this research, the hydrolysis process of tubers was carried out using acetic acid at several concentrations to study the catalyst concentration effect on the content of reducing sugar content in alternative sugars from various tubers.

2 Materials and Methods

2.1 Materials

The raw materials were tubers, consist of ganyong, suweg, uwi, and talas. For catalyst, acetic acid was used, while for Luff-Schoorl analysis the chemicals were p.a. sodium carbonate (Na_2CO_3), lead acetate ($Pb\text{-}SO_4$), Luff-Schoorl solution, KI, sulfuric acid (H_2SO_4), sodium thiosulfate ($Na_2S_2O_3$), amylum indicator.

2.2 Starch preparation

Each tuber was peeled, washed, and chopped, then crushed using a blender with the addition of water 4:1 to form a slurry. The slurry formed was filtered and squeezed to obtain a filtrate. The filtrate was then allowed to stand for 24 hours to separate the sediment and water. The precipitate, called starch, was heated in an oven for 4 hours. Furthermore, it was ground to obtain starch-powder.

2.3 Hydrolysis

12.5 grams of starch powder was mixed with 100 ml of distilled water in a glass beaker. The mixture was then

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stirred and heated at a temperature of 60-70ºC using a magnetic stirrer to form a gel. Then added 15mL of catalyst at concentration variables of 2%, 3%, 4%, 5%, 6%. After that, the mixture was heated in the oven at a temperature of approximately 120ºC for 100 minutes. So, a sample of reducing sugar was obtained and ready to be analyzed. The concentration analysis carried out was the analysis of sugar content based on the Luff Schoorl method and the specific gravity analysis using a pycnometer.

2.4 Luff-Schoorl analysis

The analysis method of reducing sugar used was the Luff Schoorl method which refers to the modified method [3], [4] The steps taken were that the sample was weighed as much as 5 g and dissolved with 200 ml of distilled water in a 250 ml volumetric flask. Then Pb-acetate was added for purification, and Na_2CO_3 to neutralize the excess Pb-acetate. After that, the mixture was diluted to the line mark on the flask. Next, 10 ml of the solution was put into an Erlenmeyer and added with 25 ml of Luff Schoorl's solution and 25 ml of distilled water. After that, some boiling stones were added to the solution, then heated in a system using a reflux condenser for 10 minutes. Then the solution was cooled and added with 15 ml of 20% KI, 25 ml of 26.5% H_2SO_4, and 1% starch indicator, then titrated with 0.1N Na2S2O3 until the blue color disappeared.

The sugar content was calculated by calculating the volume of Na2S2O3 used in the titration process. Then the volume was adjusted to the data in the Luff-Schoorl table to estimate how many milligrams of reducing sugar were contained in the sample. The numbers from the table were then used to calculate the reducing sugar content using equation 1.

$$Sugar\ content = \frac{W_1 \, x \, f_p}{W} \, x \, 100\% \qquad (1)$$

Where W_1 was the milligram of glucose contained in the sample, obtained from the figures in the Luff-Schoorl table [4]; *Fp* was the dilution factor, and w was the weight of the analyzed sample (mg).

3 Results & Discussion

Alternative sugars can be produced from tubers due to the starch content. In this study, the tubers used were ganyong, suweg, uwi, talas dan gembili. From the starch manufacturing process that has been carried out, the starch yield is 10-20%. This value is not much different from previous studies [2]. This study reported that the yield of starch from tubers was in the range of 4.56 – 21.44%.

The next stage of getting sugar from tubers was the hydrolysis process. The hydrolysis process was carried out using the acetic acid catalyst, an organic acid. Based on the Luff-Schoorl analysis, the sugar content data of the product obtained were shown in **Fig. 1**. The graph in the figure showed that the sugar content obtained increased as the acetic acid catalyst concentration increased. That was because the acid catalyst increased the rate of breaking the molecular starch chains that bound water and formed simpler sugar molecules. Besides, the graph showed that of the five types of tubers used, the highest reducing sugar content was found in alternative sugar from ganyong tubers, around 2.2878%. This value was obtained with the use of a catalyst of 6%. Meanwhile, the lowest reducing sugar content was found in alternative sugar from suweg, which was 0.4816%, obtained under a 2% catalyst.

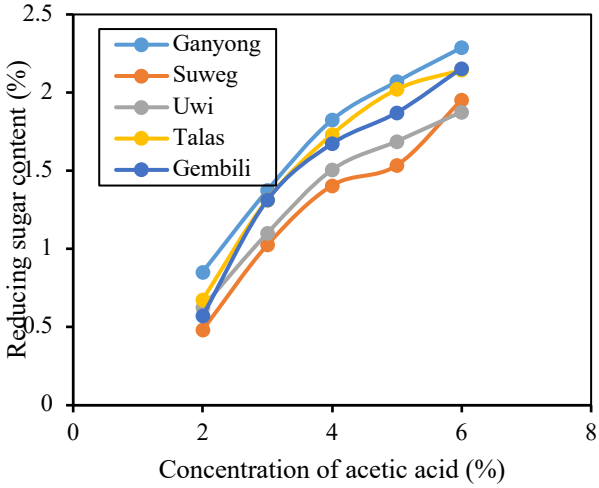

Fig.1. The effect of concentration of acetic acid (%) on the reducing sugar content (%) of alternative sugar from various tubers

The reducing sugar content in the samples of alternative sugar obtained from these five types of tubers was still relatively low compared to the sugar content based on the standard quality set by SNI, which is at least 30%. It is probably influenced by the type of acid catalyst used, which is a weak acid. Where [5] reported that the use of acetic acid in the hydrolysis process to obtain reducing sugars produced a much lower total sugar than that of a sulfuric acid catalyst. Using an acetic acid catalyst might cause the termination of the polymer chain not to occur completely. The polymer chain termination can be affected by time, temperature, and others. Therefore, based on the results of this research, it could be said that further studies are needed to obtain the optimum conditions in the process of getting alternative sugar from tubers.

The density of the alternative sugar obtained was also measured in this experiment. Sample density data were obtained based on measurements using a pycnometer, as shown in the graph in **Fig. 2**. The graph showed that the density value increased proportionally to the concentration of acetic acid catalyst used in all samples of the five tubers. This increase in value also confirms an increase in the sample's sugar recovery level. The highest density was obtained from alternative sugar from ganyong tubers using a 6% catalyst, while the lowest density was found in alternative sugar from suweg at a 2% catalyst concentration. Based on the density value, the alternative sugar obtained also did not meet the SNI standard, which was 1.6 gr/cm3, while in this study, the highest density obtained was 1.0382.

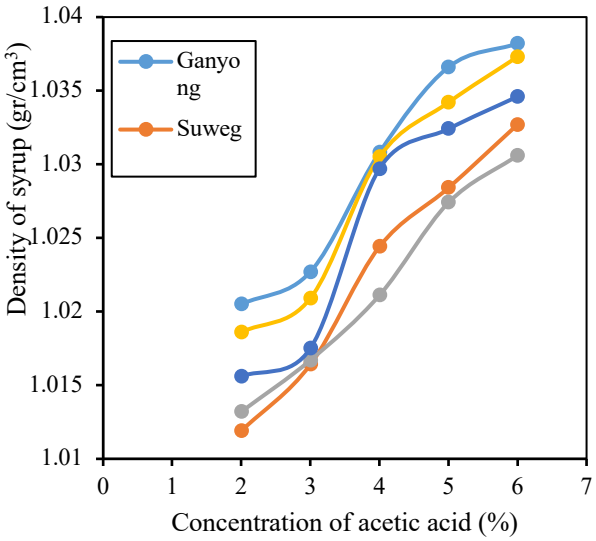

Fig.2. The effect of concentration of acetic acid (%) on the density (gr/cm^3) value of alternative sugar from various tubers

4 Conclusion

The tubers, namely ganyong, suweg, uwi, taro and gembili, have potential as alternative sugar raw materials due to the starch contained with a yield of 10-20%, which can be processed into reducing sugar through the hydrolysis process. The hydrolysis process could be carried out using acetic acid, a weak organic acid catalyst. The reducing sugar content in the alternative sugar samples ranged from 0.4816% to 2.2878%. The highest concentration of reducing sugar was obtained using a 6% catalyst with ganyong's starch as raw material, while the lowest sugar content was obtained using a 2% catalyst with the material of suweg's starch. Based on the results, in order to obtain optimal operating conditions, it was recommended that further studies be conducted on other parameters that affect the starch hydrolysis process from these tubers using acetic acid as a catalyst.

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