

BIOETHANOL PRODUCTION USING TARO ROOTS WASTE (*Colocasia esculenta*) FROM BOGOR INDONESIA AND ANALYSIS OF CHEMICAL COMPOUNDS

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ABSTRACT

Taro roots waste (*Colocasia esculenta*) was considered a starch material for the preparation of bioethanol. Conversion of starch into ethanol was conducted by enzymatic hydrolysis followed by fermentation. The hydrolysis process uses the catalyst of HCl 15% (1:10) at 100 °C for 2.5 hours and fermentation using *Saccharomyces cerevisiae*. The chemical composition was analyzed by using chromatography gas-mass spectrophotometry (GCMS). The active component of bioethanol was found as ethanol (41.14%) and glycerol (29.08 %). The other chemical compound were 2,3-dimethyloxirane, pentanal, propionic acid, and heptane-2-one. The fermentation using tape yeast resulted in the main component of glycerol (31.39%), cyclobutanol (15.26%), pentane (12.93%), and methyl 2-oxopropanoate (10.50 %). The taro roots waste were the potential to convert biomass into bioethanol, which is one of the environmentally friendly alternative fuels.

Keywords: Bioethanol, Taro Root, Chemical Compound, *Saccharomyces cerevisiae*

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INTRODUCTION

Renewable fuels such as biodiesel and bioethanol are alternative energy sources.¹ Bioethanol (C₂H₅OH) is an alternative fuel that is more environmentally friendly and has a renewable nature. Bioethanol is processed from plants that have the advantage of being able to reduce CO₂ emissions.² These plants have high carbohydrate content, such as sugar cane, sugar palm, sorghum, cassava, cashew nuts, banana stalks, sweet potatoes, maize, and corn cob. Bioethanol is a liquid produced by the fermentation process of sugar from the decomposition of carbohydrate sources using microorganisms. Bioethanol can also be interpreted as a chemical that has similar properties to premium oil.³ For high ethanol yield, starch must be broken down into monosaccharides by enzymes and microbes.⁴ Hydrolyzed fermentation is the destruction of cellulose and hemicellulose in raw materials and then fermented with yeast to produce bioethanol. This method is a direct fermentation method for raw materials. Currently, bioethanol has been produced on a large scale in the United States from corn.⁵ Biomass can produce bioethanol from agricultural waste⁶, the taro root^{7,8}, *Ulva prolifera*⁹, microalgae¹⁰, rice¹¹ and coffee husk used as a solar cell.¹² The large utilization of taro is not accompanied by the processing of the resulting taro shell waste, even though the chemical content of taro skin is starch, protein, fat, ash, fiber, and metals. Several previous studies have converted taro into bioethanol¹³, bioethanol preparation by enzymatic hydrolysis of taro (*Colocasia esculenta*)¹⁴, bioethanol from taro roots using enzymatic hydrolysis with α -amylase.¹⁵ Limited studies explore the chemical composition of bioethanol products from taro waste. The objective of our study is to form a product that is bioethanol from taro Bogor Indonesia and identification of the chemical composition.

EXPERIMENTAL

Materials

Taro root waste, HCl p.a (Merck), NaOH p.a (Merck), (NH₂)₂CO (Merck), (NH₄)₂SO₄ (Merck), C₆H₁₂O₆ (Merck), reagent anthrone (Merck), *Saccharomyces cerevisiae*, tape yeast, and aqua demineralization were used.

Sample Preparation

The waste was washed with water, dried, and smoothed using a blender. After that, the powder of taro waste was dried at 100°C for 2 hours and sieved to 20 mesh.

Hydrolyzed Process

This experiment uses HCl (15%) with ratio 4:1, 5:1, 6:1, 7:1, 8:1, 9:1 and 10:1 (volume/weight). The starch of the taro was hydrolyzed using 15% hydrochloric acid at 100°C for 2.5 hours. The results of hydrolysis were filtered and cooled to room temperature. The filtrate was measured for sugar content using a UV-Vis spectrophotometer at a wavelength of 630 nm.

Fermentation Process

The fermentation was carried out using a hydrolyzed filtrate that has the highest sugar content. The filtrate was added with 6M NaOH solution until the pH became 5. The fermentation used 8 grams of yeast (*Saccharomyces cerevisiae* and Tape yeast). The solution was fermented for 5 days at room temperature.

Separation Process

The separation step was carried out by inserting the fermented filtrate into a round bottom flask and attaching it to a series of distillation devices. Distillation is the process of separating a mixture of two or more liquids into their fractions based on their boiling points. The distillation of the fermentation was carried out at an ethanol, boiling point of 78°C.

Analysis of Chemical Compounds

The chemical analysis of the bioethanol products was carried out using gas chromatography-mass spectrophotometry (GCMS).

RESULTS AND DISCUSSION

The production of bioethanol from taro peel waste was carried out in two-step of reactions, the hydrolysis of polysaccharides to glucose and fermentation of glucose to ethanol. In the hydrolysis reaction, the polysaccharides in the taro peel waste were broken down using HCl (15%) as a catalyst. Before the hydrolysis process, the lignin content in the taro waste must be removed by soaking it with NaOH. After the lignin content is reduced, the polysaccharide hydrolysis process can take place properly. The glucose content resulting can be seen in Table-1.

Table-1: Glucose Content from the Hydrolysis Process

No	HCl (Weight:Volume)	Glucose Content (%)
1	1: 4	18
2	1: 5	20
3	1: 6	23
4	1: 7	25
5	1: 8	26
6	1: 9	27
7	1:10	28

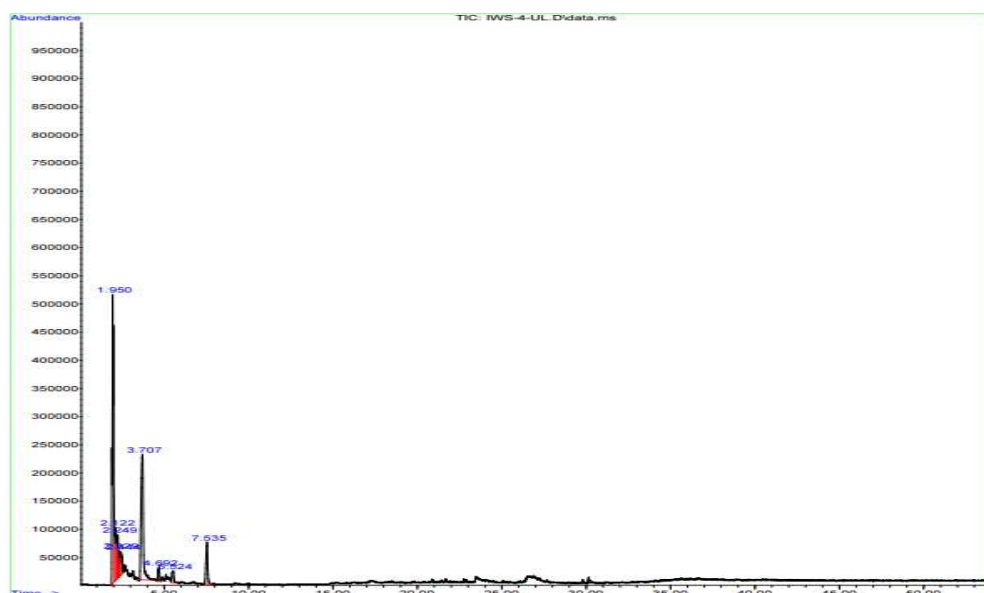
Based on Table-1, it can be seen that sugar concentrations above 25% are produced by HCl with ratios of 1:7, 1:8, 1:9, and 1:10. The highest sugar produced in the ratio of 1:10 was 28%. The pH adjustment was done first by adding NaOH solution until it reaches pH 5. Bioethanol fermentation was carried out using the yeast *Saccharomyces cerevisiae* and tape yeast (Fig.-1).

During the fermentation process, the sugar from the hydrolysis of the taro skin is a source of nutrition for yeast growth. The fermentation takes place anaerobically to produce ethanol metabolites in the solution. After five days, a filtering process was carried out to separate the filtrate from the remaining yeast. The ethanol content in the filtrate was analyzed using gas chromatography. The results of the analysis of active bioethanol compounds from hydrolysis and fermentation of taro peel waste can be seen in Fig.-2.

The chromatogram shows the volatile compounds in the product fermentation using *Saccharomyces cerevisiae*. The main compound shows the retention time at 1.950, 3.707, and 7.535 minutes. This peak indicated ethanol production. The compounds detected in this chromatogram are shown in Tabel-2.



Fig.-1: Fermentation Process

Fig.-2: Chromatogram Product of Fermentation Using *Saccharomyces Cerevisiae*Table-2: Identification of Chemical Compounds from Fermentation Product using *Saccharomyces cerevisiae*

No	Chemical Compounds	tR (minutes)	Content (%)
1	Ethanol	1.949	41.14
2	2,3-dimethyloxirane	2.122	7.70
3	Pentanal	2.248	3.34
4	1-deuteropropane1	2.3303	3.00
5	Propanoic acid	2.444	3.90
6	Glycerol	3.707	29.08
7	Heptane-2-one	4.693	2.43
8	4(1H)-pyrimidinone,2,6-diamino	5.524	2.07
9	4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl	7.536	7.33

Based on the identification of the active substances with HCl 1:10, the main compositions were ethanol and glycerol. Ethanol obtained with a content of 41.14% appeared at a retention time of 1.949 minutes. The glycerol compound was obtained at a level of 29.08% with a retention time of 3.707 minutes. This shows that the higher the acid concentration used, the higher the ethanol content produced. The concentration of HCl can increase the hydrolysis of starch into glucose so that the fermentation process will produce higher

ethanol levels. The hydrolysis of starch to glucose requires acids such as HCl while converting sugar to ethanol was used by yeast. Other research reported an ethanol content of 19.10% from taro tubers¹⁴ and ethanol content in taro tubers was 43.78 g/L.⁷ To increase the ethanol content in taro peel waste, it is necessary to fractionate it after the distillation process. The ethanol content obtained from taro tubers was obtained at 81.44% after the fractionation process.¹⁵ This level is higher because the taro root contains more carbohydrates than the waste of taro skin. The ethanol content obtained from the results of research conducted on taro peel waste was quite high, containing half of the ethanol content found in taro tubers. The results of gas chromatography and analysis of samples by fermentation using tape yeast can be seen in Fig.-3.

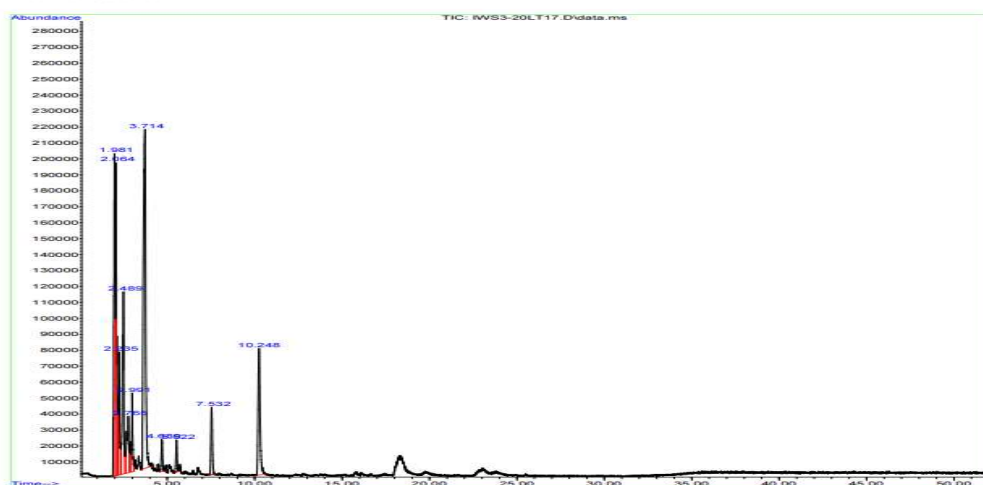


Fig.-3: Chromatogram Fermentation Product Using Tape Yeast

Based on Fig.-3 we can see the main component in the product fermentation using tape yeast with the peak at 3.714, 1.981, and 2.064. The compounds were glycerol, cyclobutanol, and pentane. The ethanol was not detected in the chromatogram. The chemical compounds detected in this chromatogram will be shown in Tabel-3.

Table-3: Identification of Chemical Component from Fermentation Product using Tape Yeast

No	Compounds	tR (minutes)	Content (%)
1	Cyclobutanol	1.981	15.26
2	Pentana	2.064	12.93
3	Butanal	2.235	5.73
4	Methyl 2-oxopropanoate	2.488	10.50
5	2-Furancarboxaldehyde	2.766	4.52
6	2-propanone,1,3-dihydroxy	2.990	2.92
7	Glycerol	3.714	31.39
8	Acetaldehyd	4.688	1.63
9	2-methyl pyromeconic acid	5.523	1.45
10	2,3-dihydro-3,5-dihydroxyl-6 methyl-4H-pyran-4-one	7.532	3.87

The identification of the active substance resulted from fermentation using tape yeast with catalysts using HCl 1:10, which produced the main alcohol compounds as glycerol and cyclobutanol with levels of 31.39% and 15.26%. In this fermentation process, ethanol compounds are not produced which function as bioethanol but as other alcoholic compounds. The result of bioethanol fermentation using *Saccharomyces cerevisiae* produces a more suitable type of alcohol and a higher ethanol content than tape yeast. This is influenced by the types of microorganisms present in both types of yeast.

CONCLUSION

Based on the results of fermentation from taro peel waste using *Saccharomyces cerevisiae* yeast the resulting bioethanol compound with catalyst using HCl (1:10). The main active compound obtained from

the fermentation of taro peel waste is ethanol (41.14%) and glycerol (29.08 %). The taro peel waste has the potential to convert biomass into bioethanol, which is one of the environmentally friendly alternative fuels.

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REFERENCES

1. H. Helmiyati, G.H. Abbas, and Y. Budiman, S. Ramadhani, *Rasayan Journal of Chemistry*, **13(1)**, 298(2020), <http://doi.org/10.31788/RJC.2020.1315497>
2. S.H. Lee, and S. Jun, *American Society of Agricultural and Biological Engineers*, **54(3)**, 1041(2011), <http://doi.org/10.13031/2013.37089>
3. D. Irawan, Z. Arifin, M. Gery, and M.A. Fithia, *Rasayan Journal of Chemistry*, **13(4)**, 2401(2020), <http://doi.org/10.31788/RJC.2020.1346005>
4. A. Kumar, R. Deb, and J. Sigh, *Current Perspective*, 427(2018), http://doi.org/10.1007/978-981-13-0393-7_24
5. M. Devarapalli, and H.K. Atiyeh, *Biofuel Research Journal*, **7**, 268(2015), <http://doi.org/10.18331/BRJ2015.2.3.5>
6. N. Sarkar, S.K. Ghosh, and S. Bannerjee, K. Aikat, *Renewable Energy*, **37**, 19(2012), <http://doi.org/10.1016/j.renene.2011.06.045>
7. Wu, *Bioresources Technology*, **201**, 27(2016), <http://doi.org/10.1016/j.biortech.2015.11.015>
8. T.M. Tekaligne, and D. Dinku, *Journal of Advanced, Botani and Zoology*, **7(2)**, 1(2019).
9. Y. Li, J. Cui, G. Zhang, Z. Liu, H. Guan, H. Hwang, W.G. Aker, and P. Wang, *Bioresources Technology*, **214**, 144(2016), <http://doi.org/10.1016/j.biortech.2016.04.090>
10. M. Gohain, M. Hasin, K.H.S. Eldiehy, P. Bardhan, K. Laskar, H. Phukon, M. Manadal, D. Kalita, and D. Deka, *Process Safety and Environmental Protection*, **146**, 190(2021), <http://doi.org/10.1016/j.psep.2020.08.046>
11. P. Binod, R. Sindhu, R.R. Singhanian, S. Vikram, L. Devi, S. Nagalakshmi, N. Kurien, R.V. Sukumaran, and A. Pandey, *Bioresources Technology*, **101**, 4767(2010), <http://doi.org/10.1016/j.biortech.2009.10.079>
12. Hasby, Nurhafidhah, Pamungkas, and S.A. Akbar, *Rasayan Journal of Chemistry*, **13(1)**, 38(2020), <http://doi.org/10.31788/RJC.2020.1315576>
13. Y.T. Shyu, and C.C. Tsai, *Food Biotechnology*, **11(3)**, 231(1997), <http://doi.org/10.1080/08905439709549934>
14. E. Praputri, and E. Sundari, *Material Science and Engineering*, **54**, 1(2019), <http://doi.org/10.1088/1757-899X/543/1/012056>
15. A.P.P. Win, S.S. Than, and K.T. Ni, *Dragon University Research Journal*, **7(1)**, 159(2016).

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