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Study Of Food Waste Usage As Renewable Energy Resource

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Abstract

Waste product in Indonesia is still a crucial problem where it is increasing every day in the accordance with the citizen population. The absence of waste management, especially organic waste, is causing bad impact on health such as infectious diseases and water pollution due to the decomposition of organic waste into organic acid or methane. The problem of sewage coming from the food waste can be overcome by using a fermentation process in anaerobic reactor which produces bio-hydrogen gas and organic fertilizer. Bio-hydrogen gas produced can be used as a source of renewable energy in which hydrogen gas has advantages when used as a fuel does not produce carbon dioxide, but only water vapor. In the research of hydrogen gas is be obtained by using the single phase anaerobic reactor without bacteria seed addition and inorganic supplement for bacterial growth. The first experiment has been done and hydrogen has been produced depend on variation of rice content in food waste with grading 47.1% of the total gas produced to the highest levels of rice. The second experiment would be done by temperature controlled around 35oC and the result is maximum content 55.07% v/v and production rate 1.031 l-H2/l/day or 106 mmol H2/l/day. Further studies using an anaerobic reactor with the addition of temperature control, pH, and substrate particle size and the expected product gas produced with a greater percentage of hydrogen gas.

Keywords：Food Waste, Fermentation Process, Bio-Hydrogen.

Introduction

Energyis always to be one ofthe mainrequirementstorunall the human activities. However, the problem around the world is the use of fossilenergy which has limited resource and causes global warming. The alternativeresource of energyor renewable energy such as: wind, water, lightsun, eventhe garbageorwasteintothe restofevery human activityitself can be developed to substitute fossil energy. Hydrogen product from organic waste fermentation can be used as clean energy and has ahigh energy yield of 122 MJ/kg(Wang, Ivanov, Joo,&Yung, 2010).

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Organic waste as product of human activity can be used as raw material for value-added product. Biochemical process for transformation of organic waste into such value-addedproduct as organic acids, biodegradable plastics, acetone, ethanol, and hydrogen. Hydrogen production as renewable fuel was interested when it became evidently that carbon dioxide production from fossil fuel combustion may cause global warming. Hydrogen production can be represented by two methods: photodecomposition and dark fermentation (Nielsen et al, 2001). The fermentative process has an advantage over photodecomposition process to convert organic waste become bio-hydrogen because it is no need light as part of process(Lay, Lee. & Noike, 1999; Chu et al, 2008). Some kind of substrate like as organic municipal solid waste, food waste, vegetables, and fruits have been demonstrated as resources for hydrogen production (Okamoto et al, 2000; Levin, Pitt, &Love, 2004).

In earlier investigation to have a higher hydrogen product by dark-fermentation process, some wastes which are rich in carbohydrate content should be choosen(Khanal, Chen, Li, & Sung, 2004; Wang, Ivanov, Joo, &Yung, 2010). Rice and corn are examples of the food that are rich in carbohydrate content, and they are widely consumed by the population. From theresults ofthe National Development Planning Agency (BAPPENAS) surveyin 2012that all overIndonesianhas riceconsumptionof about33milliontonsandcorn consumption ofapproximately20milliontons (Rusono et al, 2013).Consumption ofthese groceriesas astaple foodorthe food processing industryin the form ofrice flourorcornstarch. Inthispaper will be explainedsubstrates usedin thefermentationprocesstoproducehydrogenin the form ofstale riceandmixvariationsrice,corn, andpotatoes. Then analyzedthe influence ofthe presence or absenceof temperaturecontrolin thereactorforthe production ofhydrogengas.

Material And Methods

The tank that was used as single phase fermentation reactor is made from polyvinyl chloride or PVC and has volume 3000 cm^3. The first experiment aims to study influence of substrate composition and carried out in ambient temperature without bacteria addition. The substrate has divided to three samples; sample A consists of rice 500 gr, potatoes 400 gr, and corn 600 gr; sample B consists of rice 400 gr, potatoes 600 gr, and corn 500 gr; sample C consists of rice 600 gr, potatoes 500 gr, and corn 400 gr. Each samples was blended with water 1500 ml in 60 second until it become mush and after that was heated at 80^oC in 15 minutes to eliminate unwanted bacteria. The second experiment aims to study influence of temperature in hydrogen production for stale rice1500 gr without bacteria addition. Sample D performed at ambient temperature and sample D at temperature 35^oC.Concentrations of hydrogen gas were determined with a gas chromatograph at Chemical Engineering Department, Bandung Institute of Technology (ITB).

Data Analysis

Fermentationbyanaerobicbacteriawillproducegases,particularlyH_2andCO_2aremostlypr oducedinthisfermentation. Hydrogen product in these experiments have shown in Table 1. In the first experiment, the sample C has produced more hydrogen gas than another samples. When it is viewedfrom thecarbohydratecontent ofeachwhole, ricehas thehighestcarbohydrate (80 gr/100 gr), cornandpotatoescontain carbohydratesthat are notmuch different, but thepotatoeshavea higherstarch(15.44 g/100g) thancorn(5.7 g/100g) that is sample A has hydrogen production is lower then sample B (National Nutrient Database for Standard Reference, United States Department of Agriculture, 2014). In the second experiment, sample

D and E have more hydrogen production if it is compared with the first because the substrate is only stale rice. It also seems stale rice has more hydrogen produced bacteria than the first experiment samples. Sample E that was controlled on 35^{o}C temperature settting,but actually it has 35-38^{o}Ctemperature range is produced more hydrogen gas (Lin & Chang, 2004). For 1500 gr stale rice there are 1200 gr carbohydrate or 6.6 mole carbohydrate. Based on Siegrist et al. (2002), biochemical reactions in anaerobic reactor with flows expressed as percent of COD can calculate for hydrogen theoretically, where to 6.6 mole carbohydrate will be 0.3366 mol H_2. The result of sample E can convert in mole hydrogen gas by assuming ideal gas behavior and it is obtained 0.106 mol H_2 at third day. It is means for 1500 gr stale rice substrate ideally can be converted to 8.38 liter hydrogen gas, but in this experiment the hydrogen product is 2.64 liter. However, in research procedures there is no bacteria seed addition and inorganic supplement for bacterial growth, but the result of hydrogen content is comparable with Lin and Chang, 2004 (34.9-48.4%) and Chang and Lin, 2004 (42.4%).

Table 1. *Hydrogen Production*

Sample	Temperature	Operation Time (day)	Hydrogen gas	
			Content (%,v/v)	Production rate (l-H_2/l/day)
A	-	1	0.5563	-
		2	23.2064	-
		3	0.0381	-
B	-	1	0.2093	-
		2	27.0892	-
		3	21.3143	-
C	-	1	0.0046	-
		2	47.1032	-
		3	22.1987	-
D	26-29^{o}C	1	36.6547	0.117
		2	39.7857	0.226
		3	26.1043	0.188
E	35-38^{o}C	1	33.4906	0.173
		2	47.6636	0.855
		3	55.0747	1.031

The amount ofhydrogen production byfermentationdependson thepH value, temperature, andpartialgas pressure. For optimal results, it was reported thatthe pHshould be maintainedbetween5-6(Lay, Lee.& Noike, 1999; Chu et al, 2008). In this experiment before the substrate would b inserted into reactor it has average pH 6.7, but after three days it is decreased until aroud 4.7. This fact would be caused decline in hydrogen production. After sixth day no more hydrogen production in reactor. Partial pressure of hydrogenalsoaffects the production ofhydrogen gas. If concentration of hydrogen increases then hydrogen syntesis decreases and fermentation process shift to production of another reduced substrate such as simple organic acids, acetone, and ethanol (Levin, Pitt, & Love, 2004).

Summary And Conclusion

Production of hydrogen has been succeeded carried out in this research by using the single phase anaerobic reactor without bacteria seed addition and inorganic supplement for bacterial growth. The result of hydrogen production is maximum content 55.07% v/v and production rate 1.031 l-H_2/l/day or 106 mmol H_2/l/day. The substrate that has more rice content will produces more hydrogen gas. Temperature treatment will increase hydrogen production because hydrogen-producing bacteria needs ambient temperature around 35^oC or optimum mesophilic and it is higher than room temperature. The next experiment will try to control at thermophilic temperature, homogenity of substrate, and pH in optimum condition for higher hydrogen production.

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