The Effect of C/N Ratio and Type of Microbes Sludge to Biogas Production: Combination of Tapioca Industrial Wastewater and Tofu Industrial Wastewater

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Abstract. Biogas will be produced from a single organic substrate and controlled the ratio of carbon nitrogen by added inorganic nitrogen substances. The study has been tried to combine substrates from industrial tapioca industrial wastewater with tofu industrial wastewater. The experiments were carried out in batch anaerobic digesters with a C/N ratio range of 20 - 30 and variation of microbial sludge from cow rumen, anaerobic sludge of tofu wastewater treatment plant (WWTP) and anaerobic sludge of tapioca WWTP. The ratio of C/N in the range of 20-30 didn't significant effect on the volume of biogas production. The microbial from cow rumen gives the best biogas production performance. Biogas yield is 2,199 liter per kg COD.

1. Introduction

Biogas can be produced by the decomposition of one types of substrate organic, but we need chemicals such as Urea, NPK. or nitrate salts for control C/N ratio. However, given the variation of the elemental content present in various substrates or wastes, it is possible to mix two or more types of waste as biogas substrate as well as regulate the composition of its elements. The combination of different types of substrates or wastes to be converted into biogas is known as co-digestion [1].

Co-digestion is an anaerobic processing of mixtures of two or more different organic substrates with the aim of increasing the efficiency of the digestation process [2]. The co-digestion process is usually carried out by mixing the base substrate with an additional substrate in small amounts [3]. Co-digestion has better nutritional balance and digester work so the ability to produce biogas is higher [4]. Many studies have developed co-digestion methods such as biogas production from industrial waste beer and cow dung [5], co-digestion of livestock manure with food and sludge waste in order to increase biogas production [6], co-digestion of Thaihu algae and waste food waste in kitchens [7], anaerobic co-digestion of water hyacinth and sheep dung [8] and many others. Materials used as the main ingredients are generally derived from livestock waste and food industry waste. In this study, mixed tapioca industrial liquid wastes with tofu industry liquid waste. In tapioca industry liquid waste has an organic content rich in carbon. According to J. Fettig (2013) in tapioca industrial liquid waste containing an organic substrate expressed as COD of 20.640 mgO2/l [9], containing carbohydrate 25.37 gr in 100 g tapioca liquid waste, carbohydrates in tapioca industrial liquid waste is 25.37 gr in 100 gr of tapioca liquid waste [10]. The waste also contains 0.46% nitrogen and 39.58% carbon, with a C/N ratio of about 86: 1. In situations where the amount of nitrogen required for bacterial growth is very small compared to carbon it will limit the production of biogas [11]. Nitrogen can be added in inorganic form eg ammonia or in organic form eg urea, manure or food waste [12]. Nitrogen derived from tofu waste water has a nitrogen content of 161.5 mgN / l. [13]. Nitrogen content in this tofu waste can be utilized and combined with tapioca industrial waste to make biogas for C/N ratio is optimal, so it can increase biogas production.

The specific objective of this study was to study the effect of C/N ratio on the combination of liquid industrial liquid tapioca substrate with the tofu industry liquid waste to biogas produced production and to study the effect of active sludge type used to decompose waste on biogas produced production.

2. Methods

For the above purpose an organic substrate prepared from combination of tapioca industrial waste water and tofu industrial waste water filtered through 200 mesh, then stored at 4^{o} C before use. Likewise activated sludge from anaerobic sludge of wastewater treatment plant (WWTP) of tapioca industry at Sidomukti Village, Pati Regency, activated sludge of anaerobic sludge of WWTP of Tofu/Tahu Industry in Semarang City and Cow rumen from slaughterhouse Semarang City. They are all taken and filtered through a 200 mesh before use. The study was conducted by varying the C/N ratio at 20,

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25 and 30, system processed batch, in 2 liter biodigester. The substrate to microbial (F/M) ratio was set at 0.5, neutral initial pH. The volume of biogas produced is measured daily with the principle of the volume of water transferred by biogas equal to the volume of biogas produced (water displacement methode). The CODCr content of the substrate combination is also measured daily until the decomposition process is completed for about 60 days. The COD is analyzed by SNI 06-6989.15-2004. Initial COD of tapioca wastewater and tofu wastewater is 11,931 mg/l and 9,256 mg/l. Carbon content by Walkey and Black method is 11,309 mg/l and 8,690 mg/l. Total Nitrogen content by SNI 19-7030-2004 is 150 mg/l and 589 mg/l. The C/N ratio of tapioca and tofu wastewater is 75,1 and 14,75.

3. Results and Discussion

Based on data are presented at Figure 1, can be describe as follow. Before the 20th day, the volume of biogas produced is very small. After that there will be increased continously. The trend pattern of biogas production shown in the figure 1 indicates that the ideal residence time to produce biogas with cow rumen , minimum is on the 20th day. Beside from the figure it can be concluded that the largest accumulative biogas volume was produced at a C/N ratio of 30. However, the C/N ratio 20-30 didn't significant for produced of biogas volume [14]. With statistical analysis (ANOVA), obtained P value on biogas production of 0.821. It means that the ratio of C/N in the range of 20-30 does not give a significant effect on the volume of biogas produced.

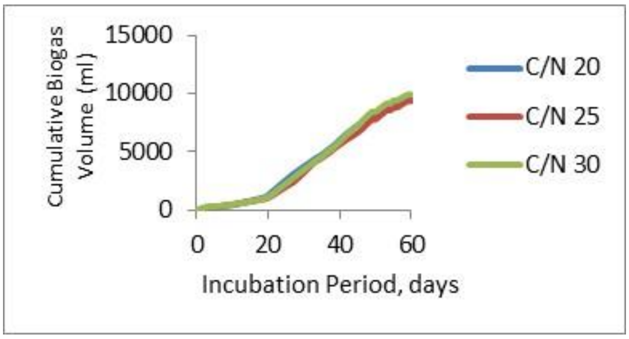

Fig. 1. Biogas production based on incubation period and C/N ratio

The low of C/N ratio (20-25) indicate that nitrogen in the substrate is available in large quantities. The final product of decomposition process is gas and ionic forms, among them is NH_3 dan NH_4^+. Total ammonia nitrogen of 0,17- 14 g/L will be inhibited methanogenic activity to produce methane gas and reduce methane gas until 50% [15, 16]. By the concentration of NH_3 in the range of 25-140 mg/l is toxis [17].

Based on biogas production rate, there are four stages , similar to the microbial growth pattern. Table 1 are presented the stages. The first is lag or adaptation stage in the range of 0-7 days incubation periods. Biogas production rate in the range of 43-49 ml/day, The second is growth stage in the range of 7-20 days incubation periods.

Table 1. Average Biogas Production rate, ml per day

Incubation Period, days	C/N 20	C/N 25	C/N 30
0 – 7	43	47	49
8 – 20	73	55	59
20 – 49	371	352	388
49 – 60	137	141	134

Biogas production rate increase slowly in the range of 55-73 ml/day. Biogas production rate increase fastly in third stage or the stationary stage (20-49 days) in the range of 352-388 ml/day. Finally, the fourth stages or death stage, the biogas production rate decrease slowly in the range of 134-141 ml/day.

Table 2. COD removed based on incubation period

Incubation Period, days	COD removed (mg/L)		
	C/N 20	C/N 25	C/N 30
0 – 7	892	537	613
7 - 20	2,685	4,081	4,283
20 - 49	3,848	3,744	4,024
49 - 60	1,204	1,466	1,505

The COD removed based on incubation period can be seen in Table 2. At growth stage of 7-20 days, organic compounds were converted from organic acid to fatty acid (propionic, butiryc and acetic acid), but methane gas hasn't been widely performed. At the stationary stage, the fatty acid were converted to methane gas. Table 3 presented biogas yield as a function of incubation period and C/N.

From the table it can be seen that most biogas production occurs at the stationary stage (incubation period range of 20-49 days) , greater than at other stages. Biogas yield in the range of 2,146-2,200 litre/kgCOD.

Table 3. Biogas Yield, Liter/KgCOD as a function of incubation period and C/N.

Incubation Period, day	C/N 20	C/N 25	C/N 30
0 - 7	0,404	0,735	0,676
7 - 20	0,422	0,212	0,216
20 - 49	2,200	2,146	2,199
49 - 60	1,454	1,270	1,177

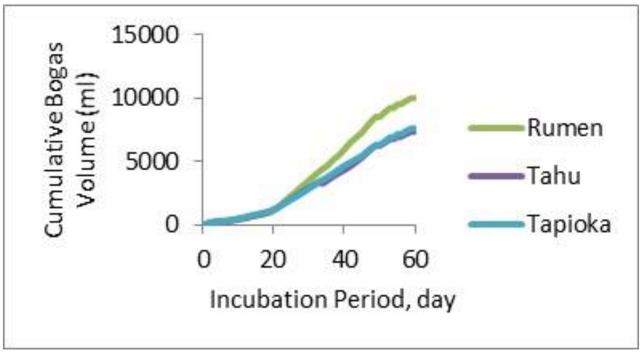

Fig. 2. Biogas production based on incubation period and variation of microbe sludges

The cumulative patern of biogas volume at incubation period value are illustrated in Figure 2 . The rate of biogas production with microbe from cow rumen had a better performance than other microbes. Forty to sixty per cent of microbes in the cow rumen include bacteria and protozoa. They digest non structural carbohydrates of tapioca (amylopectin) respectively.

The biogas production yield based on variation of microbe sludges or activated sludge , C/N ratio 30 , F/M = 0,5 was presented by Table 4.

Table 4. Biogas Yield, Liter/KgCOD as function of incubation period and activated sludge (AS).

Incubation Period, day	Cow Rumen	AS Tofu	AS Tapioca
0 - 7	0,676	0,390	0,319
7 - 20	0,216	0,408	0,474
20 - 49	2,199	1,865	2,051
49 - 60	1,177	2,130	1,688

Table 4 report that the largest biogas yield takes place at a stationary period with rumen microbes (2,199 liter biogas/kgCOD) then with microbe sludge from tapioca (2,051 liter biogas/kg COD) and microbe sludges from tofu (1,865 liter biogas/kgCOD).

4. Conclusions

Variation of C/N ratio range of 20-30 didn't signifi cance difference to biogas production. Microbes derived from cow rumen had better performance than microbes derived from anaerobic sludge WWTP of tapioca industry and activated sludge from WWTP of tofu. In the stationary phase , the biogas yield is 2,199 liters per kg of COD removed.

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