Biogas Production from Crab Picking (Portunus Pelagius) Wastes

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Abstract: Crab picking waste is a product by process with low economic value. Waste in the form of solid wastes (shell, offal) and waste water (remnants water of crab stew). The amount of waste was generated by one of the fisheries industry Putra Mandiri Mini Plant which causes environmental pollution that has a negative impact on the community. Therefore, good and efficient waste management is needed to be effective and eco-friendly. The waste can be fermented to make gas for the picking product of the biological breakdown of organic waste under oxygen free conditions. This study aims to determine the raw material content of crab waste and the best formula in making biogas. The process of making biogas using different formulation, there are wastes; wastes + cow rumen and wastes + cow rumen + molasses. Then the samples were fermented in aerobic digester for 21 days to produces methane gas. Methane gas is best obtained from anaerobic fermentation processes with crab picking; rumen and molasses waste formulas with ration of 1:1:1 (w/v/v) can produce methane gas of 2.42%.

1. Introduction

Petroleum-based materials that are depleted give rise to the potential for contamination, to cause damage to nature; it can be replaced with biogas which has a content methane and carbon dioxide gas. Adityawarman et al. [1], he elements contained in biogas are methane gas (CH₄), carbon dioxide gas (CO₂), oxygen gas (O₂), hydrogen sulfide gas (H₂S), hydrogen gas (H₂), and carbon monoxide gas (CO), of all these elements, play a role in determining the quality of biogas, namely methane gas (CH₄) and carbon dioxide (CO₂) gas.

The characteristics of biogas can potentially be an alternative to renewable biogas. BIGAS is specifically designed to process waste into biogas which can be utilized again by the miniplan. Agustina et al. [2], biogas is any fuel either solids, liquids or gases produced directly from organic materials. Biogas can be produced directly from plants or indirectly from industrial, commercial, domestic or agricultural waste. In the biogas production process, methane gas is a gas that has the largest percentage in biogas, in addition to other gases such as carbon dioxide, nitrogen, and oxygen. The composition of biogas which is dominated by methane gas is what makes biogas referred to as an alternative energy source. BIGAS is expected to be able to be utilized in the Miniplan Putra Mandiri industry as the main ingredient for LPG gas replacement in the process of boiling the crabs before undergoing the stripping
process. So that the innovation and technology of BIGAS that is effective, can reduce expenditure in purchasing LPG gas, and be able to be applied sustainably by Miniplan Putra Mandiri.

Blue swimming crab (*fortunes Pelagius*) is a type of crab family that have striking blue body characteristics. This crab has very high economic value. Indonesia is a crab exporting country to various countries such as Singapore, Malaysia, China, Japan, and several countries in Europe, especially the United States. Every year nearly 90% of Indonesian crab meat production goes to the American market [3]. The handling process is carried out in a mini crab plan including washing of raw materials, boiling and picking. In the process of removing its shell, one crab produced waste that consists of 57% shells, 3% reject weight and 20% boiled water. The increase of crab waste will have an impact on environmental pollution if it is not handled [5].

Shell and offal waste is a by-process product with low economic value. This causes environmental pollution which affects the citizen. Therefore, good and efficient waste management is needed to be effective and eco-friendly. The waste can be fermented to make gas which allows the picking industry to be used as an alternative fuel to replace government-subsidized LPG gas. Salam *et al.* [9], biogas is produced from anaerobic digestion of fish waste and also from anaerobic co-digestion of fish waste and cow dung. This study aims to determine the raw material content of crab waste and the best formula in making biogas.

### 2. Research Methods

#### 2.1. Collection of raw materials

The crab waste in the form of shell, *lemi* and gill were tested for water content using the gravimetric method [11] and protein content tested by Kjeldahl method [4] to determine the raw material content before the fermentation process was carried out at the Analysis Laboratory, Faculty of Fisheries and Marine Science, Diponegoro University.

The crab picking waste in this study was obtained from the Putra Mandiri Mini plan in the village of Gedongmulyo, Lasem, Rembang. Waste taken the form of solid waste (shells, *lemi* and gills) and liquid waste (leftover boiling crabs), *cow rumen* and molasses obtained from animal slaughterhouses in the Rembang area.

#### 2.2. Biogas production

To produce natural biogas from crab picking waste, solid waste (shell, *lemi*, gill), liquid waste (remaining crab cooking water), *cow rumen* and molasses were mixed thoroughly in a ratio of 1: 1: 1 (w/v/v). carried out with three treatments namely solid and liquid waste; waste + *cow rumen* and waste + *cow rumen* + molasses which were tested in a laboratory scale using 2 L. Each volume was 300 ml with a fermentation process for 21 days and then the methane gas content was tested using Gas Chromatography Mass Spectroscopy (Shimadzu, GCMS QP2010 Plus) in the Integrated Laboratory, Diponegoro University.

Bio digester for producing biogas was made using closed drum (capacity of 300 L) and connected using PVC pipes (Fig. 1). The mechanism of working of the bio digester is an anaerobic fermentation or airtight fermentation device to obtain gas content. Bio digester is equipped with two holes namely the input hole and the outer hole. The input hole is made of 2.5 inch PVC pipe which is connected to the body of the drum with a distance of ⅓ of the total height of the drum facing upwards making it easier for the owner to enter the sample to make bio digester. This is intended to dispose of anaerobic fermentation by-products that can be reprocessed into fertilizer. So that if the gas pressure on the drum has filled the space it can be channeled through a pipe that is connected directly to the gas stove for the boiling process of the crab.
3. Results and Discussion

3.1. Moisture and protein content of raw materials

Water content testing is intended to determine the hydro scope content of a raw material as to produce a fast fermentation process and produce methane gas content.

| No. | Sample | Moisture Content (%) | Protein Content (%) |
|-----|--------|----------------------|---------------------|
| 1.  | Lem   | 73.025               | 13.380              |
| 2.  | Shell | 15.950               | 11.124              |
| 3.  | Gill  | 85.647               | 7.043               |

The highest water content obtained by the gills was 86.033%, while the shells had the lowest water content value of 15.424%. These numbers was in accordance to the research by Sarower et al. [9] where the crab gills have humidity around 83.59% higher than the water content of the crab’s lemi which is around 47.35%.

Protein content is used to determine the nitrogen content contained in ingredients that function as bacterial food to produce the right gas. The results of testing the protein content of the remaining crab picking waste can be seen in Table 1. The highest protein content obtained by lemi was 13.38%, while the gills had the lowest protein content of 7.043%. Sarower et al. [10] crab’s gills have a protein content of 8.10% lower than the protein content in crab’s lemi 34.67%. High protein levels capable of producing amino acids will be overhauled as a producer of methane gas. Marwah et al. [11], research shows that methanogenetic bacteria utilize H₂, CO₂, amino acids and other NH₄ nitrogen compounds that are capable of forming methane gas content.

3.2. Biogas profile

Methane gas is a gas that can be used for alternative fuels. In general, methane can be produced from solid waste, liquid waste, and starter, while the fermentation process can be carried out in three treatments, they are solid fermentation, the mixture of solid-liquid-molasses, and the mixture of solid-liquid-molasses-rumen. In our preliminary studies, it was shown that the mixture of solid-liquid-molasses-rumen could produce flames in biogas fermentation testing for 21 days. Methane gas content can be obtained through the fermentation process of residual crab picking with the addition of cow rumen and molasses. This can be obtained because the rumen of the cow is bacterial. Bacteria found in the rumen of the cow will consume the nutrients obtained by residual crabs and molasses. Bacteria will produce secondary metabolism in the form of C / N. The carbon content (C) is obtained from molasses while nitrogen (N) obtained from the remaining crab picking waste containing protein and nitrogen is the result of protein remodeling. Gas profile data are presented in Table 2.
Figure 2. The Test Result of Fermented Solid and Liquid Wastes

Table 2. Gas Profile on Fermented Solid and Liquid Wastes

| Name                                       | Concentration (%) |
|--------------------------------------------|-------------------|
| Methanamine, N-methyl- (CAS)                | 98.75             |
| Ammonium bicarbonate (pyrolysis)           | 1.25              |

Based on data from biogas fermentation with solid and liquid waste samples do not produce methane gas (Fig. 2). This is because in the fermentation process the nitrogen content produced is very high so that bacteria are poisoned by nitrogen. Mujdalipah et al. [8] showed that the source of C and N needed by microbes which play anaerobic process as a source of nutrients for the growth and development of these microbes. If the N content in the substrate is small, the bacteria cannot produce the enzymes needed to synthesize carbon-containing compounds. While the substrate that contains a lot of N will increase the content of ammonia which inhibits bacterial growth.

Figure 3. The Test Result of Fermented Wastes and Rumen

Table 3. Gas Profile on Fermented Solid, Liquid Wastes, and Rumen

| Name                                                   | Concentration (%) |
|--------------------------------------------------------|-------------------|
| Methanamine, N-methyl- (CAS)                           | 99.77             |
| N-[2,2,2-Trifluoro-1-(isopropylamino)-1- (trifluoromethyl)ethyl] isovaleramide | 0.06              |
| 8,9,9,10,10,11-Hexafluoro-4,4-dimethyl-3,5- dioxatetracyclo[5.4.1.0(2,6).0(8,11)] dodecane | 0.07              |
| Heptanal (CAS)                                         | 0.11              |
Based on data from biogas fermentation with a sample of solid and liquid waste with the addition of rumen does not produce methane gas (Fig. 3). This is because in the fermentation process the nitrogen content produced is very high (Table 3) so that bacteria have nitrogen poisoning. Rumen is a substrate remover microorganism that will produce secondary metabolic compounds in the form of methane gas. The fermentation process of crab picking residual waste with the addition of cattle rumen is not able to overhaul the substrate into secondary metabolism because microorganisms are poisoned due to the abundance of nitrogen in the waste. Wati et al. [12], the use of a lot of rumen will inhibit the flow of gas in the fermentation process because of the amount of water. The number of bacteria that is not equivalent to the number of substrates results in interbacterial competition so that the methane gas produced is small.

![Figure 4. The Test Result of Fermented Wastes, Rumen and Molasses](image)

**Table 4. Gas Profile on Fermented Wastes, Rumen and Molasses**

| Name                                                      | Concentration (%) |
|------------------------------------------------------------|-------------------|
| TRANS-BETA-IONON-5,6-EPOXIDE                                | 89.38             |
| Methane, oxybis- (CAS)                                     | 2.42              |
| Methane, thiobis- (CAS)                                    | 1.09              |
| 2,2’-(1,4-Phenylene)bis[4-(2,4-dichlorobenzylidene)-4,5-dihydro-5-oxazolone] | 1.15              |
| (2,3-Dimethylaziridin-1-yl)-(4,4,6-trimethyl-7-oxabicyclo[4.1.0]hept-2-yldiene)amine | 0.83              |
| 1,2,5-Oxadiazole (CAS)                                     | 1.37              |
| Cyclohex-1,4,5-triol-3-one-1-carboxylic acid                | 0.76              |
| Pentanedioic acid (CAS)                                    | 1.05              |
| HEXANAL                                                    | 1.13              |
| Dodecane, 1-bromo- (CAS)                                   | 0.80              |

Based on the data of biogas fermentation with crab picking waste, rumen and molasses formula capable of producing 2.42% methane gas (Fig. 4, Table 4) because the microorganisms found in the cattle rumen will consume nutrients obtained by the remaining crab picking waste and carbohydrates from molasses. Bacteria will produce secondary metabolism in the form of C / N. The carbon content (C) is obtained from molasses while nitrogen (N) obtained from the remaining crab picking waste containing protein and nitrogen is the result of protein remodeling. Lestarie et al. [4] the number of methanogenic bacteria will be directly proportional to the methane gas produced. This depends on the number of pegurai microbes with the nutritional needs found in the raw material. Nutrients in bacteria function to regenerate and produce secondary metabolites in the form of methane gas.

4. Conclusion
Biogas produced through anaerobic fermentation process from crab. The results showed that the fermentation of solid waste and liquid waste with a ratio of 1: 1 (w/w) produced 98.75% Methanamine,
N-methyl- (CAS) gas; crab picking waste formula with the addition of cattle rumen in a ratio of 1: 1 (w/v) of 99.77% Methanamine, N-methyl- (CAS); and the formula for crab picking waste with the addition of bovine rumen and molasses in a ratio of 1: 1 (w/v/v) can produce methane gas of 2.42%. Methane gas is best obtained from anaerobic fermentation processes with crab picking, rumen and molasses waste formulas. It is necessary to be tested using different rumen volumes and molasses to produce greater methane gas.

Acknowledgements. This research was funded by Ministry of Research, Technology and Higher Education of the Republic of Indonesia through Program for Creativity of Higher Education Students (PKM) 2018.

References
[1] Adityawarman A C dan Salundik, Lucia C 2015 Pengolahan Limbah Ternak Sapi Secara Sederhana di Desa Pattalassang Kabupaten Sinjai Sulawesi Selatan Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan 3(3): 171-177 (In Indonesian).
[2] Agustina A R, A K Mudzakir dan T Yulianto 2014 Analisis Diritribusi Rajungan (Portunus pelagicus) di Desa Betahwalang Kabupaten Demak Journal of Fisheries Resources Utilization Management and Technology 3(3): 190-199 (In Indonesian).
[3] Ahn J Y, D Y Kil, C. Kong and B G Kim 2014 Comparison of Oven-drying Methods for Determination of Moisture Content in Feed Ingredients Asian Australas J Anim Sci 27(11): 1615-1622.
[4] Coniwati, P., A. Herlanto and I. Anggraini 2009 Biogas Production from Tofu Wastes. Journal of Chemical Engineering. 1(16).
[5] Hastuti, S., S. Arifin dan D. Hidayati 2012 Utilization of Waste Crabs (Portunuspelagicus) as a Check for Natural Foods. Agrointek. 6(2).
[6] Lestarie E S, Y A Hidayati dan W Juanda 2016 Analysis of the Quality of Methane Gas and the Amount of Bacteria Anaerobic in the Process of Biogas Formation From the Stools of the Cut from the Stools of the Rice Cut in the Hate Savings. Jurnal Agritech 1(1): 1-10 (In Indonesian).
[7] Marwah S, E Harlia dan W Juanda 2016 Analisis Kualitas Gas Metana Dan Jumlah Bakteri Anaerob Pada Proses Pembentukan Biogas Dari Feses Sapi Potong Dari Feses Sapi Potong Dalam Tabung Hungate. Jurnal Agritech 1(1): 11-17 (In Indonesian).
[8] Mujdalipah S, S Dohong, A Suryani dan A Fitria 2014 Pengaruh Waktu FermentasiTerhadapProdukt Biogas Menggunakan Digester DuaTahap Pada BerbagaiKonsentrasi Palm Oil-Mill Effluent Dan Lumpur Aktif Journal Agritech 34(1): 56-64 (In Indonesian).
[9] Salam B, M Islam and M Rahman 2009 Biogas from Anaerobic Digestion of Fish Waste Proceedings of the International Conference on Mechanical Engineering.
[10] Sarower G, S Bilikis, A Rauf, M Khanam and S Islam 2013 Comparative Biochemical Composition of Natural and Fattened Mud Crab Scylla serrate. Journal of Scientific Research 5(3): 545-553
[11] Prayoga. R., S. Loekman and Sumarto 2015 Consumer Questionnaire Study Against Ice Cream Cone With Addition of Shelled Starch Shell (Portunus pelagicus).1-13.
[12] Rochima E 2005 Characterization of Chitin and Chitosan Origin Waste Cirebon Rajungan West Java. Bogor. Department of Food and Nutrition Technology, Bogor Agriculture Institute.
[13] Simamora, S., and Sakundik 2006 Biogas Production in Lieu of Fuel Oil and Gas from Livestock Dung. Jakarta: Agro Media Pustaka.
[14] Sinaga S M, M Intan and J Silalahi 2014 Protein Analysis of Canned Legumes by using Visible Spectrophotometry and Kjeldahl Method International Journal of Pharm Tech Research 8(6): 258-264.
[15] Syahbuddin, S.A., P.T. Riyadi and Romadhon 2014 The Influence of Added Egg (Portunus pelagicus) with Different Concentration on Wet Noodle Quality. Journal of Fishery Products Processing and Biotechnology. 3(4): 65-70.
[16] Wati L, Y Ahda dan D Handayani 2014 Pengaruh Volume Cairan Rumen Sapi Terhadap Bermacam Feses Dalam Menghasilkan Biogas Journal EKSAKTA 1(15): 20-29 (In Indonesia).