

# Biogas Production of Co-digestion from Beverage Industry Waste and Organic Fertilizer Raw Material

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This research aims to study efficiency of bio co-digestion from beverage industry waste (xW) and organic fertilizer raw material (OFM). The researcher was studied suitable mixing ratio between beverage industry wastes were taken from dairy (DW), beer (BW), coffee (CW) and energy drink (EW) industry mixing with OFM. For this study, mixing ratio are 100:0, 75:25, 50:50, 25:75 and 0:100 (ratio by mass of OFM:xW) considered by dry basis and using batch reactor on shaker machine. The experiment result showed the fermented ratio of 75:25 of all industrial wastes seemed to have higher accumulated biogas production compared to other fermented ratios, especially it was found in dairy industry waste, higher more than 2.1 times. The heating values show (at OFM:xW equal 75:25) of OFW with CW equal 2530.92 J > CW equal 1,141.13 J > BW equal 840.48 J > EW 515.79 J, respectively. The proportion OFM:xW at 75:25 show highest gas production and the heating value. The dairy industry waste was suitable for mixing with Organic Fertilizer Raw Material.

## 1. Introduction

Nowadays, the industrial plants have increased with rapidly expanding. The problem is the waste which generated by industrial processes called industrial waste. At present, the industrial waste is generated up to 2.04 million tons/year, accounting for 77% from total amount of waste which is 2.65 million tons/year. There are many types of industrial waste disposal such as landfill, burn in the kiln, recycling, etc. The most popular disposal process of non-hazardous waste is the landfill process which is the cheapest and the most convenient disposal method. The process of disposal by landfill is a process that cannot use the industrial waste to recycle. Therefore, it can cause the zero value of some industrial wastes which can be useful, for example, industrial wastes from non-hazardous beverage factories. The removal method uses natural degradation process by using microorganisms to digest. This reaction occurs in landfill process without harm. From the reaction, methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>) and other gases were produced by fermentation of organic matter under anaerobic conditions which has an effect on landfill (Chen et al. 2010, Khan et al. 2015, Aggarangsi et al. 2013, Pipatmanomai et al. 2009 and Budzianowski 2016). This requires the removal of gas production with cannot be useful. The gas generated by this digestion can be passed through the process to obtain biogas and bring methane to reuse with can generate heat.

Industrial wastes from beverage factories as raw materials for biogas production in closed ponds under anaerobic conditions were interested in this research. According to previous research, it was found that more than one organic compound can increase the volume of biogas, according to a report by the Energy Systems Engineering Institute and a report from the Hazardous Substances Management Division. Pollution Control Department reported that 26 food, beverage and pulp factories had wastewater and sludge production were produced up to 40,200 tons/month. The total amount of wastewater and sludge was 1,045,200 tons/month and the average utilization was 8,333 tons/month/plant. The use of 108,333 tons/month or 10.36% of the total amount of waste generated by the relevant industry. Efficiency of biogas production from old community waste from waste junk from fresh community waste by using a fermented tank which was completely agitated. The results were found that the old community waste mixed with fresh community biomass for biogas production were highest. The old community waste amount to 1: 3 at the total solid content of 5%. The biogas yield was

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0.12 liters per gram of total evaporated solids. At the end of the experiment, COD was reduced by 63.19% with COD removal of 3,136 mg/L. In the heat treatment of waste at the old community waste mix ratio of 1: 3 at the total solid content of 5%. It was found that the heat treatment resulted in higher methane content of biogas with up to 73.33 percent (Tamyern 2008). The production of biogas from wastewater from pig farms with Napier grass and Scrap. The ratio of volatile solids content of swine wastewater to Napier grass and food waste was 70:30 and 40:60, respectively, in comparison with the use of swine wastewater alone. Experiment was conducted using this ratio with the ASBR reactor at the laboratory level. The results obtained from the first experiments using Napier grass were found to be a common compost (Mernji 2010). The anaerobic co-digestion (co-AD) of the pre-hydrolysed Organic Fraction of Municipal Solid Waste (hOFMSW) and Maize Cob Waste (MCW) was studied in lab scale anaerobic digester (Surra 2018). The results showed that the pre-treatment is recommended before submitting MCW to co-AD and the chemical pre-treatment of MCW with H<sub>2</sub>O<sub>2</sub>, at room temperature, is a promising low-cost way to valorise MCW through co-AD. The biogas digestion was studied for the energetic valorisation of the sewage produced in swine farms (Leite 2018). Results showed the models based on physical chemical parameters and the model based on quantity of growing pigs were coherent with results provided by lab-scale bioreactor.

Therefore, the researcher selected industrial wastes from 4 beverage factories, dairy industry waste (DW), beer industry waste (BW), coffee industry waste (CW) and energy drink industry waste (EW). These industrial wastes have high COD. The aim of this research was to study the optimum mixing ratios for organic fertilizer raw material (OFM) and 4 beverage industrial wastes (xWs) to maximize biogas quantity and quality. The other one was to remove industrial waste from the target beverage factory. It could be used to improve the production of biogas in the organic fertilizer industry that was currently used and production.

## 2. Research Experiment

Industrial waste was selected the from the wastewater treatment plant of the beverage industry to study and analyze in the laboratory. The equipment was prepared for sampling and fermentation biogas. Each group was divided into five experiments. The experiment will be conducted in the various ratios which were (0: 100), (25:75), (50:50), (75:25) and (100: 0), respectively. Briefly, the experiments were carried out with 27 sets of experiments with 5 samples, 5 ratios, 3 fermenters and prepared ingredients of mixing fermentation. Mixing Raw Materials were prepared followed the method of mixing industrial wastes and OFM into 500 ml amber bottle by fixed 300 ml fermented volume (Figure 1). The biogas system was then stored for a period of time until the end of the biogas process. Place all batches on an automatic shaker. The tester was divided into 5 groups, 5 each and 3 times. The fermentation was performed for 22 days. The shaker was operated from 7 am to 7 pm and shutdown the machine. Finally, recorded the test results at 1:00 pm for about 5 minutes every day in the morning and evening before and after the shutdown.

This paper studied the properties of the mixture were analyzed at the laboratory. To study on biogas ratio, the ratio between the industrial wastes and OFM, the organic fertilizer plant anaerobic closure of organic fertilizer plant was investigated. Finally, compare the volume of produced biogas and the components of biogas include methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>).

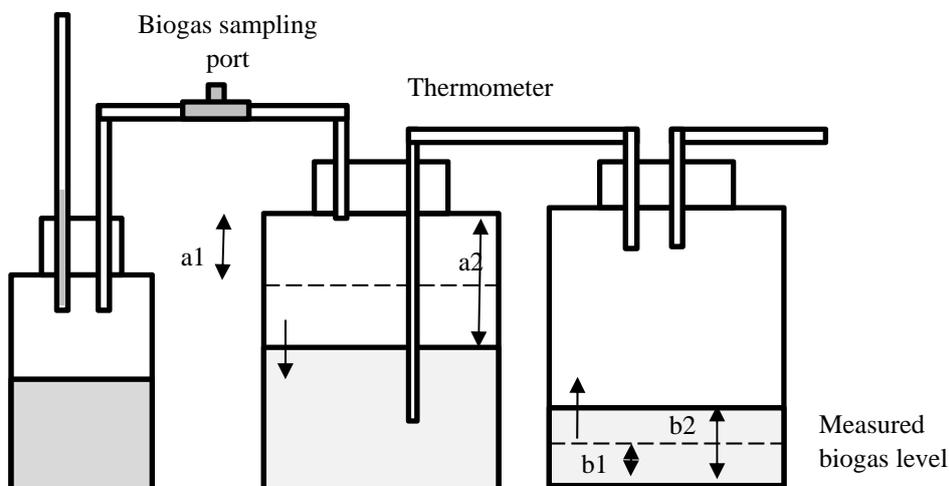


Figure 1: Biogas collecting and measuring system.

### 3. Results and Discussions

#### 3.1 Dry weight, volatile solids content, pH and Chemical Oxygen Demand (COD) of fermented raw materials

Dry weight, volatile solids content, pH and Chemical Oxygen Demand (COD) of fermented raw materials were determined as shown in Table 1. The sample from biogas system was kept in ice plastic plastic bag at temperature of 0-2 °C and sent to laboratory to analyze the dry weight of fermented raw materials. The volatile solids content was analysed by heated at 550 °C. The results of dry weight analysis of organic fertilizer sludge were 107.560 mg/L and volatile solids content of the OFM was 55,584 mg/l. It was found that the fermented sludge with the highest dry weight content occurred in organic fertilizer raw material which was 107,560 mg/l, followed by the dairy industry with 74,344 mg/l. The highest volatile solids content was from dairy industry waste which was 69,256 mg/l, followed by the beer industry with 68,000 mg/l. The pH of organic fertilizer raw material and every types of industry waste was measured before fermentation. The COD used in this study was from the industrial waste analysis report prepared for the disposal of industrial waste in the plant. The COD represented the total amount of oxygen required for the chemical reaction (Oxidation) with organic substances in water. After the reaction, the carbon dioxide and water would be replaced.

Table 1: Total solids, volatile solids content, pH and COD of OFM and industrial wastes (xW).

	Unit	OFM	Total of Industrial Waste			
			DW	BW	CW	EW
Total Solids	mg/L	107,564	74,344	12,400	29,088	30,732
Volatile Solids	mg/L	55,584	69,256	68,000	27,204	30,168
pH		7	7	5	7	4
COD	mg/L	109,653	54,802	51,350	51,986	48,400

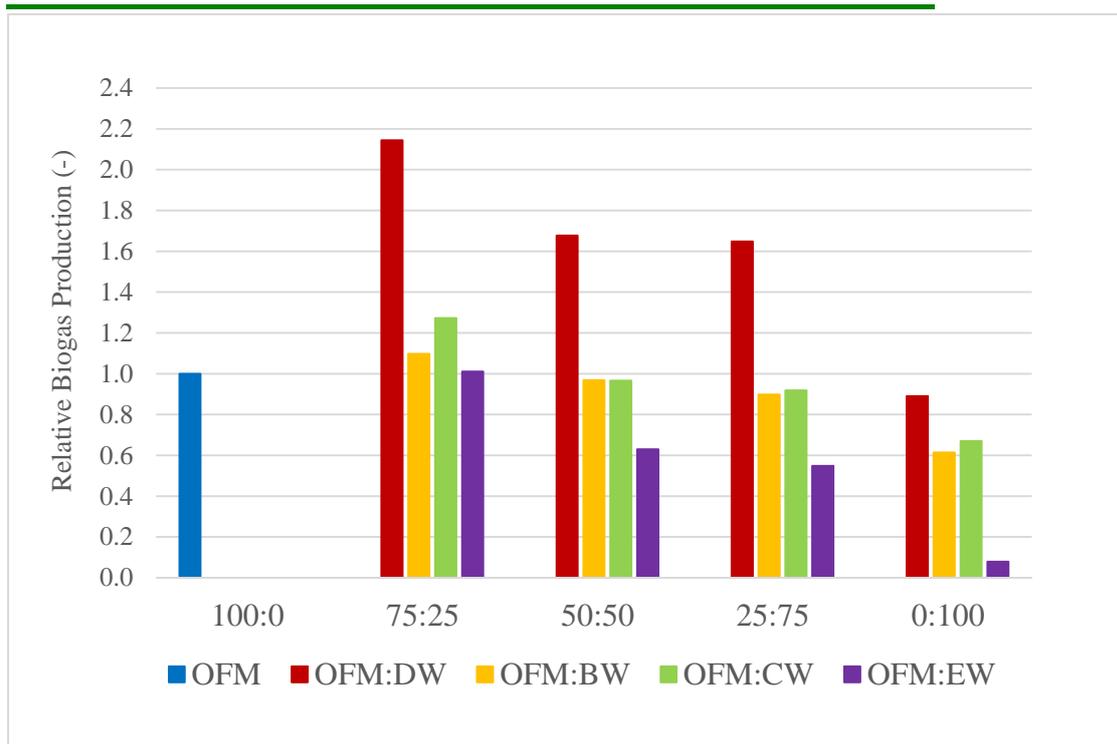


Figure 2: Relative biogas production of fermented raw materials in different ratios.

#### 3.2 Biogas Production

The relative biogas production with OFM of different ratios of fermented raw materials was determined as shown in Figure 2. It was found that dairy industry waste occurred the highest content of accumulated biogas production with all fermented ratios (75:25, 50:50, 25:75, 0:100). On the other hands, the lowest content of accumulated biogas production was found in energy drink waste with all fermented ratios. The experiment

result showed the proportion 75:25 of illustrated the maximum quantity of accumulated biogas of OFM with DW equal 272 ml > CW equal 162 ml > BW 139 ml > EW equal 128 ml, respectively. The fermented ratio of 75:25 of all industrial wastes seemed to have higher accumulated biogas production compared to other fermented ratios, especially it was found in dairy industry waste, higher more than 2.1 times. However, the ratio of 0:100 seemed to have the lowest of accumulated biogas production of all fermented raw materials, especially it was found in energy drink waste. In addition, beer industry waste and coffee industry waste seemed to produce the same amount of accumulated biogas production of OFM.

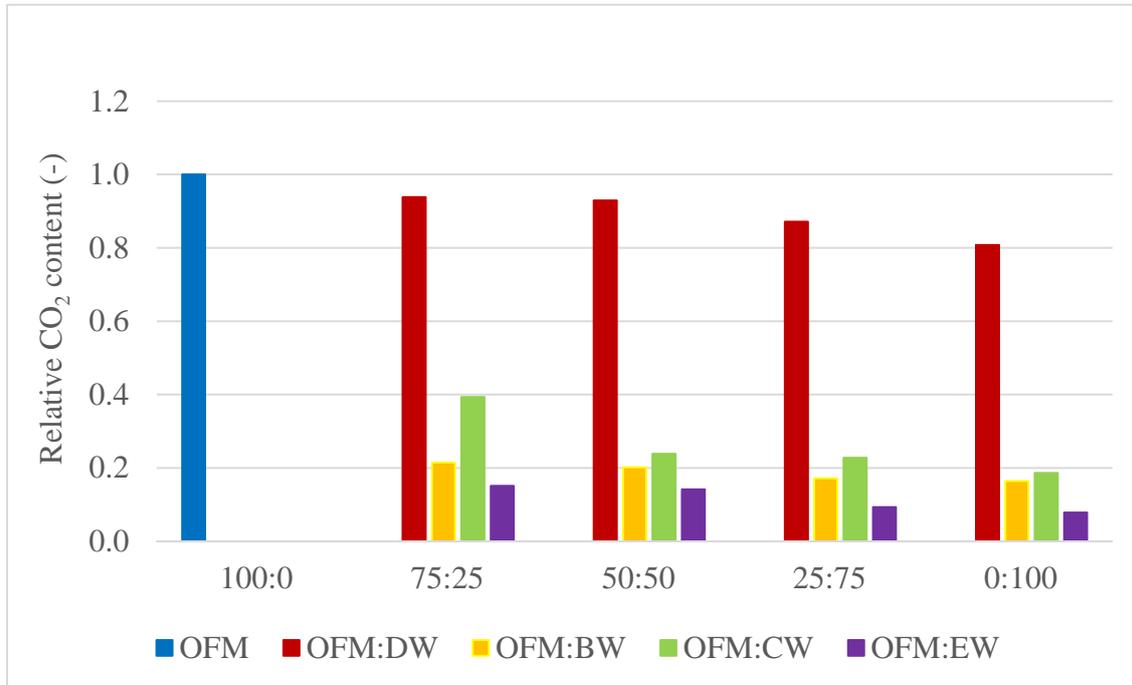


Figure 3: Relative carbon dioxide production with OFM in various ratios.

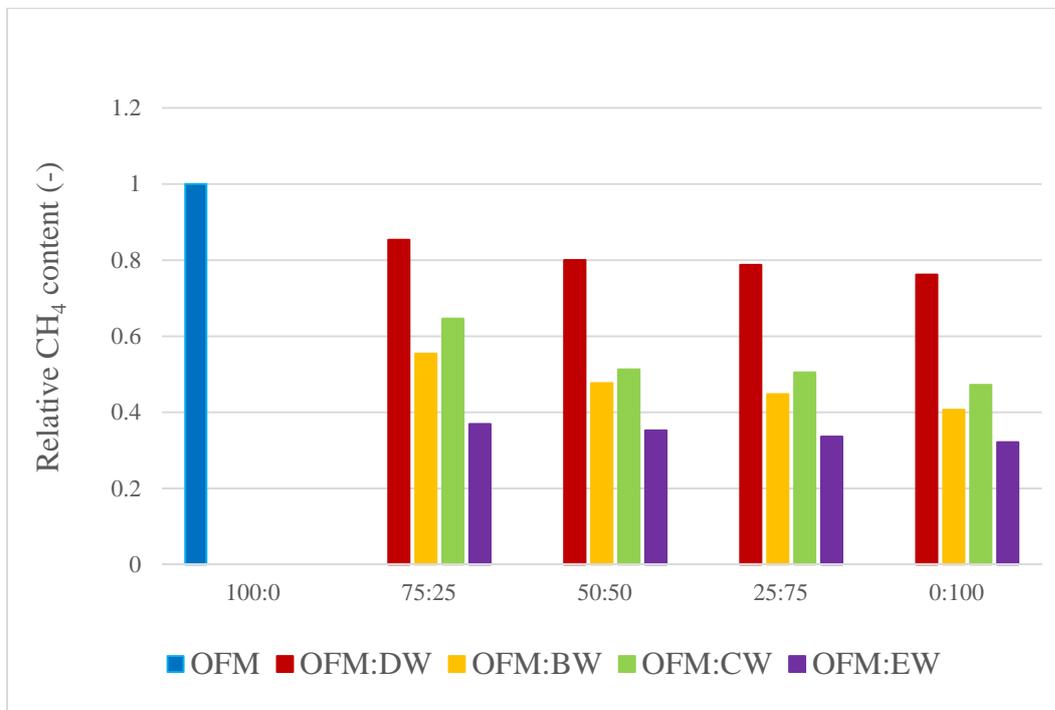


Figure 4: Relative methane production with OFM in various ratios.

### 3.3 Carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) Production

From Figure 3, it was found that the composition of biogas, a relative carbon dioxide content when compared with OFM, were decreased when the OFM was mixed with various industrial wastes (xW) in various ratios. The maximum carbon dioxide content of mixed-wastes occurred in ratio of 75:25 and decreased when increasing the industrial wastes in the mixture. The highest carbon dioxide content was 75:25, followed by 50:50 and 25:75, respectively. The CO<sub>2</sub> contents of mixed-wastes were nearly the pure OFM. From the results of methane content CH<sub>4</sub> (%) (figure 4.), it shows same trend of CO<sub>2</sub>. The CH<sub>4</sub> contents of mixed-wastes decreased when increasing industrials wastes (xW).

### 3.4 Energy heating value

Figure 5 showed that the suitable biogas co-digestion was only OFM:DW. The ratio of fermentation of fertilizer raw material with dairy industry at 75:25 gave a heating value of 2530.93 Joule (1.83 times), followed by the ratio of 50:50 with a heating value of 1806.55 Joules (1.34 times) and the ratio of 25:75 revealed a heating value of 1794.63 Joules (1.29 times), respectively.

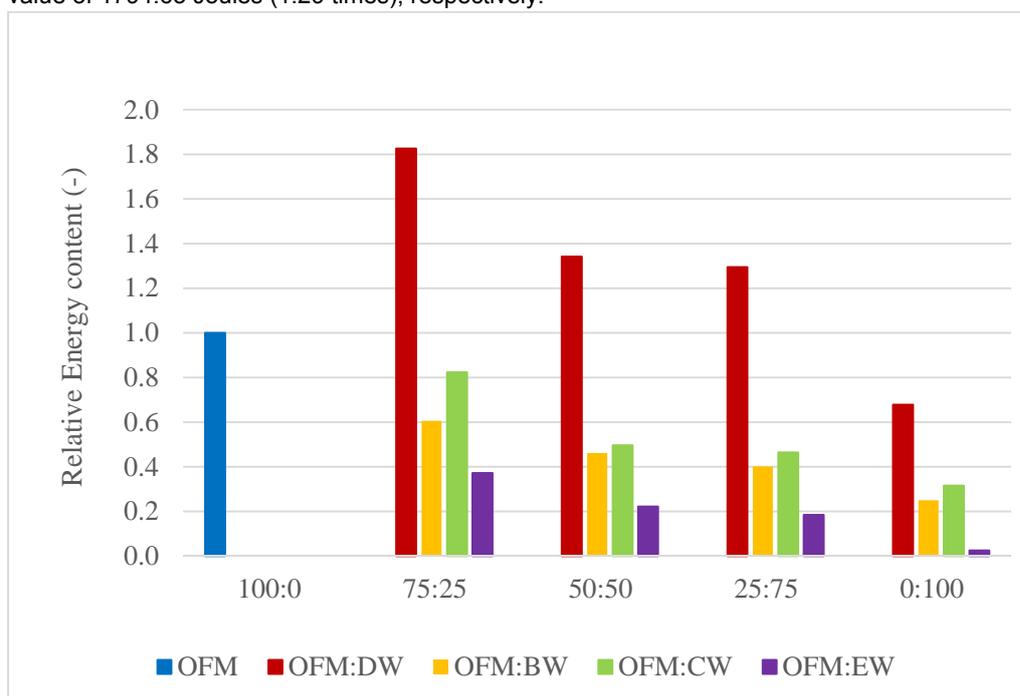


Figure 5: Heating value relative with OFM in various ratios.

## 4. Conclusion

The study found that the ratio of the maximum biogas volume was occurred at 75:25. The DW had the highest biogas volume at 272 ml, followed by CW, BW and EW with the accumulated biogas volume at 162, 139 and 128 ml, respectively. The heating value from the experiments showed that when mixing industrial waste with OFM, the heat value was increased by added industrial waste gave higher value of biogas compared to ferment with only fertilizer raw material. The best ratio was 75:25, followed by 50:50 and 25:75, respectively. The appropriate industrial wastes for co-digest with OFM in this experiment was dairy industrial waste (DW).

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