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Methane Production from Pineapple Waste

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Abstract

Pineapple is a fruit that is produced in large quantities, and anaerobic digestion can convert pineapple waste into methane, a renewable energy source that is environmentally friendly. Pineapple waste is usually burned or dumped in a landfill for disposal, which causes environmental pollution, including greenhouse gas emissions. The objectives of this study are to examine the methane production from pineapple waste. In this study, the methane production at a batch scale using pineapple waste (a combination of peel and pulp) inoculated with anaerobic microbes from the biogas plant inoculum was conducted. The batch reactor was operated at an inoculum-to-substrate ratio of 0.4, and water displacement was used to measure methane production. The characterization of pineapple waste and inoculum for both total solids and volatile solids follows the APHA 2005, while chemical oxygen demand was tested by using a HACH spectrophotometer. Methane generation was observed on day one (294 ml), and production gradually decreased starting from day 2. An acidic condition is the primary reason for the decline in methane production. In conclusion, pineapple waste has shown potential to generate methane. However, the appropriate experimental setup shall be provided to produce the consistent methane production.

1. Introduction

Generally, pineapple (*Ananas comosus L. Merr.*) is a tropical fruit belonging to the family of Bromeliaceae [1]. Malaysia is one of the countries that supplies 0.25% of the world's pineapple demand. Malaysia produces between 400,000 to 600,000 metric tonnes of pineapple annually. Johor is the largest state in Malaysia, also known as the largest pineapple-producing state, with 16,204 hectares. Additionally, the Malaysian Pineapple Industry Board (MPIB) aims to increase pineapple production to 700,000 metric tonnes by 2025 [2].

The pineapple processing industry generates a substantial amount of waste that contributes to and exacerbates the global environmental problem [1]. The pineapple waste, like core, peel, stem, crown, and leaves, accounts for about 50% of pineapple weight [1]. Pineapple waste is organic waste that contains high biological oxygen demand (BOD) and chemical oxygen demand (COD), which makes it difficult for pineapple waste disposal [3]. The pineapple residues produced, which are mostly burned or buried, contribute to environmental and health issues [4]. The pineapple waste that was subjected to open burning contributes to greenhouse gas emissions [5].

The pineapple waste is a potential feedstock for a biodegradable process since it is classified as organic material due to the presence of fiber [5]. In addition to that, pineapple waste also contains an abundance of carbohydrates and protein, making it a suitable raw material for biogas production [6]. Pineapple waste also contains cellulose and hemicellulose, which serve as the carbon source for methane biogas production [7]. Agro-industrial solid waste, including pineapple waste, is a useful product by converting the biomass to be transformed into methane gas [8]. Thus, pineapple waste is viewed as a readily available resource for agricultural waste, suitable for anaerobic digestion and the production of methane [9]. Aili et al. [6] reported an ultimate methane yield of 59.09 to 85.05 ml CH4/g VS, with an increment in biogas yield of about 23% to 44% from untreated pineapple waste inoculated with cow dung. Therefore, this study aims to evaluate the methane potential of pineapple waste digestion. In this study, pineapple waste was inoculated with digested sludge obtained from a biogas plant.

2. Material and Methods

2.1 Pineapple Waste and Inoculum Collection

The rotten collected pineapple was used in this study. The pineapple waste consists of peel and pulp. After that, the collected pineapple waste was rinsed with tap water to clean up debris [10]. The pineapple waste was chopped and ground into small pieces in the kitchen blender [11]. The pineapple waste is a mixture of pineapple pulp and peel in a 1:1 ratio of pulp to peel [12].

The inoculum was the anaerobically digested sludge taken from a biogas plant (active) in Yong Peng, Johor. Rusín. et al, [13] used inoculum taken from the mesophilic agricultural biogas plant for the anaerobic digestion setup. The inoculum was stored in a cold room at a temperature of 4^{o}C [14].

2.2 Biochemical Methane Potential (BMP) Test

The BMP test was prepared at an inoculum-to-substrate ratio (I/S) of 0.4, following [9], and operated in a water bath at mesophilic conditions of 35±0.5 °C [14]. The methane production was monitored using the water displacement method for biogas measurement [15]. Nitrogen gas was purged into the reactor for 2 to 3 minutes to provide the optimum anaerobic condition [6]. Fig 1 shows the BMP for this study.

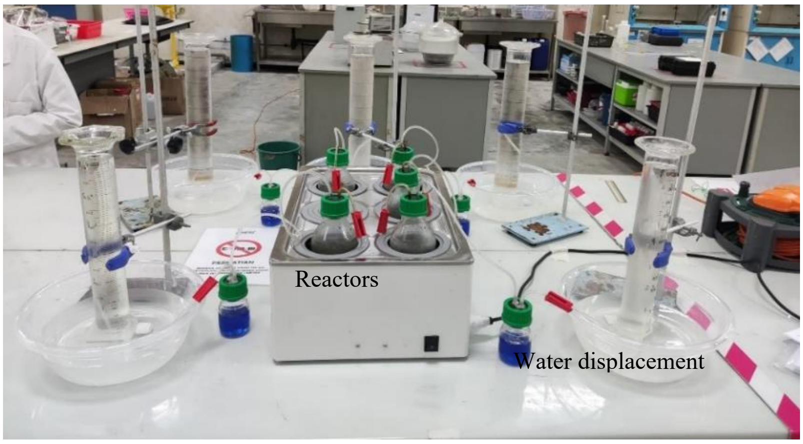

Fig. 1 *Batch reactor*

In this study, three sample reactors, each filled with pineapple waste and inoculum, were prepared, and two blank reactors containing only inoculum were included, as shown in Table 1. The pH ranges from 6.30 to 7.70 for both blank and sample reactors, as shown in Table 2. According to [9], pH should range between 6.6 and 7.7, which is around neutral, to undergo the optimum anaerobic digestion process.

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Table 1 *Volume of inoculum and substrate*

Reactor	Inoculum (mL)	Pineapple waste (mL)
Blank 1	314.8	-
Blank 2	314.8	-
Sample 1	314.8	85.2
Sample 2	314.8	85.2
Sample 3	314.8	85.2

Table 2 *pH of different reactors*

Reactor	pH			Average pH
	1	2	3	
Blank 1	7.60	7.70	7.70	7.67
Blank 2	7.70	7.70	7.70	7.70
Sample 1	6.80	6.80	6.80	6.80
Sample 2	7.00	6.90	6.90	6.93
Sample 3	6.70	6.70	6.70	6.70

2.3 Analytical Method

The characterization of total solids (TS), and volatile solids (VS) for both pineapple waste and inoculum was done following APHA, 2005 [16]. COD was measured using a HACH spectrophotometer. Li et al. [17] utilized a HACH spectrophotometer for COD measurement. pH was measured using a pH meter [18].

3. Results and Discussion

3.1 Characterization

Pineapple waste has total solids (TS) and volatile solids (VS) of 121360 mg/L and 94180 mg/L. Wichitsathian et al.,[16] reported that pineapple waste contained TS and VS less than 40000 mg/L/. The VS/TS ratio of used pineapple waste is 0.78 and [9] reported a VS/TS of 0.92 for pineapple waste. The COD of pineapple waste in this study is 114500 mg/L, which is almost twofold of the observation by [16].

As for the inoculum, TS and VS are 20900 mg/L and 18320 mg/L, respectively. Nguyen et al. [19] reported the TS and VS of 44800 mg/L and 39100 mg/L, respectively. The VS/TS ratio of the inoculum for this study is 0.88, which is similar to the value of 0.91 reported by [9].

3.2 Methane Production from Pineapple Waste

The biochemical methane potential (BMP) test ends on day 6. The daily net methane production was recorded. The methane production from the sample reactors was low compared to the blank reactor. Starting from day 2, the accumulation in the sample reactors started to decline, resulting in the termination of the BMP test on day 6. The sample reactor consistently shows a low pH (acidic). Acidic pH indicates the high production of volatile fatty acid that leads to the microbial flop phenomenon [20]. The high concentration of volatile fatty acid (VFA) caused the acidic environment, which inhibits the methanogenic bacteria due to unionized fatty acids that penetrated the microorganism membrane and resulted in cytoplasm acidification [21]. Nguyen et al. [19] stated that 4.0 g/L of volatile fatty acid (VFA) loading can reduce the methane yield by 18%. As for blank reactors, the pH remains between 7.3 and 7.5. pH between 6.5 to 8.2 is considered the optimum environment for the anaerobic digestion process [15].

4. Conclusion

This study concludes that pineapple waste is a potential substrate for methane production, as indicated by the lack of a lag phase. Furthermore, the pineapple waste was high in solid and organic content. However, due to the inappropriate inoculum-to-substrate (I/S) ratio and the initial pH, methane generation consistently decreases. In the future, this study could be conducted at various I/S ratios to identify the best and greatest methane yield.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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