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Biogas production from restaurant waste with the addition of co-substrate variation of tofu liquid waste and cow dung

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ABSTRACT

Restaurant waste is a potential biomass that can be developed into a renewable energy source, especially for biogas production. It is the main substrate for the anaerobic process, as it contains many organic materials. Tofu liquid waste and cow dung have the potential to be used as additional substrates in this process. This research aims to determine the effects of variations in restaurant waste, tofu liquid, and cow dung composition on the quality of methane gas in biogas production. This research was conducted using a 30-liter reactor with 75% working volume. Measurements of pH, temperature, Chemical Oxygen Demand (COD), Volatile Suspended Solid (VSS), Volatile Fatty Acid (VFA), and methane gas concentration were carried out daily for 49 days. Biogas production volume was also measured at the end of the period. The substrate variables included: 50% restaurant waste: 50% liquid tofu waste (Reactor A); 93.75% restaurant waste: 6.25% cow dung (Reactor B); and 100% restaurant waste (Reactor C). The results showed that variations in the composition of organic waste affected methane gas quality in biogas production. Reactor C, with 100% restaurant waste substrate, obtained the highest yield in each parameter. The largest volume of biogas produced in this reactor was 109 litres with a methane concentration of 51.307 ppm, followed by reactor B and then reactor A, with biogas production of 48 and 45 liters, respectively.

1. Introduction

The rapid growth of Indonesia's urban population has increased activity levels, posing challenges to infrastructure services and waste management [1]. One of the most significant urban centers in the country is Pekanbaru City, which has experienced a

population growth rate of 2.63% annually and generates 400.461,54 tons of landfill waste per year [2] and worldwide; it is estimated that the amount of waste will reach 2.2 billion tons by 2025 [3]. In Indonesia, the composition of municipal waste is predominantly food waste [4], which is classified as organic waste. This accounts for approximately

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70% of the total waste, while non-organic waste represents approximately 28% and includes materials that may be subject to scavenging activities [5]. The solid waste management process must use the appropriate approach to avoid health problems for humans and the surrounding environment [6].

One category of food waste comes from restaurants, specifically the kitchen waste. This waste is composed primarily of small pieces of meat, fish, poultry, vegetables, and bones. These items represent unused food source material that should be discarded or not consumed. Additionally, restaurant waste includes leftover food items that have been served [7]. The processing of restaurant waste is conducted through an anaerobic process, which offers several advantages, including reductions in chemical oxygen demand (COD), biological oxygen demand (BOD), total volatile solids, organic nitrogen, and nitrates [8]. During this process, the waste is decomposed into methane gas, which can be utilized as an alternative energy source, specifically as biogas. The use of restaurant waste as the main substrate in the anaerobic process is noteworthy, as it contains a significant amount of organic material that has not been widely utilized, especially for biogas production [9].

It is well documented that food waste from restaurants contains a significant proportion of organic matter, with carbohydrate content ranging from 11.8 to 74%, protein from 13.8 to 18.1%, and fat from 3.78 to 33.72% [10]. Previous research indicates that tofu and cow dung have the potential to serve as additional substrates in the biogas formation process. Additionally, tofu liquid waste has been found to contain a relatively high percentage of organic matter, specifically 25–50% carbohydrates, 40–60% protein, and 10% fat [11]. Cow dung slurry has been found to contain 1.8–2.4% nitrogen, 1.0–1.2% phosphorus (P₂O₅), 0.6–0.8% potassium (K₂O), and 50–75% biological compounds [12]. The biogas composition produced from restaurant waste and cow dung has been determined to consist of 66.8% methane (CH₄), 27.2% carbon dioxide (CO₂), 1.5% oxygen (O₂), and 4.5% nitrogen (N₂) [13]. The methane biogas generated from restaurant waste was 56.8%, while that produced from tofu liquid and cow dung was

67.17%. The use of biogas, resulting from the anaerobic process, aligns with Indonesia's national energy policy, which aims to develop alternative energy sources as a substitute for crude oil [14]. Furthermore, this digestion process yields a slurry containing nutrients that can be used directly as organic fertilizers, which possess economic value [15].

One study sought to determine the effect of varying concentrations of cow dung starter at five levels: 0%, 6.25%, 12.5%, 18.75%, and 25%. The results showed that increasing the concentration of the cow dung starter reduced biogas production. The highest yield (971.4 mg/L) was observed using a 6.25% starter [16]. A study on biogas production in a 20 L lab-scale digester design involved the addition of cow dung, followed by the introduction of food waste once gas production commenced [17]. The principal residual components included rice, peeled vegetables, cucumber, bitter melon, and other assorted items. The total biogas yield was 3964.5 L over 31 days, with the temperature ranging from 37 to 41°C. Another study conducted at room temperature over six weeks yielded the highest biogas production from a 1:1 (v/v) mixture of tofu liquid and restaurant waste, reaching a total of 21,200 ml [18]. The anaerobic process also demonstrated notable reductions in COD levels, ranging from 57–68%, as well as in BOD, with a reduction of 29–43%. Additionally, the Total Solid (Total Solid) and Volatile Solid (VS) exhibited decreases ranging from 64–80% and 64–79%, respectively. Based on previous studies, the present study investigated the production of biogas from restaurant waste as the primary substrate, with the addition of tofu liquid and cow dung, to determine the quality of the methane gas produced using gas chromatography.

2. Materials and methods

2.1. Research tools and variables

The reactor used was comprised of three 30-liter drums of anaerobic biodigester. The independent variables were varied at the following levels: 50%, 93.75%, and 100% variations of restaurant waste; 50% tofu liquid; and 6.25% cow dung. The restaurant waste used in this study was obtained from a Padang-style restaurant, featuring a plethora of coconut milk-based dishes on its menu.

The effects of the independent variables on the dependent variables were determined by observing and measuring temperature, pH, COD, VSS, VFA, methane concentration, and biogas volume. In the present study, the dependent variables were the Co-Substrate variation of restaurant waste, tofu liquid waste, and cow dung waste. The fixed variables were maintained at a constant level throughout the experiment. These included the initial pH in the anaerobic process, which was kept within the neutral range of 6.0–7.0 [19], and the working volume of the biodigester, which was a 30-liter drum filled to 75% of its capacity [20]. The ratio of substrate organic waste to water was maintained at 1:1 [21]. The purpose of this mixing process was to maximize biogas production, facilitate the flow of raw materials, and prevent the formation of sediment in the inlet [22]. Figure 1 shows a schematic of a biogas digester.

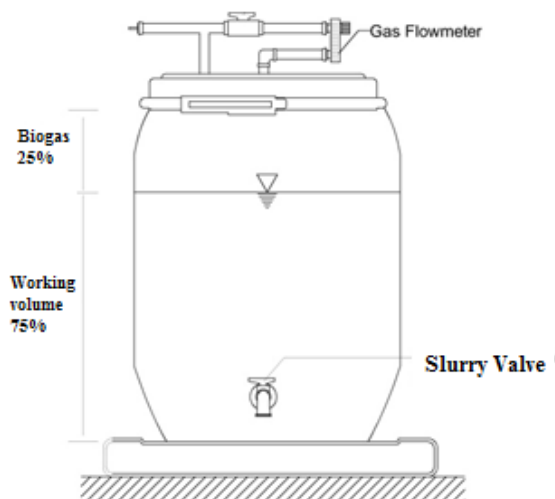


Fig. 1. Schematic of a biogas digester.

2.2. Restaurant waste substrate preparation

The waste materials used were procured from restaurants that serve rice and side dishes, including portions of vegetables, fruit, and other foodstuffs that were not subjected to cooking or should be discarded, as well as food that was not consumed. In the collection of restaurant waste for the present study, several procedures were required, including separating the remaining chicken bones, a type of unused scrap. This was because the food waste underwent a blending process and was unable to blend the chicken bones [23]. A total of 54.84 L of restaurant waste,

comprising kitchen waste and leftover food, was used in the present study. These were homogenized with water on the basis of weight/volume (w/v) using a blender. This mixing process was employed to maximize biogas production, facilitate the flow of raw materials, and avoid sediment formation in the inlet [24].

2.3. Preparation of tofu liquid waste substrate

The tofu liquid used was procured from a tofu factory and was still in a state of freshness, as it had not been subjected to a mixing process with other waste materials, and originated from the dough lifting process.

2.4. Preparation of the cow dung substrate

The cow dung utilized in this study was procured from a slaughterhouse and was still fresh, having been harvested a day prior. This contributed to the overall moisture content of the substrate. Before initiating the anaerobic process, the cow dung was thoroughly homogenized with water at a 1:1 ratio.

2.5. Preparation of main research materials

In the present study, three reactors were used, with restaurant waste serving as the primary substrate and tofu liquid and cow dung as additional substrates. In the first reactor, a substrate variation of 50% restaurant waste with 50% tofu industrial liquid was employed. In the second reactor, 93.75% restaurant waste with 6.25% cow dung was utilized. In the third reactor, 100% of the substrate was derived from restaurant waste. The volume of each material in the three reactors is shown in Table 1.

Prior to initiating the anaerobic process, it was necessary to ensure the homogenization of the biomass (waste) present in each reactor. This ensured that the substrate was more readily digestible by the microorganisms involved. Following the completion of the homogenization process, a series of parameters were measured at regular intervals from day 1 to day 49. These included pH, temperature, COD, VSS, VFA, biogas volume production, and methane gas concentration. The sample analysis was conducted in accordance with the *21st Standard Methods for the Examination of Water and Wastewater*.

2.6. Biogas production stage

The biogas production in the present study employed a batch feeding method, in which the organic material was filled and then allowed to rest until biogas production commenced. The substrate, which had retained an acidic pH, was then neutralized through the addition of Ca (OH)₂, as a base atmosphere. The substrate was subsequently transferred to the digester and sealed for the duration of the fermentation process, which lasted for 49 days.

3. Results and discussion

3.1. Substrate characterization in the context of biogas production

At the outset of the study, measurements of the physical and chemical characteristics of each reactor were conducted. The objective of this initial

characterization was to determine the distinctive attributes of each reactor by assessing several key parameters, including COD, VSS, VFA, pH, and temperature as shows in Table 2.

The initial acidity (pH) of the substrate in each reactor remained acidic, necessitating the addition of lime to each treatment. The initial pH of reactors A, B, and C was 4.67, 5.71, and 5.37, respectively. The objective of adding lime was to achieve a neutral initial pH in the substrate [25]. In the present study, substrates with initial pHs of 6.7, 6.64, and 6.63 were conducive to biogas production.

As illustrated in Table 2, the COD values observed in the three reactors were largely similar. However, reactor C exhibited considerably higher VSS and VFA values compared to the other two reactors. The production of biogas for each gram of VSS was found to be equal to the biogas production for each gram of COD.

Table 1. A comparative overview of the experiments conducted.

Reactor A	Reactor B	Reactor C
A total of 25% of the reactor was reserved for biogas, with a volume of 7.5 liters.	A total of 25% of the reactor volume was reserved for biogas, with a volume of 7.5 liters.	A total of 25% of the reactor volume was reserved for biogas, with a volume of 7.5 liters.
A total of 75% of the reactor volume, or 22.5 liters, was designated as the working volume:	A total of 75% of the reactor volume, or 22.5 liters, was designated as the working volume:	A total of 75% of the reactor volume, or 22.5 liters of restaurant waste, was utilized as the work volume.
<ul style="list-style-type: none"> 50% (11.25 liters) of the tofu liquid waste 50% (11.25 liters) of the restaurant waste 	<ul style="list-style-type: none"> 6.25% (1.41 liters) of the inoculum from cow dung 93.75% (21.09 liter) of the restaurant waste 	

Table 2. Results of the chemical and physical characteristics analysis of the substrate.

Parameter	Reactor A	Reactor B	Reactor C
COD (mg/L)	509.091	509.091	525.523
VSS (mg/L)	6080	14520	14820
VFA (mg/L)	15057.03	12547.53	23498.1
pH	4.67	5,.71	5.37
Temperature (°C)	29.3	29.7	29.5

Consequently, if the COD contains a greater proportion of volatile solids, the hydrolysis process becomes faster and increases the production of biogas. Therefore, the amount of biogas produced depends on the amount of VSS [26]. Meanwhile, VFAs are produced in the anaerobic process by decomposing organic materials [27].

3.2. Biogas yield for each treatment

The data regarding the volume of biogas produced in each variation treatment of organic waste composition are presented in Figure 2

As illustrated in Figure 2, reactor A generated 48 liters of biogas, averaging 0.99 liters per day over the course of 49 fermentation days. Moreover, reactor B produced biogas that was not significantly different from reactor A, with a total

of 45 liters and an average production of 0.92 liters per day. Subsequent to this, reactor C was able to produce the highest volume of biogas, with a total of 109 liters and an average production of 2.23 liters per day.

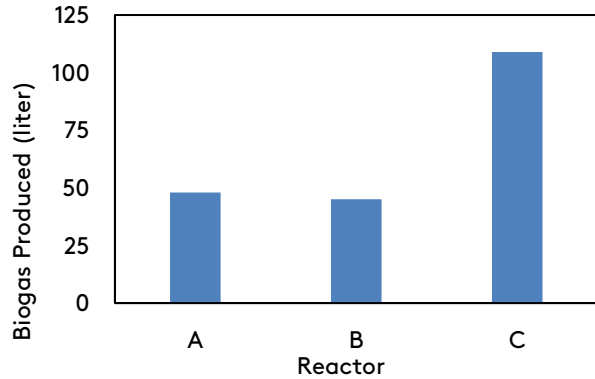


Fig. 2. Biogas volume in each treatment

The highest biogas production was observed in reactor C, with a total volume of 109 liters. This was due to the fact that the reactor consisted of 100% food waste from a restaurant, including small pieces of vegetables, fruit, and other food material that were not cooked or required disposal, such as tea dregs, coffee grounds, and food leftovers. The majority of the restaurant waste used in this study was vegetable matter. According to [28], vegetable waste produces eight times more biogas than that of livestock. Additionally, it is readily decomposable, resulting in an enhanced organic matter degradation in reactor C compared to the other treatments. This finding aligns with the observations reported by [29], in which the type of organic material employed affected the fermentation duration by bacteria. The biogas volume produced in reactors A and B was lower than that observed in reactor C. The biogas volume production in reactors A and B was not optimized due to the absence of initial control over the substrate. The substrate used in reactor A was of a liquid consistency, derived from a mixture of 11.25 liters of restaurant waste combined with water in a 1:1 ratio and 11.25 liters of tofu liquid. At an unbalanced mixed substrate concentration, the process does not run optimally because hydrolysis is low, resulting in lower biogas production [30]. The process of mixing organic matter and water typically uses a ratio of 1:1 to 1:2. In reactor B, the substrate from cow dung was not subjected to

seeding and acclimatization, as these processes can impede biogas formation [31].

3.3. Concentration of methane gas in each reactor

In the laboratory, the composition of methane was determined using a gas chromatograph equipped with a conductivity detector, which has previously been employed to evaluate the concentration of CH₄ gas in sewerage systems [32]. The biogas volume data for each treatment of organic waste composition is presented in Figure 3.

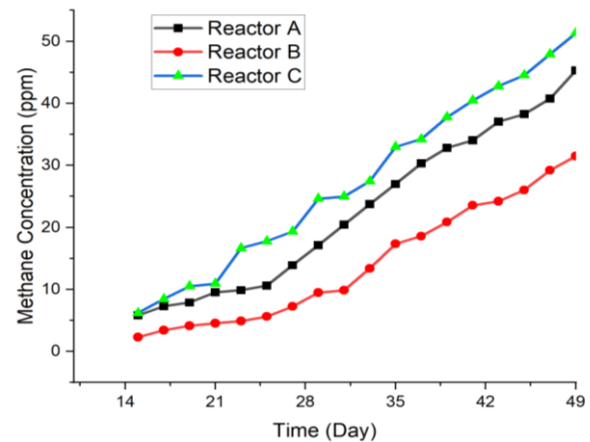


Fig. 3. Concentration of methane gas in each treatment

Methane gas concentrations were tested starting from day 15 onward. Based on the findings of [17], the concentration of methane gas in the digester began to emerge from the first day of filling, or 24 hours after the raw material was placed in the digester, though the concentration was very minimal. With the digester temperature maintained at a constant level, the methane gas concentration began to increase during the second week. Previous studies by [33] indicated that the fermentation process was also observed at the end of the second week during biogas production. The results demonstrated that the methane gas produced in reactor A was 45.295 ppm, while reactors B and C yielded 31.493 ppm and 51.307 ppm, respectively. During the fermentation process, the methane concentration value continued to increase, and the highest biogas yield among the three treatments occurred in reactor C, which utilized 100% restaurant waste, at 51.307 ppm. The concentration produced was proportional to the biogas volume in each treatment. Additionally, during the 49-day treatment period,

the highest methane concentration and biogas volume occurred in reactor C, which used a substrate composition of 100% restaurant waste. The results of the methane concentration in this research were not optimal, with the highest yield of 51.307 ppm. This was due to the fact that the anaerobic process utilizes only bacteria from the substrate in question, without the addition of others. According to a previous study by [34], the processing of waste through anaerobic digestion produces biogas as an environmentally friendly alternative energy source. This is achieved by adding microbes as a starter to accelerate the decomposition process of the organic materials in the debris.

This insufficient production of methane gas was also attributed to the absence of a stirring process during the study, which was conducted at the outset of fermentation. The stirring technique proved less effective due to the potential for material deposition during fermentation, which resulted in heterogeneous particle and bacterial distribution. The increase in methane production was influenced by stirring, as the metabolic activity of acetate- and methane-forming bacteria necessitated close proximity to each other [35]. When the input material was more homogeneous, the remodelling process was more complete. Therefore, in biogas production, optimal conditions were required to achieve maximum methane gas yields [36].

In the present study, methane levels were calculated using the concentration of the gas produced. In reactor C, the concentration of methane and carbon dioxide produced on the 49th day was 51.307 ppm and 34.321 ppm, respectively. These results indicated that the levels of methane and carbon dioxide in the biogas at each reactor were 60% and 40%, respectively. The methane content was in accordance with a previous study by Jameel et al. (2024), which reported that the ideal methane and carbon dioxide content in biogas were 50-70% and 30-40%, respectively. The minimum methane content required for a gas turbine to operate was 40% [37].

3.4. Effect of pH on biogas production

In this study, the degree of acidity (pH) was the control variable for the anaerobic fermentation process of organic matter, which was converted

into biogas and methane gas. The degree of acidity was found to be a significant determinant of the success of biogas formation [38]. The substrate condition in the digester was monitored at each sampling point. The monitored conditions indicated the performance of bacteria in degrading organic matter, which was either optimal or suboptimal. The pH should be maintained at an optimal level between 6.8 and 7.2. When the substrate pH decreases, it reduces the amount of biogas produced. It is also important to avoid a pH value that is too high, as this causes the final product to be primarily CO₂ rather than methane [39].

The pH of the three starting materials placed in the biodigester was observed to be between 6.63 and 6.7. From day zero to day seven, a decrease in pH was observed at the outset. In reactors A, B, and C, the substrate pH decreased by 6.33, 6.46, and 6.58, respectively. This condition indicated that an acidification process was occurring in the digester. A study by [40] found that methanogenic bacteria could survive in the pH range 6–6.7, even though the substrate acidity killed bacteria, because methane gas was still produced in small amounts. On the subsequent day, the pH value exhibited an increase, approaching the range considered normal. As long as the pH remained acidic, biogas and CH₄ production persisted [41]. After 12 days, the pH of all samples had reached a state of normality relative to the initial value, and the methanogenic bacteria exhibited increased activity until the optimal pH for biogas production was attained [38]. On the 12th day, it was evident that the methanogenesis process was efficacious, as methanogenic bacteria produced methane at a pH of 6.8–8.5. Figure 4 shows the pH of biogas produced in each treatment.

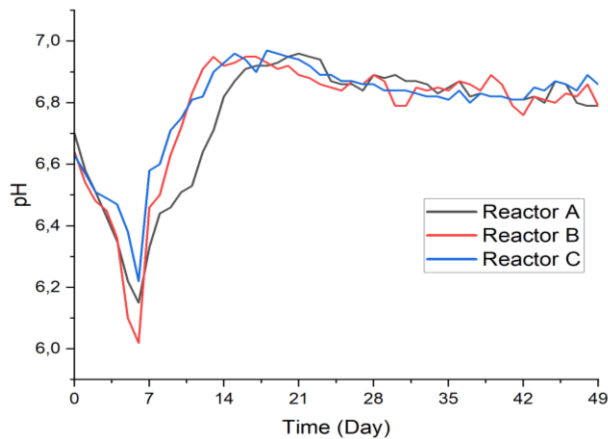


Fig. 4. The pH of the biogas produced in each treatment

3.5. Effect of temperature on biogas production.

The formation of methane gas in biogas production was observed to be influenced by the temperature in the digester, and the formation process typically occurs within a range of 25–40°C [42]. It was also observed that small-scale anaerobic digesters, which are often found in proximity to humans, operate with mesophilic bacteria at temperatures ranging from 25°C to 37°C.

The temperature in the digester exhibited fluctuations, with a minimum of 28°C on the seventh day and a maximum of 29.7°C. In this analysis, the temperature value did not represent the maximum content of the product, as biogas had been produced since the first day of testing. However, fluctuations in digester temperature affected the viability of the bacterial population within the system. Specifically, temperatures that are too low or too high during the bacterial breeding process can impede bacterial survival [43], thereby prolonging the biogas manufacturing process and reducing methane gas production.

3.6. Chemical oxygen demand

As illustrated in Figure 5, COD concentrations exhibited an increase in all reactors on day one. The COD concentration in reactor A was recorded at 589.9 mg / L, while reactors B and C were 525.253 mg/L and 622.22 mg/L, respectively. The observed increase in COD concentration on day one can be attributed to the hydrolysis process. In accordance with the findings of [44], the initial 24-hour period represents the stage of the hydrolysis process wherein polymer compounds, including carbohydrates, proteins, and fats, undergo

hydrolysis to form simple compounds, namely glucose, amino acids, and volatile fatty acids. After day one, the COD tended to decline and fluctuate in all reactors.

This was due to the consumption of the simple compounds resulting from hydrolysis, such as glucose, amino acids, and glycerol, by acidogenic and acetogenic bacteria until a steady state was reached.

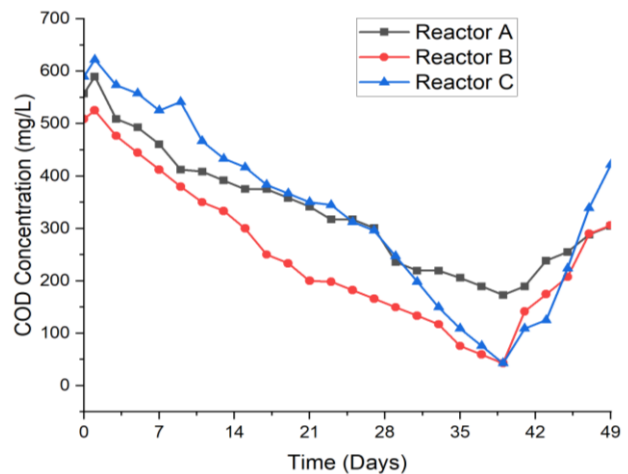


Fig. 5. COD value for each treatment

A decrease in COD indicates a reduction in organic matter in the substrate, which was converted to methane production and total biogas.

A study by [45] indicated that the reduction in COD concentration was due to the conversion of organic compounds into methane gas (CH₄) during the methanogenesis stage. On day 41, the COD concentration increased. This rise results from cell lysis, during which the contents of deceased microbial cells (proteins, carbohydrates, lipids, and other organic substances) are released into the surrounding liquid. These released organic molecules add to the soluble organic matter in the system, which is measured as COD [46]. The COD value indicated that microorganisms used the organic matter content to produce biogas.

3.7. Volatile suspended solids

The VSS value represents the quantity of organic material that can be readily evaporated at 550°C. It is indicative of the number of microorganisms present in the sample. This is because volatile organic compounds, including proteins, carbohydrates, and glucose, are present in bacteria. Consequently, the quantity of these

compounds can be used to estimate the number of bacteria in the sample [47].

In Figure 6 the VSS concentration exhibited an increase in all reactors on day one. This increase ranged from 6040 mg/L to 7060 mg/L for reactor A, from 13060 mg/L to 15240 mg/L for reactor B, and from 15420 mg/L to 15480 mg/L for reactor C. According to a previous study, the initial 0–24 hours represented the hydrolysis process stage, during which polymer compounds, including carbohydrates, proteins, and fats, were hydrolysed into simpler compounds, such as glucose, amino acids, and volatile fatty acids [44]. During the initial seven-day period, a decline in VSS value was observed, indicating that the bacteria were unable to adapt effectively to the prevailing conditions. Figure 4 illustrates a decrease in pH following day 0, which prompted the onset of hydrolysis and acidogenesis stages and resulted in a reduction in pH. Consequently, a decrease in pH led to increased bacterial mortality and a reduction in VSS concentration in the reactor. This was due to the fact that microorganisms adapted and exhibited reduced reproductive capacity in the environment. This was caused by a decrease in bacterial biomass due to low pH, which was caused by volatile acids resulting from acidogenic bacteria metabolism [48].

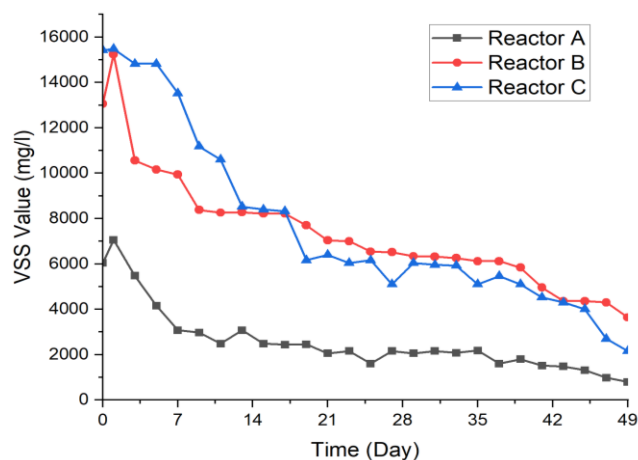


Fig. 6. VSS value for each treatment

As the pH approached neutrality after the seventh day (Figure 4), the majority of methanogenic bacteria exhibited optimal growth in these conditions. Consequently, the number of microorganisms increased once more. The fluctuation in the number of microorganisms was

due to the growth and death of bacteria, influenced by environmental factors, including pH. On the 13th day, the condition in which the VSS concentration tended to be stable indicated that the number of carbon and nutrient sources available was decreasing, thereby enabling bacteria to compete for these nutrients and facilitate their growth. In the absence of nutrients, the death phase manifested, which was characterized by a reduction in microbial solids [49].

3.8. Volatile fatty acid

The anaerobic process resulted in the production of short-chain volatile acids, including acetic, propionic, valeric, and butyric acids. The formation of these volatile acids was quantified through the measurement of VFAs.

As illustrated in Figure 7, the concentration of VFAs in the three reactors exhibited an increase from days 0 to 21. On day 21, the highest concentration of VFA was observed in reactor C, with a value of 321,673.0038 mg/L. In reactors A and B, the highest concentrations were 255,513.3079 mg/L and 278,555.1330 mg/L, respectively. The elevated VFA concentration observed from day 0 to 21 was attributed to the acidic atmosphere within the reactor. At the acidic pH, the highest amounts of butyric and acetic acid were obtained. The number of volatile acids formed in this ratio was indicative of the success of the acidogenesis process. This acidic pH environment promoted acidogenic bacteria to function optimally in order to produce VFA [50]. The VFA levels, especially acetic acid, continued to increase with production, indicating that the acetogenic microbe growth continued to increase with elevated biogas production.

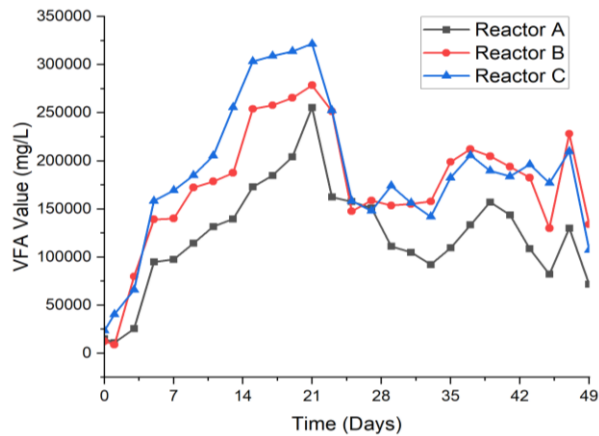


Fig. 7. VFA values in each reactor

A decrease in VFA concentration was observed after 21 days. This was due to the fact that in the three reactors, the acid formation process had begun to decrease, and an intermediate process had commenced, which still produced volatile acids, with a total concentration that was smaller than that observed during the acid formation stage. During this process, methane bacteria formation (methanogenesis) occurred, converting acetic acid, hydrogen, and carbon dioxide into methane gas [51]. The length of fermentation in the digester resulted in a reduction in total VFA from day 21 to day 49. There was an increase in VFA values on days 35 and 48 and another decline after that. This rise and decrease in VFA concentration are most likely due to varied proportions of organics with varying degrees of biodegradability in the substrates. Thus, relatively quickly biodegradable fractions caused an initial increase in VFA concentration, methanogenesis decreased VFA concentration, and relatively slowly biodegradable fractions were eventually converted to VFA [52]. This rise and decrease in VFA concentration are most likely due to varied proportions of organics with varying degrees of biodegradability in the substrates. Thus, relatively quickly biodegradable fractions caused an initial increase in VFA concentration, methanogenesis decreased VFA concentration, and relatively slowly biodegradable fractions were eventually converted to VFA. Volatile acid production declined in conjunction with the reduction in sludge organic components within the digester. This resulted in a corresponding decrease in biogas production until the organic material components were depleted. Ultimately,

the microbes entered a death phase. Additionally, the reduction in acetic acid production was attributed to the increasingly anaerobic conditions within the digester. As the organic material was depleted, acetogenic bacteria utilized hydrogen (H₂) to synthesize acetic acid, thereby competing with the growing methanogenic bacteria that employed H₂ for methane gas production. Meanwhile, the affinity of methanogenic bacteria to H₂ was 10 to 100 times that of acetogenic bacteria. Consequently, the H₂ partial pressure decreased, leading to the cessation of acetogenic bacterial development [53]. Overall, the highest VFA formation occurred in reactor C, with a concentration of 321673.0038 mg/L.

4. Conclusion

Anaerobic treatment with 100% restaurant waste substrate in reactor C yielded the highest values for each parameter. Additionally, the largest volume of biogas produced in this reactor was 109 liters, followed by reactor B with 48 liters, and then reactor A with 45 liters. It is recommended that further research be carried out to investigate the effects of biological additives and their work in sustainable systems.

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Author's contribution

Aryo Sasmita: Conceptualization, Data Collecting, Methodology and Manuscript Writing; Viola Dwivannie: Data Collecting and Manuscript Writing; Ety Pratiwi: Data Collecting and Methodology.

Conflict of interest

No potential conflict of interest was reported by the authors.

Data availability

Not Applicable.

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