








Aerobic and anaerobic biological treatment of extracted chicken manure mixed with cassava dregs for potential use as liquid organic biofertilizer

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Original Research

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Abstract:

Purpose: This study aims to investigate the biological treatment of excreta wastewater to evaluate the effective production of liquid organic biofertilizer (LOB).

Method: This research was carried out by the pre-initial mixing process of excreta with cassava dregs, then biological processing with the aeration rate of 4 L/minutes at environmental temperature (28 °C) and pH of 5 for 42 days with two treatments in triplicates: aerobically (T1), and anaerobically (T2) conditions. LOB was analyzed for physical, chemical, and microbiological parameters.

Results: We showed that the characteristics of waste solids analysis of LOB were significantly decreased ($P < 0.05$) in both aerobic and anaerobic treatment on the initial day of composting compared to the final day (42 days) by measuring the content of total solid (TS), total volatile solid (TVS), total fixed solid (TFS), and settleable solid (SS). Next, we showed the chemical properties of LOB respectively as follows: total N 6.73 mg/L and 7.31 mg/L; total P 36.27 mg/L and 87.17 mg/L; total K 640.85 mg/L and 674.82 mg/L; total C-organic 65.57 mg/L and 22.48 mg/L; and C/N ratio 10.13 and 3.5. The microbiological quality was evaluated at the end of LOB production by measuring total plate count (TPC) of 182000×10^5 cfu/ml and 203667×10^5 cfu/ml; total lactic acid bacteria of 31×10^5 cfu/ml and 32.67×10^5 cfu/ml; and there is no coliform growth observed in LOB, respectively.

Conclusion: Finally, we concluded that the biological treatment is an important process in composting organic wastewater as a key to managing wastewater in the environment as reuse for liquid organic biofertilizer. The processing of excreta wastewater has managed to remove the total solid pollutants.

Keywords: Aeration; Chicken excreta; Fermentation; Liquid waste; Microorganism; Total solid

1. Introduction

Excreta manure is produced from the digestive system along with body fluids that are no longer needed by the chicken's body in the form of a mixture of urine and feces excreted by the chicken through the cloaca which can cause problems for the environment if not managed or reprocessed. Chicken excreta waste contains high nitrogen in the form of ammonia (NH₃) and hydrogen sulfide (H₂S) which can pollute the environment (Bleizgys et al., 2013; Kalus et al.,

2020; Such et al., 2021). Therefore, excreta waste needs to be processed so that it does not negatively impact the livestock environment, humans, and the surrounding environment (Kyakuwaire et al., 2019; Seidavi et al., 2019). The relatively high levels of organic matter and nutrients from chicken manure (Chen et al., 2017) have become a potential source to be processed into other products, such as liquid fertilizer, that have added value.

One of the processing treatments that can be conducted is by

carrying out excreta fermentation which aims to maintain the nutrient content remaining in the excreta that can be stored and used later, and does not pollute the environment. Fermentation can be carried out by utilizing the activity of microorganisms to help the process of decomposing waste organic matter (Mengqi et al., 2021). Utilization of excreta mixed with cassava dregs and processed by fermentation using proteolytic bacteria, *Bacillus* sp. LS2B, to degrade the ammonia has been carried out in previous studies (data not shown) because *Bacillus* has the ability to degrade ammonia (Duan et al., 2020; Niu and Li, 2022). The decomposing of ammonia by microbes into nitrites and nitrates through the nitrification process (Deng et al., 2014; Li et al., 2015; Fitriyanto et al., 2016; Pastawan et al., 2017) will occur in fertilizer processing. The mixing of excreta with organic waste as a carbon source, such as straw and rice husk (Duan et al., 2020; Alarefee et al., 2023), is an alternative to produce a balanced C/N ratio composition (Macias-Corral et al., 2019; Thomas et al., 2020). One of the other carbon sources that can be used for balanced C/N is cassava dregs. The innovation of mixed excreta with cassava dregs has become an option to obtain the appropriate C/N ratio before being further processed. Fermentation results in the decomposition of organic matter from excreta are still not completely perfect, so it is necessary to have further processing into a stable product. The treatment of extracting the mixture of excreta and cassava dregs to a wastewater form is an innovative way for further processing chicken excreta which will become a product of liquid organic biofertilizer (LOB). Organic waste management through waste processing has become one focus in the environment regarding air or soil pollution, especially the organic waste from the poultry industry (Bryant et al., 2022). Air pollution is the biggest problem in many countries in line with the organic waste produced from farms (Kyakuwaire et al., 2019; Such et al., 2021). Recently, biofertilizers have become a common product as the result of organic waste processing in Europe and Asia (Drózdź et al., 2020; Rahman et al., 2022) because biofertilizers production would be used to solve environmental pollution caused by ammonia from poultry waste (Seidavi et al., 2019) and are rich in nutrients for soil (Cruz-Conesa et al., 2022).

Liquid organic fertilizer is derived from the remains of agricultural and industrial organic matter (Ji et al., 2017; Phibunwatthanawong and Riddech, 2019), one of those is excreta which is extracted in liquid form and could increase nutrients. The processing of chicken excreta wastewater into LOB is important because the high nitrogen (N) content in the excreta (Naseem and King, 2020; Cruz-Conesa et al., 2022) will be dissolved in the liquid form as excreta wastewater and it will have a high yield concentration of nitrogen as one of the necessary nutrients available. The principle of making liquid organic fertilizer is to reduce the C/N ratio of organic matter to the same or close to the C/N ratio of soil (<20) (Macias-Corral et al., 2019). The organic matter contained in the excreta cannot be used directly as an organic fertilizer because the C/N ratio of excreta is not suitable or does not yet approach the C/N ratio of soil, where the C/N ratio of fresh excreta is around 9-10 (Macias-

Corral et al., 2019; Chang et al., 2020; Thomas et al., 2020). Liquid organic fertilizer could be made from excreta extraction through biologically further processing which can be decomposed into simpler compounds and can be easily absorbed by plants (Ji et al., 2017).

Liquid organic fertilizer processed from the origin of solid waste is rarely conducted. Most liquid fertilizer products were made from liquid waste such as liquid waste from livestock, agriculture, or fisheries organic waste without any additional things (Ching and Redzwan, 2017; Yuan et al., 2018; Phibunwatthanawong and Riddech, 2019). The raw excreta waste material mixed with cassava dregs powder, which is in the mixture of excreta solid waste being processed from solid waste into liquid organic fertilizer through aerobic and anaerobic conditions, was rarely conducted and has not been done before. Treatment for producing liquid organic fertilizer can be done by aeration process as aerobic and through fermentation process as anaerobic. Therefore, the production of liquid organic fertilizer extracted from the mixed excreta and cassava dregs is carried out to produce LOB products with good quality and to optimize the decomposition process of organic matter in excreta. This study gives insight and information regarding the processing of solid chicken excreta become potentially as a liquid organic biofertilizer by mixing the excreta with cassava dregs in order to reach the good initial C/N ratio of the waste. In this study, we investigated the biological treatment to evaluate the effectiveness production of liquid organic biofertilizer, and to improve the physical, chemical, and microbiological properties of LOB extracted from the chicken excreta.

2. Materials and methods

Chicken excreta processing wastewater preparation

Chicken excreta was collected from the processing of layer farm production in Sidoarjo, East Java, Indonesia, which was purchased from a local farmer. The processing of excreta involves hand-collecting and separating using a shovel. The excreta were collected immediately after being obtained from the laying hens chicken and the pure manure excreta was stored in the barrel for future use. Molasses of 500 mL were used and dissolved in water 1:1 in the processing of excreta wastewater. Strain of *Bacillus cereus* LS2B was mixed into the molasses solution and was cultured for 3 days. Next, 21 kg of excreta, 9 kg of cassava dregs, and 1 L of molasses solution containing *Bacillus cereus* LS2B were mixed and then homogenized. The mixture of excreta, cassava dregs, molasses, and the strain LS2B was fermented for initial fermentation for 21 days. Furthermore, a mixture of 1 kg of excreta and cassava dregs was put into a bucket-barrel of 10 L water capacity. The water was previously heated to a temperature of 90 °C and then poured into a bucket-barrel. The mixture of excreta and cassava dregs was extracted using 10 L of water at 90 °C until the water temperature decreased to room temperature (28 °C). Next, the extraction solution (excreta wastewater) is filtered and then the filtered solids are discarded. The wastewater was then kept in a polyethylene barrel and subsequently stored in the refrigerator for further processing (Fig. 1).

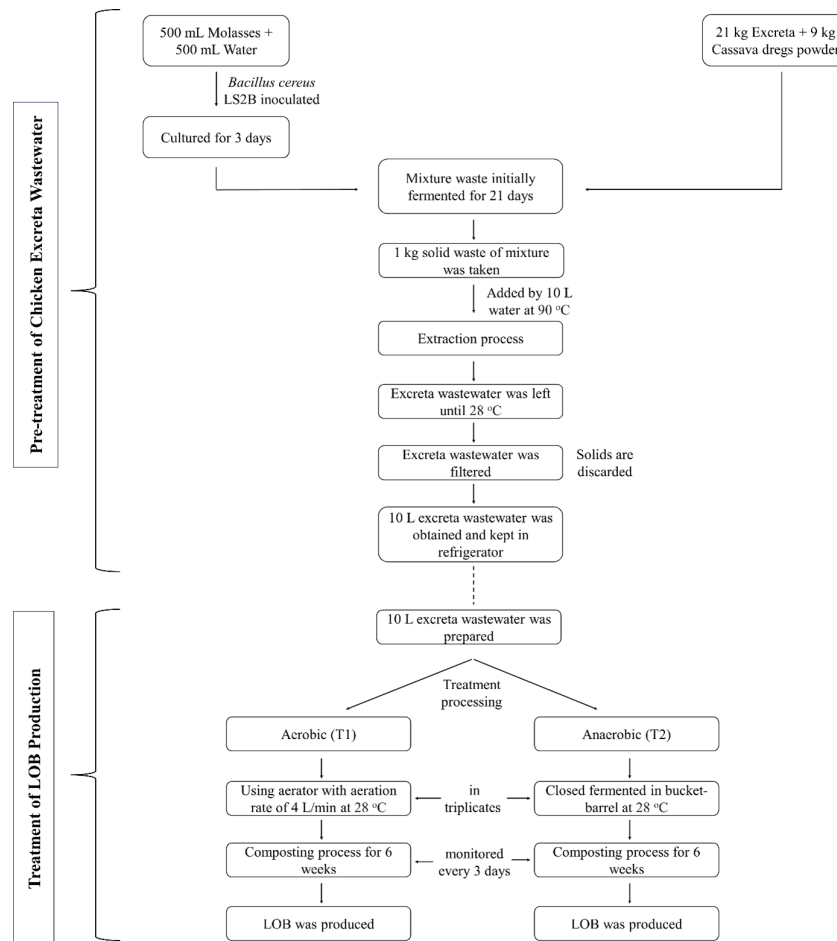


Figure 1. The diagram of flow processing of LOB production.

Liquid organic biofertilizer production

Organic substrates used for the processing of liquid organic fertilizer included excreta wastewater, cassava dregs powder, and molasses. Molasses was obtained from a sugar factory. The mixed raw materials were analyzed for the initial conditions for physical and chemical parameters. The excreta wastewater was degraded using different treatment conditions; T1: aerobically, and T2: anaerobically processing, for 6 weeks of composting in the bucket-barrel of capacity 10 L. Aerobic processing was conducted using an aerator to supply the oxygen as an aeration process with the aeration rate of 4 L/minutes, while anaerobic processing was carried out by fermentation without any oxygen involved in the excreta wastewater processing at ambient temperature (28 °C) and pH of 5. Each experiment was performed in triplicates. The mixture was contained in the bucket-barrel and stored at the processing room (Fig. 1). The mixture of wastewater was monitored every 3 days during the composting process for pH and temperature measurement. Liquid organic fertilizer was sampled on the initial day (0 days) and the final day (42 days) for physical, chemical, and microbiological analysis.

Measurement of the physical parameter

The physical parameters such as pH in liquid organic fertilizer were measured by using a pH meter. The pH value in this research was monitored by pH meter model PH98211. The temperature of wastewater processing was measured

every 3 days. Temperature is the most important factor affecting the microbes in the biological processes and the ambient temperature determines the biological process of wastewater. Throughout the study, the temperature was constant around 25 °C - 28 °C (Fig. 2). Total Solids (TS), Total Volatile Solids (TVS), Total Fixed Solid (TFS), and Suspended Solid (SS) parameters were analyzed according to the procedures outlined in Standard Methods for Wastewater Examinations (Association, 2017).

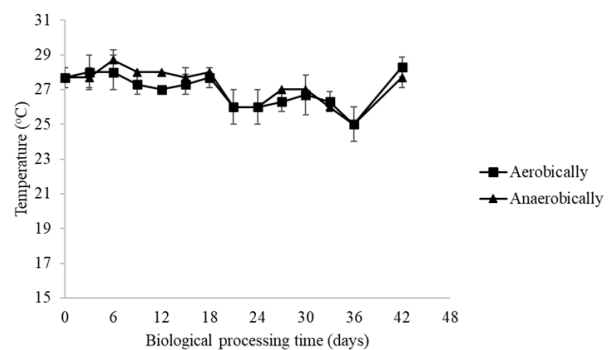


Figure 2. The changes of temperature in the processing of liquid organic biofertilizer from excreta wastewater treatment for 42 days. Error bars indicate the standard deviation of three replicates.

Measurement of chemical and microbiological parameter

The chemical content of total nitrogen (N), phosphorus (P), and potassium (K) of the representative chemical quality of fertilizer was determined using spectrophotometer analysis. Total N was determined by taking a 5 g sample of organic fertilizer and measured using the Kjeldahl method. Total P was analyzed using HNO₃ and HClO₄ by wet digestion spectrophotometer UV-1601 PC Shimadzu at the wavelength of 600 nm. Analysis of total K was performed using a Flame photometer, Atomic Absorption Spectrophotometer (AAS) method. Organic matter and carbon organic (C-organic) were determined using wet oxidation. The microbiological parameters were analyzed by taking the sample of liquid organic biofertilizer to measure the total community of microorganisms through the measurement of total plate count (TPC) colony forming unit per mL (cfu/ml), total lactic acid bacteria, and total coliform. A volume of 1 mL sample was taken in 9 mL of sterile water in a vial and shaken well to make a uniform suspension of bacteria. After that, 0.1 mL of the corresponding diluted solution was inoculated and spread into a sterile petri plate. The petri plate was incubated at 28 °C for 12 h. The number of colonies on the agar media was counted using the colony counter. The total plate count was evaluated by plate count agar (PCA) media, lactic acid bacteria was evaluated on mannrogosa sharpe agar (MRSA) media, and coliform was screened on brilliant green lactose bile (BGLB) agar media.

Statistical analysis

The differences between means of the data were analyzed by using the T-test. The difference between means was considered homogeneity data. The obtained data were expressed as means \pm standard errors.

3. Results and discussion

Excreta processing wastewater characteristics

We observed the initial condition of raw excreta wastewater before it was processed. Wastewater characteristics of original excreta processing wastewater are represented in Table 1. We showed the condition of chicken excreta waste at the beginning of the treatment at 0 days before it was processed through aerobic and anaerobic conditions. The mixture of excreta and cassava dregs showed a high total solid content (12400 mg/L) and high organic matter (77.99%) which means the excreta still contained the pollutant of waste (Seidavi et al., 2019). Based on the data analysis, the mixing of excreta and cassava dregs increased dry matter that could improve the C/N ratio content (Macias-Corral et al., 2019), and could decrease the odor emission from the chicken excreta (Gržinić et al., 2023; Bist et al., 2023). The initial C/N ratio and organic matter content were important (Macias-Corral et al., 2019; Such et al., 2021) to determine the appropriate condition of excreta wastewater before processing (Table 1). In previous studies, chicken excreta wastewater was prepared to dilute the nitrogen content to minimize ammonia production (Shapovalov et al., 2020). It was also processed as a raw material for biogas production and cultivated in anaerobic conditions (Fakkaew

Table 1. Characteristics of the original substrate excreta wastewater at the initial condition (0 day).

| Characteristic | Raw excreta waste | The mixture* |
|---|-------------------|-------------------|
| TS (mg/L) | - | 12400 \pm 983.8 |
| TVS (mg/L) | - | 9567 \pm 883.8 |
| TFS (mg/L) | - | 2833 \pm 185.6 |
| pH | - | 4.60 \pm 0.15 |
| Water content (%) | 59.10 \pm 5.54 | 9.13 \pm 0.01 |
| Dry matter (%) | 40.90 \pm 5.54 | 90.86 \pm 0.01 |
| Ash content (%) | - | 22.01 \pm 5.54 |
| Organic matter (%) | - | 77.99 \pm 5.54 |
| C/N ratio | - | 19.05 \pm 0.57 |
| Extract eter (%) | - | 3.65 \pm 0.28 |
| Crude fiber (%) | - | 24.18 \pm 0.39 |
| Crude protein (%) | - | 14.50 \pm 0.43 |
| Total Plate Count ($\times 10^5$ cfu/ml) | - | 159 \pm 058.01 |

*The mixture of excreta and cassava dregs wastewater

and Polprasert, 2021). In this study, we showed the processing of excreta wastewater that had the potential to be used as liquid organic biofertilizer. Furthermore, the cassava dregs support the availability of carbon sources as the necessary carbon nutrient in the LOB product and maintain the C/N ratio for the fertilizer standard (Macias-Corral et al., 2019).

Biologically liquid organic biofertilizer production

The condition of TS, TVS, TFS, pH, water content, dry matter, organic matter, crude protein, and total plate count microbial in the original substrates of excreta mixed with cassava dregs were measured and the results of initial properties of the original substrates (Table 1) showed an improved content of nutrient which is representing for the liquid organic production. Moreover, in aerobic and anaerobic treatment of excreta wastewater, the pH value increased during the 42-day treatment operation as represented in Fig. 3 indicating that liquid organic biofertilizer was processed. We showed that the increasing pH value of the aerobic was higher than the anaerobic treatment of excreta processing wastewater (Fig. 3). The aerobic treatment resulted in a higher pH than the anaerobic treatment because the protein degradation produced more N-protein (form as NH₄OH) (Huang et al., 2020; Kalus et al., 2020; Such et al., 2021; Bist et al., 2023) and it was assumed due to the water

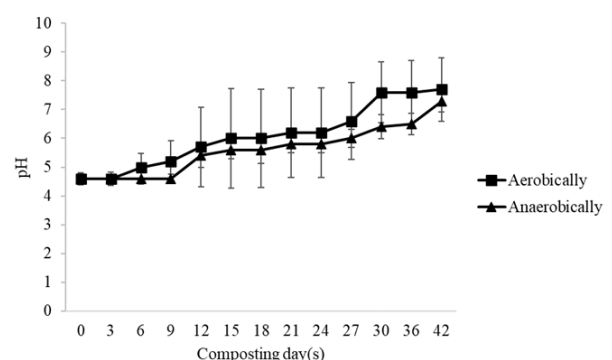


Figure 3. pH value changes during the processing of liquid organic wastewater treatment for 42 days. Error bars indicate the standard deviation of three replicates.

evaporation, which occurred in aerobic process, causing the concentration of mixture wastewater get high density and makes the pH value higher. The highest pH increase was observed at 42 days, changing from acid to alkaline conditions during composting. The pH value of LOB through aerobic and anaerobic treatment processes was increased from the acidic condition of 4.60 ± 0.15 on the initial day (Table 1 and Fig. 3) to the neutral condition on the final day of 7.70 ± 0.06 and 7.30 ± 0.17 , respectively (Table 2). These acidic pH conditions were due to the amount of sugars in the molasses used as substrate which are converted to lactic acid (Czarnecka-Komorowska et al., 2022; Mistry et al., 2023) by the biological activities of bacteria in the processing of excreta wastewater (Ching and Redzwan, 2017; Chang et al., 2020). In this study, the pH of the excreta processing wastewater was increased during the treatment processes (Fig. 3) and the increasing pH value indicated that the wastewater processing had a high biomass of microbial growth. The microorganism population produced the ammonium (NH_4^+) ion in the liquid media wastewater that increased pH value (Li et al., 2015; Macias-Corral et al., 2019; Huang et al., 2020).

Organic biofertilizers had the potential utilization to improve soil fertility, and greenhouse gas mitigation (Sharma et al., 2019) as well as liquid organic biofertilizers (Ji et al., 2017; Phibunwatthanawong and Riddech, 2019), and could be used as biopesticides during growing hydroponic plants (Abbey et al., 2019; Phibunwatthanawong and Riddech, 2019). Liquid organic waste through mobilizing the available nutrients, such as N, P, K, and C, in the biological activities (Chew et al., 2019) could enhance the quality of the product LOB for environmental sustainability (Sharma et al., 2019).

Liquid organic biofertilizer properties

Next, we measured the physical and chemical properties of liquid organic biofertilizer produced from the biological treatment using aerobic and anaerobic conditions of excreta wastewater. The physical analysis of liquid organic biofertilizer showed the total solid, total volatile solid removal, and pH value in the aerobic (T1) process was significantly different ($P < 0.05$) compared to the anaerobic (T2) treatment (Table 2). While, the total fixed solid and settleable

solid, was not significantly different.

Table 2 indicates the organic waste contained in the excreta wastewater has already decomposed which can be seen in the decreasing of total solid in both aerobic (T1) and anaerobic (T2) treatment compared to the initial substrate condition (Table 1). It described that the excreta wastewater has been processed to become liquid organic biofertilizer (Ching and Redzwan, 2017). The percentage of total solid (TS) in liquid organic biofertilizer was significantly decreased ($P < 0.05$) on day 42 compared to day 0 (Fig. 4a) during processing in both aerobic (66.94%) and anaerobic (42.50%) treatment. Fig. 4b showed that the percentage of total volatile solid (TVS) also significantly decreased ($P < 0.05$) after 42 days of processing of liquid organic biofertilizer. The study reported by Koupaie et al. (2019) revealed that solids content from organic wastewater was used for methane production. The solids content decreased because of the activity of microorganisms in the anaerobic treatment that obtained the lower concentration of dissolved organic matter. However, the aerobic treatment decreases the solid waste content significantly (Ching and Redzwan, 2017; Yuan et al., 2018) in the LOB processing excreta wastewater.

The biological treatment of excreta wastewater in this study has a substantial impact on reducing solids content, especially volatile solids, which represent organic matter. This

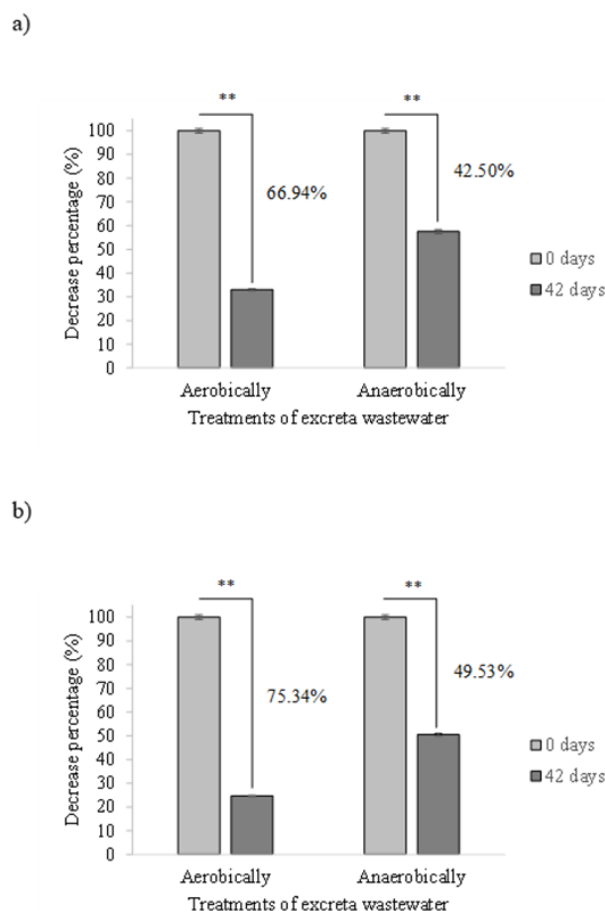


Figure 4. The decreasing percentages of: a). total solid (TS); and b). total volatile solid (TVS), in the LOB after processing for 42 days. Error bars indicate the standard deviation of three replicates. ** $P < 0.05$.

Table 2. Physicochemical analysis of liquid organic biofertilizer from excreta wastewater processing at the final day processing (42 days).

| Parameters (mg/L) | Liquid organic biofertilizer processing condition | |
|-------------------|---|----------------------|
| | Aerobically (T1) | Anaerobically (T2) |
| TS | 4095 ± 662.5^a | 7133 ± 883.8^b |
| TVS | 2362 ± 256.1^a | 4833 ± 635.9^b |
| TFS | 1733 ± 409.6^a | 2300 ± 321.5^a |
| SS | 1833 ± 144^a | 1867 ± 170^a |
| pH | 7.70 ± 0.06^a | 7.30 ± 0.17^b |
| Total N | 6.73 ± 1.79^a | 7.31 ± 1.65^a |
| Total P | 36.27 ± 12.88^a | 87.17 ± 51.56^a |
| Total K | 640.85 ± 30.54^a | 674.82 ± 21.51^a |
| C-organic | 65.57 ± 4.26^a | 22.48 ± 6.73^b |
| C/N ratio | 10.13 ± 1.78^a | 3.50 ± 1.96^b |

^{ab} Means in the same row without common letter are different at $P < 0.05$.

clearly indicates that the organic pollutants in the wastewater can be effectively removed by more than 40% through aerobic and anaerobic treatments within 42 days (Fig. 4). The results of the chemical composition of liquid organic fertilizer after periods of composting are presented in Table 2. After 42 days of processing, liquid organic fertilizer with the anaerobic treatment condition had the highest content of total N (7.31 ± 1.65 mg/L), total P (87.17 ± 51.56 mg/L), and total K (674.82 ± 21.51 mg/L), while the aerobic processing condition showed the highest C-organic (65.57 ± 4.26 mg/L), and the appropriate C/N ratio (10.13) similar to soil (Macias-Corral et al., 2019). Although the total N, P, K of liquid organic biofertilizer in the aerobic (T1) treatment is not significantly different compared to anaerobic (T2). The content of C-organic and C/N ratio showed a significant difference ($P < 0.05$) between the treatments, which indicates that aerobic processing generates more nutrients provided in LOB (Phibunwatthanawong and Riddech, 2019; Cruz-Conesa et al., 2022).

The aerobic treatment assumed that the oxidizing process decomposed organic matter perfectly by microorganisms compared to anaerobic because the aeration process provided enough oxygen for the growth of aerobic bacteria to optimally obtain the higher C-organic content which resulted in appropriate C/N ratio for soil needs and also provided the nutrients available in LOB (N, P, K, and C) (Ching and Redzwan, 2017; Yuan et al., 2018; Phibunwatthanawong and Riddech, 2019). Total N content increased with the time of composting due to the activity of nitrogen-fixing microorganisms (Pastawan et al., 2017; Huang et al., 2020; Bist et al., 2023) that decomposed the organic protein contained in excreta wastewater. The microorganism decomposes organic nitrogen materials in the decomposing process and increases the pH due to the loss of evaporation of ammonia (Huang et al., 2020). Table 2 showed that the total P and K were higher in the anaerobic (T2) treatment, this indicated due to the large population of phosphate-dissolving microorganisms which had an important role in mineralizing P (Phibunwatthanawong and Riddech, 2019). The total K content was the highest chemical nutrient content in the LOB either in aerobic (T1) or anaerobic (T2) treatment. The organic carbon content decreased in the anaerobic treatment due to during the fermentation process, microorganisms used organic carbon as a source of energy and nutrients (Chang et al., 2020; Alarefee et al., 2023). The physico-chemical analysis of solids content after 42 days of processing showed a decrease in TS, TVS, and TFS on each treatment compared to the initial day (0 days) of excreta wastewater processing. TS and TVS were significantly different ($P < 0.05$) between the treatments (Table 2), however the TFS and Suspended solid (SS) were not significantly different. The SS has indicated that the amount of sludge obtained during liquid fertilizer processing had less production in aerobic and anaerobic treatments (Table 2), and the sludge represented the organic matter that degraded and settled (Aziz et al., 2019). Measuring the C/N ratio in liquid organic biofertilizer found that the C/N ratio at 42 days of the composting process was lower than 20 both in aerobic and anaerobic treatments. When the C/N ratio of fertilizer

was lower than 20, the substrate was easily decomposed and initially immobilized by microbes (Macias-Corral et al., 2019). The anaerobic treatment indicated that the use of carbon organic matter is more necessary than aerobic treatment, resulting in a low C/N ratio for the final product as liquid organic biofertilizer.

Microbial community in liquid organic biofertilizer

Finally, we measured the microbial community in the liquid organic biofertilizer from excreta wastewater processing. The total microbial community in the liquid organic biofertilizer is represented in Fig. 5. In common conditions, microorganisms in organic wastewater are mostly active through biological treatment in pH values from 6.5 to 7.5 for optimal growth activity to degrade the organic matter (Ching and Redzwan, 2017; Huang et al., 2020; Bist et al., 2023). In addition, the C/N ratio is an important requirement for the growth condition of microorganisms. The mixed excreta with cassava dregs is one of an effort to make an appropriate C/N ratio for microorganism activity. Microorganisms use carbon as an energy source and nitrogen as a basic nutrient for growing to degrade organic matter (Duan et al., 2020; Huang et al., 2020; Niu and Li, 2022). Fig. 5 shows the total plate count of bacteria increased on the final day of LOB processing (42 days) in the aerobic and anaerobic treatments ($182000 \pm 28178 \times 10^5$ cfu/ml and $203667 \pm 24513 \times 10^5$ cfu/ml, respectively). The aerobic (T1) treatment of LOB production is not significantly different compared to the anaerobic (T2) treatment. Pollutant organic matter in the excreta processing wastewater was degraded by microorganisms under aerobic (T1) treatment conditions with the supplement of sufficient oxygen using an aerator. The microorganisms were grown by utilizing the organic material as their feed to reproduce and could increase their population as probiotics and also remove the pathogenic bacteria (Souza Vandenberghe et al., 2017; Duan et al., 2020; Huang et al., 2020). We observed the growth activity of lactic acid bacteria in the LOB product which indicated the existence of probiotics for use in the plant (Ji et al., 2017; Chang et al., 2020; Alarefee et al., 2023). Lactic acid bacteria were observed in each treatment (T1 and T2) of $31 \pm 0.82 \times 10^5$ cfu/ml and $32.67 \pm 2.05 \times 10^5$ cfu/ml, respectively. The activity of microorganisms contained in

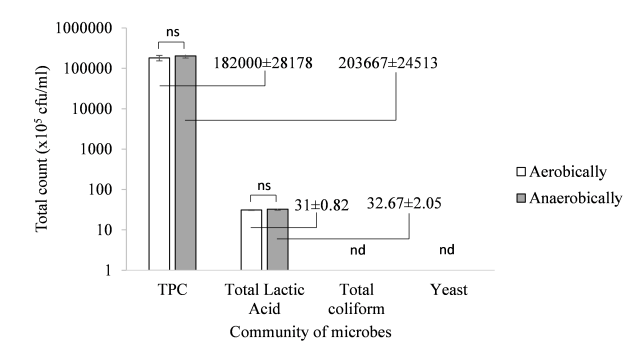


Figure 5. The community of microbes in the LOB after processing for 42 days. Error bars indicate the standard deviation of three replicates. #nd: not detected. *ns* Non-significant difference.

the LOB could enrich the quality as biofertilizers for sustainable agriculture (Abbey et al., 2019; Hernández-Fernández et al., 2021; Seenivasagan and Babalola, 2021).

Cassava dregs and molasses as a carbon and sugar source were used as raw materials for the processing of liquid organic biofertilizer. These substrates were degraded by microorganisms with natural activity in producing enzymes (Macias-Corral et al., 2019; Mengqi et al., 2021). The process of producing organic fertilizer was directly related to the microbial decomposition of the substrate in organic matter. The results of the microbial community showed that plant growth-promoting bacteria, such as nitrogen fixer bacteria (Deng et al., 2014; Fitriyanto et al., 2016; Pastawan et al., 2017), were involved in the LOB production from excreta wastewater processing which was represented by the increasing number of TPC both in aerobic and anaerobic treatment. Microorganisms in liquid organic fertilizer could increase organic N and nutrient content for plant growth. The beneficial existence of microbes in the liquid organic biofertilizer could improve product quality (Macias-Corral et al., 2019; Niu and Li, 2022). The LOB product was measured for total coliform, and the results showed that there was no contamination of pathogenic bacteria represented by total coliform which was not detected (Fig. 5). That indicated that the product LOB has perfectly processed from liquid waste became an organic valuable product, although the yeast population was not detected too (Fig. 5).

4. Conclusion

Based on the results, we concluded that the biological treatment is an important process in composting organic wastewater as a key to managing wastewater in the environment which improves the physical and chemical quality. Aerobic conditions in processing of excreta wastewater have managed to remove the pollutant as total solid significantly (decreased by more than 50%) during 42 days of treatment. The mixture of solid waste of chicken excreta and cassava dregs obtained a good initial C/N ratio that can be used for optimizing wastewater processing. The treatment processing in both aerobic and anaerobic chicken excreta wastewater could become an alternative biological waste management and potentially reuse the processing product as liquid organic biofertilizer for improving soil and plants. Aerobic and anaerobic treatments of LOB production prepared from excreta wastewater have omitted the pathogenic bacteria which indicates the safety for environmentally friendly. The results of chemical measurements of nutrients are recommended for soil fertility because the LOB product can be utilized as it contains significantly higher yields of nutrients. Therefore, biological treatment can be one way of sustainably reducing organic waste. Moreover, our products are environmentally friendly and can be effectively recycled waste products, while having a rich nutrient source for further use.

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Author contributions

The authors confirm the study conception and design: V. Pastawan, M.D. Shiddiq, Z. Ahsan; data collection: V. Pastawan, M.D. Shiddiq, Z. Ahsan; analysis and interpretation of results: V. Pastawan, M.D. Shiddiq, Z. Ahsan, D.H.V. Paradhista, M.Z. Abidin; draft manuscript preparation: V. Pastawan, M.K. Zaki, N.A. Fitriyanto. The results were evaluated by all authors, and the final version of the manuscript was approved.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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