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FERMENTATION OF CHICKEN SLAUGHTERHOUSE WASTEWATER (CSWW) WITH WHITE SUGAR AS A CARBON SOURCE FOR MANUFACTURING OF LIQUID FERTILIZER

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Abstract
Along with the increase in the production of broilers, the amount of liquid waste produced will increase. Liquid waste resulting from chicken slaughterhouse activities will cause odor pollution and aquatic pollution. Chicken slaughterhouse wastewater (CSWW) is suitable for use as a raw material for Liquid Organic Fertilizer (LOF) production, based on nutrient analysis results of waste samples collected from a facility in South Jakarta. According to the results of the analysis, the Biochemical Oxygen Demand (BOD) was measured at 214.52 mg/L, and the Chemical Oxygen Demand (COD) was significantly higher at 2310 mg/L. Furthermore, the samples contained 37.39 mg/L of oil and fat, and an ammonia (NH_3) concentration of 37.39 mg/L. The presence of high concentrations of organic substances, such as protein, oil, and fat, confirms the potential of CSWW as a valuable raw material to produce LOF. To facilitate this study, bioconversion, the fermentation method was employed. In this study, four formulations of (LOF) were prepared using varied concentrations of a carbon source (sucrose) and Effective Microorganisms 4 (EM4) solution bacterial inoculum. The efficacy of these formulations was subsequently evaluated via a bioassay on land kangkong (Ipomoea reptans Poir). The results revealed that the greatest positive effect on plant growth was achieved by the LOF variation, which incorporated 150 g of sucrose and 0.05 L of EM_4 solution. Samples of plants that were given the addition of LOF showed the highest number of leaves, as many as 24 strands and the highest plant height value of 18 cm.

Keywords:
Liquid waste, chicken slaughterhouse, fermentation, organic fertilizer

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1. Introduction

Waste, as an unavoidable by-product of human and natural activities, requires proper management and processing, ideally through conversion into economically valuable raw materials. Waste streams are generally categorized into solid, liquid, and gaseous forms. Among these forms, wastewater generated by one chicken slaughterhouse poses a significant environmental challenge, especially for facilities located in residential areas. The discharge of this organic-rich waste highly contributes to water and air pollution, leading to a decline in overall environmental sanitation and water quality [1]. Therefore, developing effective strategies to enhance the value of this specific organic wastewater stream is crucial for mitigating its environmental impact.

In 2022, the demand for broiler chicken meat in Indonesia was recorded at 3.11 billion [2]. Due to this high consumption of broiler chickens, chicken slaughtering production activities and the resulting CSWW will inevitably increase. Generally, waste has the potential to cause negative impacts on the environment and human health in surrounding settlements. However, CSWW can be enhanced in value by processing it into organic fertilizer [1]. The large-scale development of organic fertilizer has already been carried out. Various types of organic sources can be used as raw materials, such as livestock solid waste, agricultural waste, and organic industrial waste [3]. Fertilizer derived from organic materials is one that can play a role in enhancing the soil's biological, chemical, and physical activities, which are crucial for soil and plant fertility [4].

While organic fertilizer can be derived from liquid and solid livestock waste, the focus of this research is on the liquid waste generated by chicken slaughterhouses. The liquid waste (effluent) from slaughterhouse production contains 0.5–9% macro and micro nutrients, 11–15.2% organic carbon (C-organic), and 0.15–13.6% amino acids [5]. Liquid waste, which constitutes 80% of the total waste content, exists as a poorly digested substrate. This presents a significant potential for its use as a raw material for organic fertilizer [5].

With the aim of increasing the value of this CSWW, this research focuses on the production process of Liquid Organic Fertilizer (LOF). This process utilizes supporting materials such as water (as a solvent), EM4 bacteria solution, and sucrose. EM4 solution contains several bacteria (such as *Lactobacillus* sp, photosynthetic bacteria, *Streptomyces* sp). The sucrose acts as the carbon source for the EM4 bacteria solution during the fermentation process that converts the waste into LOF [6]. This fermentation proceeds through four distinct stages: hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Furthermore, the resulting LOF product is tested directly using land kangkong plant samples with varying fertilizer concentrations.

2. Experimental Section

A. Materials

The Chicken Slaughterhouse Wastewater (CSWW) was obtained from a chicken slaughterhouse located in Cipulir, Kebayoran Lama, Jakarta Selatan, DKI Jakarta. The Effective Microorganisms 4 (EM4) bacterial solution, which contains *Lactobacillus* sp, photosynthetic bacteria, and *Streptomyces* sp, was purchased commercially, while the sucrose source was derived from local crystalline sugar. The detailed ratio of EM4 to sucrose can be seen in Table 1. The liquid organic fertilizer (LOF) testing was practiced on land kangkong sourced from the East West Seed Company, using various LOF concentrations as clearly presented in Table 3.

B. Pre-treatment of CSWW

The CSWW sample was subjected to sampling and testing at the Chemical Engineering Laboratory, Faculty of Industrial Technology Universitas Pertamina and the Environmental Laboratory DKI Jakarta. The sampling was carried out to analyze the content of the acquired sample before it was processed into LOF.

C. Fabrication of LOF

The sampled CSWW was subsequently poured into a fermented vessel. It was then mixed with clean water, the EM4 bacterial solution, and sucrose, according to the ratio variations presented in Table 1. Stirring was carried out for 2 minutes, and the fermenter vessel was sealed. The fermentation process lasted for 14 days. The resulting LOF was then subjected to sample testing at the Chemical Engineering Laboratory of Universitas Pertamina.

Table 1. Variations of LOF samples.

Sampel No.	Waste (L)	Em4 (L)	Water (L)	Carbon Source (Kg)
1	2	45	0.2	0.15
2	2	45	0.2	0.2
3	2	45	0.2	0.25
4	2	45	0.2	0.25

D. Parameter

Observations were conducted during the 14-day fermentation process and immediately after the LOF sample was produced. The observation variables included color, odor, pH, the presence of gas in the sample, and the total sample volume percentage (yield) at the beginning of fermentation and after 14 days of fermentation. The yield volume can be calculated using Equation 1, where Vi and Vf denote the initial and final volumes, respectively.

$$Yield = \frac{V_i V_f}{V_i} \times 100\% \tag{1}$$

E. Plant Testing

The plant experiment was conducted using land kangkong seeds as the research object. The seeds were planted in polybags$(15 \times 15)\ cm$ using burnt rice husks, obtained from a local ornamental plant store, as the planting medium. Five treatments were performed: four plant samples were given the LOF with an equal addition of $30\ ml$ for each sample, and one sample was used as a comparator (control) without the addition of the LOF.

Three land kangkong seeds were used for each experimental plant. The development of the land kangkong lasted for 21 to 30 days, with watering done once a day [7]. The application of the LOF sample to the treated plants was done once every 3 days during the planting process. Specifically, the LOF was applied on days 7, 14, and 21. The parameters observed during the planting process were plant height and number of leaves.

3. Result and Discussion

A. Characteristic of CSWW

Prior to the production of the LOF, the CSWW sample was first tested for its nutrient content. This was aimed at determining the potential and composition of the CSWW sample originating from the chicken slaughterhouse. $30\ Liter$ sample of the CSWW was collected and analyzed at an environmental. The detailed results of the CSWW sample content analysis can be seen in Table 2.

The results of the CSWW sample testing showed that several parameters exceeded the quality standards issued by the Environmental Ministry of the Special Capital Region of Jakarta Province [8]. Nearly all parameters were found to be above the standard quality, except for the oil and fat test. Thus, it can be concluded that the CSWW discharged by the chicken slaughterhouse poses a potentially dangerous risk to living organisms in the environment surrounding the slaughterhouse [1].

Specifically, the value of Biochemical Oxygen Demand (BOD) is a measure of the amount of oxygen consumed by the microbial population present in a water sample in response to the introduction of biodegradable organic matter. The high BOD value of $215.52\ mg/L$ indicates the high potential of organic matter in processing the organic substances contained within the sample [9]. Chemical Oxygen Demand (COD) represents the total organic material, both difficult and easy to decompose. The COD value of $2310\ mg/L$ obtained from the CSWW sample analysis in this study is significantly higher than the standard BOD value. This difference arises because the COD value includes a larger number of organic substances in the sample that can be chemically oxidized but are not susceptible to biological oxidation (non-biodegradable) [10].

Similarly, the high amount of ammonia can serve as an energy source for the bacterial nitrification process during fermentation, and this ammonia can also enhance the fertility of a planting medium within an ecosystem [10]. Therefore, with this CSWW testing, it can be stated that through processing, the value of CSWW can be enhanced by converting it into LOF, which is more beneficial for other living organisms.

Table 2. Analysis of fluid waste sample content of chicken slaughterhouse.

No.	Parameter	Unit	Test Results	Waste Quality Standard
1	BOD	mg/L	214.52	100
2	COD	mg/L	2310	200
3	TSS	mg/L	530	100
4	Oil And Fat	mg/L	0.82	15
5	Ammonia	mg/L	37.39	25
6	pH	mg/L	7.9	6 – 9

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B. Fermentation effect on LOF

The production of LOF was carried out using several materials that have been mentioned. Additional ingredients such as the EM4 bacterial solution and sucrose are substances that can accelerate the LOF production process and improve the quality. This is justifiable because the EM4 solution contains 90% Lactobacillus sp. (lactic acid-producing bacteria), photosynthetic bacteria, and Streptomyces sp. Which function to optimize the utilization of organic substances contained in the CSWW [5]. Therefore, the components in EM4 can directly digest sucrose, cellulose, starch, sugars, protein, and fats in the CSWW [11]. This anaerobic fermentation process comprises four stages, which include [5]:

1. Hydrolysis

   Hydrolysis is the initial stage of the digester process, where organic matter is converted into simpler forms, making it easier for microorganisms to decompose. This digester process is often referred to as depolymerization, breaking down the macromolecules contained within the CSWW sample. More specifically, the hydrolysis reaction of the glucose macromolecule can be seen in Equation 2. This equation involves water (H_2O) and EM4 bacteria, which are capable of breaking down sucrose into glucose and hydrogen (H_2).

$$CSWW + H_2O \xrightarrow[Bacteria]{Facultative} C_6H_{12}O_6 + 2H_2 \quad (2)$$

2. Acidogenesis

   Acidogenesis is the stage where glucose, fatty acids, and amino acids resulting from the hydrolysis process are converted into organic acids such as acetic acid (CH_3COOH), propanoic acid (CH_3CH_2COOH), butyric acid ($CH_3CH_2CH_2COOH$), and alcohol. The process of converting glucose into alcohol, propanoic acid, and acetic acid, which is carried out by Lactobacillus bacteria or bacteria with acidogenic content, corresponds to Equations 3 to 5.

$$C_6H_{12}O_6 \leftrightarrow 2CH_3CH_2OH + CO_2 \quad (3)$$

$$C_6H_{12}O_6 + 2H_2 \leftrightarrow 2CH_3CH_2COOH + CH_3(CH_2)_2COOH + 2H_2O \quad (4)$$

$$C_6H_{12}O_6 \rightarrow 3CH_3COOH \quad (5)$$

3. Acetogenesis

   Acetogenesis is the process that converts organic acids and alcohol into acetic acid (CH_3COOH). In the acetogenesis stage, the residual products from acidogenesis, such as propanoic acid, butyric acid, and alcohol, are converted by acetogenic bacteria (Lactobacillus) into hydrogen, carbon dioxide, and acetic acid. The corresponding fermentation reactions can be seen in Equations 6 and 7.

$$CH_3CH_2COOH + 2H_2O \rightarrow CH_3COOH + CO_2 + 3H_2 \quad (6)$$

$$CH_3(CH_2)_2COOH2 \rightarrow CH_3COOH + 2H_2 \quad (7)$$

4. Methanogenesis

   During the methanogenesis process, methanogenic microorganisms convert the hydrogen and acetic acid formed in the preceding process into methane gas (CH_4) and carbon dioxide (CO_2) via fermentation reactions. The detailed reactions can be seen in Equations 8–9.

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O \quad (8)$$

$$CH_3COOH \rightarrow CH_4 + CO_2 \quad (9)$$

Based on the graph obtained, as shown in Figure 1, the pH value started to decrease on the first day. This indicates that the CSWW underwent a fermentation process which had entered the first stage, is the Hydrolysis stage [12]. Hydrolysis is a decomposition process carried out by facultative bacteria, converting organic matter into fatty acids and amino acids. This is followed by the Acidogenesis stage, where the glucose, amino acids, and fats present in the LOF sample are converted by hydrolase bacteria into organic acids [5]. This entire process takes place under anaerobic conditions (without oxygen), which initially causes the pH value to rise, before the sample LOF's pH subsequently begins to decrease as it becomes more acidic due to the formed acids [13].

The second stage is Acetogenesis. In this phase, the sugar components produced from the preceding fermentation stage undergo acidification and become a food source for the microbial bacteria present in the LOF sample. Subsequently, the organic acid compounds and ethanol formed earlier are broken down by Acetogenic Bacteria into acetic acid, as well as CO_2 and H_2 [13]. This breakdown process is what further caused the average pH value of the sample to decrease until the third day. Overall, the fermentation process leads to an increase in microbial activity, a decrease in the pH value, and an increase in the acid content of the fermented product.

From the third to the fourteenth day, it can be observed that the pH value began to stabilize, maintaining a consistent range of 3 to 4 (Figure 1). This indicates that the LOF sample is entering the final stage of the fermentation process in LOF production, which is Methanogenesis. Methanogenesis is the fermentation process that produces methane gas [13]. The presence of methane gas is attributed either to the process of converting acetic acid into carbon dioxide or to the reduction of carbon dioxide by hydrogen [13].

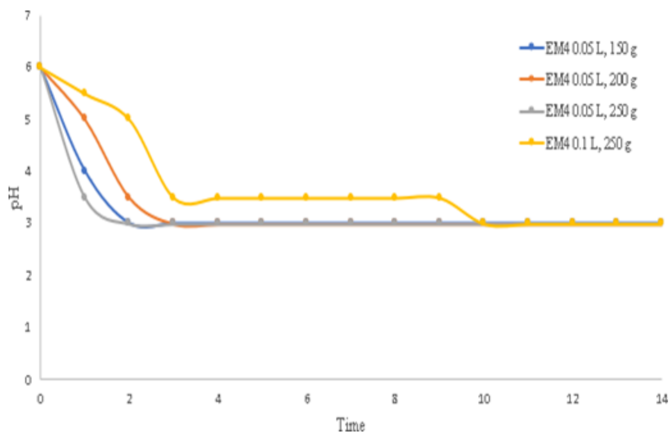

Figure 1. pH observation data for liquid organic fertilizer samples.

C. Plant Response

Table 3. Effect of LOF from CSWW on land kangkong plant growth.

Treatment	Crop Height (cm)			Leaf Number		
	7 days	14 days	21 days	7 days	14 days	21 days
Added Fertilizer	8.5	13.1	18	12	19	24
Without Fertilizer	5.8	9.7	11	8	13	16

Table 3 shows the effect of the LOF application on land kangkong plants. It can be concluded that the addition of the LOF had a positive influence on the growth of the land kangkong samples. This positive effect is due to the additional nutrients contained within the LOF sample. This also confirms that the LOF sample contains essential nutrients such as N, P, and K. The N, P, and K elements are highly required by plants for physiological and metabolic processes, thus increasing the height of the sample plants [14], [15]. Consequently, the number of leaves formed is correlated with the plant height; the taller the plant, the greater the number of leaves formed [19].

Table 4. Data volume of LOF

Sampel Number	Initial volume (L)	Final volume (L)
1	2.25	2.065
2	2.25	2.045
3	2.25	2.040
4	2.30	2.190

Table 5. Yield value of LOF

Sampel Number	Yield (%)
1	8.222
2	9.111
3	9.333
4	4.782

Using the data obtained from Table 4 and the yield equation, the resulting yields are shown in Table 5. It is observed that the quantity of the LOF sample produced in this study decreased. The Optimal Condition showed the highest yield of 9.333% in Sample 3, which indicates that the fermentation conditions, specifically the CSWW to EM4 ratio, were optimal. In contrast, Sample 4 indicated a suboptimal yield value of 4.782%, which could be caused by several factors, including an incomplete fermentation process and an unfavorable ratio that did not mutually support each other [14].

4. Conclusion

There are four stages of fermentation that occur in the process of producing liquid organic fertilizer (LOF) from chicken slaughterhouse waste CSWW: Hydrolysis, Acidogenesis, Acetogenesis, and Methanogenesis. The plant samples treated with an addition $30\ ml$ of the LOF showed a positive effect on the growth of the land kangkong samples. Based on the growth observation data obtained in this study, the plant samples treated with the LOF sample performed better than the blank (control) sample. Specifically, the optimal plant height reached $24\ cm$ with a leaf count of 24 leaves by the twenty-first day of planting. Therefore, it can be assumed that the LOF sample produced in this study already contains the expected nutrient content.

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References

[1]. M. A. Yaakob, R. M. S. Radin Mohamed, A. Algheethi, and A. H. mohd kassim, “Characteristics of Chicken Slaughterhouse Wastewater,” Chem. Eng. Trans., vol. 63, Jul. 2018, doi: 10.3303/CET1863107.

[2]. Sumiati, R. Fadilah, A. Darmawan, and R. Nadia, “— Invited Review — Challenges and constraints to the sustainability of poultry farming in Indonesia,” Anim Biosci, vol. 38, no. 4, pp. 802–817, Apr. 2025, doi: 10.5713/ab.24.0678.

[3]. S. R. Shanmugam, R. Schorer, W. Arthur, E. Drabold, M. Rudar, and B. Higgins, “Upcycling nutrients from poultry slaughterhouse wastewater through cultivation of the nutritional yeast, Yarrowia lipolytica,” J. Environ. Chem. Eng., vol. 13, no. 1, p. 115245, 2025, doi: https://doi.org/10.1016/j.jece.2024.115245.

[4]. M. Boru, “Review of Organic Fertilizer and Its Role in Organic Farming,” Int. J. Energy Environ. Sci., vol. 10, pp. 31–37, Apr. 2025, doi: 10.11648/j.ijees.20251002.11.

[5]. Y. Sastro, B. Bakrie, and N. Sudolar, “The effect of fermentation method, microbes inoculation and carbon source proportion on the quality of organic fertilizer made from liquid wastes of chicken slaughterhouse,” J. Indones. Trop. Anim. Agric., vol. 38, Dec. 2013, doi: 10.14710/jitaa.38.4.257-263.

[6]. N. E. A. Nasution and C. R. Rizka, “Production of Liquid Compost with EM4 Bio Activator Volume Variation from Vegetable and Fruit Waste,” META J. Sci. Technol. Educ., vol. 1, no. 1 SE-Articles, pp. 87–99, Jun. 2022, [Online]. Available: https://meta.amiin.or.id/index.php/meta/article/view/7

[7]. C. Anselmo, “Phytoremediation Potential of Kangkong (Ipomoea Reptans Poir) in Lead-Induced Hydroponic System,” Int. J. Res. Sci. Innov., vol. Volume 11, pp. 909–921, Jul. 2024, doi: 10.51244/IJRSI.2024.1107072.

[8]. M. Aprilia, H. Effendi, and S. Hariyadi, “Water quality status based on Pollution Index and Water Quality Index of Ciliwung River, DKI Jakarta Province,” IOP Conf. Ser. Earth Environ. Sci., vol. 1109, p. 12051, Nov. 2022, doi: 10.1088/1755-1315/1109/1/012051.

[9]. Sugito, K. Diah, Binawati, and M. Al Kholif, “The effect of BOD concentrate influet to remove pollutant load in waste water of a chicken slaughterhouse,” ARPN J. Eng. Appl. Sci., vol. 11, pp. 3519–3524, Mar. 2016.

[10]. T. Karchiyappan, P. Ettiyagounder, P. S. Selvaraj, D. Veeraswamy, J. Ponnusamy, and K. Ramanujam, “A review on sustainable poultry slaughterhouse wastewater management based on electrochemical technology,” Desalin. Water Treat., vol. 322, p. 101212, 2025, doi: https://doi.org/10.1016/j.dwt.2025.101212.

[11]. T. M. Patria and W. Suwito, “Sustainability Engineering on Chicken Slaughterhouse Waste as a Source of Liquid Biofertilizers Supporting Eco-Farming,” IOP Conf. Ser. Earth Environ. Sci., vol. 1246, p. 12003, Sep. 2023, doi: 10.1088/1755-1315/1246/1/012003.

[12]. S. Chainetr, R. Khiewwijit, N. Maneetien, and S. Chaiwongsar, “Chicken Slaughterhouse Wastewater Characteristics, Current Treatment and Future Challenges: A review,” RMUTL Eng. J., vol. 5, no. 1 SE-Review Article, pp. 41–55, Jun. 2020, doi: 10.14456/rmutlengj.2020.6.

[13]. H. ali, J. Faraj, and F. Hussien, “Effect of pH on biogas production during anaerobic digestion,” J. Univ. Shanghai Sci. Technol., vol. 23, pp. 224–231, Aug. 2021, doi: 10.51201/JUSST/21/08369.

[14]. A. Ranasinghe, R. Jayasekera, S. Kannangara, and R. M. C. S. Ratnayake, “Effect of Nutrient Enriched Organic Liquid Fertilizers on Growth of Albemonchus esculentus,” pp. 96–106, Sep. 2019.

[15]. S. Kataki, S. Hazarika, and D. Baruah, “Assessment of by-products of bioenergy systems (anaerobic digestion and gasification) as potential crop nutrient (SCI IF 2020: 7.15, NAAS IF:13.15),” Waste Manag., vol. 59, Oct. 2016, doi: 10.1016/j.wasman.2016.10.018.

[16]. H. Setiadi *et al.*, “An Extreme Learning Machine Based Adaptive VISMA for Stability Enhancement of Renewable Rich Power Systems,” Electronics, vol. 11, no. 2, 2022, doi: 10.3390/electronics11020247.

[17]. J. C. Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., no. 2. Oxford: Clarendon Press, 1892.

[18]. R. Tschuncky, K. Szielasko, and I. Altpeter, “Hybrid methods for materials characterization,” in *Materials Characterization Using Nondestructive Evaluation (NDE) Methods*, G. Hübschen, I. Altpeter, R. Tschuncky, and H.-G. Herrmann, Eds. Woodhead Publishing, 2016, pp. 263–291. doi: 10.1016/B978-0-08-100040-3.00009-2.

[19]. S. Hastuty, H. A. Prasetyo, N. N. Kirana, A. Nugroho, H. S. Oktaviano, and M. Awwaluddin, “The Effectivity of Oil Palm Inhibitor Processed by Aminolysis to Control Corrosion on Steel in Sodium Chloride Environment,” in *Journal of Physics: Conference Series*, 2021, vol. 2080, no. 1, p. 12027.

[20]. A. Dahliyanti, C. A. Curie, and W. I. Dyah, “Production and Characterization of Silica as a Multifunctional Material from Corn Waste [Produksi dan Karakterisasi Silika sebagai Material Multifungsi dari Limbah Jagung],” J. Teknol., vol. 2, no. 1, p. 1, 2019, [Online]. Available: https://aperti.e-journal.id/teknologia/article/view/22

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