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Research Paper

Transforming Tofu Wastewater into Sustainable Organic Fertilizer: A Fermentation Approach with EM4 and Coconut Water

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Abstract
This growing need for sustainable agriculture has made using recycled waste material in plant cultivation a significant area of research. The tofu industry, as a leading producer of nitrogen (N), phosphorus (P), and potassium (K)-rich wastewater, is a valuable substrate resource for microbial fermentation. The application of solid-state fermentation using EM4 with coconut water under aerobic and anaerobic processes works towards acidification of DM, increasing bioavailable nutrients and minimizing environmental implications from untreated wastewater discharge. This study determined the feasibility of fermenting tofu wastewater with coconut water and EM4 to produce liquid organic fertilizer and analyzed the product's N, P_2O_5, K_2O, C-organic, and C/N ratio. Fermentation occurred at 4:1 of tofu wastewater: fermentation materials, with EM4 concentrations of 10%, 25%, and 50% under anaerobic conditions for 14 days. The fertilizer produced was analyzed and compared with liquid organic health fertilizer according to nonstandard percent by Minister of Agriculture no. 70/Permentan/SR.140/10/2011. Results showed that fermentation increased tofu wastewater's protein and amino acid contents. The highest nitrogen content (3.09 $\pm$ 0.023%) was obtained by treatment C (50% EM4), meeting standard requirements (3-6% N). The K_2O concentration of treatment C peaked at 3.28 $\pm$ 0.025% (K_2O) within the acceptable range (3-6% K_2O). The C-organic content in treatment C reached 10.5 $\pm$ 0.094%, exceeding the minimum quality (6%). The P_2O_5 contents never exceeded the maximum limit (2.22 $\pm$ 0.0057%). Although it indicates a rapid-acting fertilizer, the C/N ratio remained low for all treatments.

Keywords
Tofu Wastewater Fermentation, Liquid Organic Fertilizer, Effective Microorganisms (EM4), Coconut Water Fermentation, Sustainable Agriculture

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1. INTRODUCTION

The growing interest in organic fertilizers from industrial waste products stems from increasing emphasis on environmentally friendly agricultural practices. Tofu industry wastewater has the potential to be a valuable resource due to its high organic content and plant-essential nutrients like nitrogen (N), phosphorus (P), and potassium (K) (Rasmito et al., 2019; Sugiharti et al., 2022). These nutrients, often held in organic forms, require microbial transformation for plant availability. Fermentation using Effective Microorganisms 4 (EM4) can potentially convert tofu wastewater to high-value liquid organic fertilizer. Coconut water has been proven a suitable fermentation medium for microbial metabolism, supporting microbial activity and accelerating organic matter decomposition (Gustiari, 2023). Studies show combining tofu wastewater, EM4, and coconut water can improve organic fertilizer nutrient composition, increasing N, P, and K bioavailability (Al-Hadi and Masjud, 2021; Indrawati et al., 2020). Fermentation also stabilizes nutrient composition, decreases biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in wastewater, and reduces environmental impacts (Rasmito et al., 2023).

Tofu production generates large amounts of waste liquids, leading to serious environmental problems if poorly handled. This effluent contains organic components (proteins and carbohydrates) generating a high BOD and COD with concentrations between 4000 in fresh milk and up to 400,000 mg/L in processing using curdling enzymes, reaching almost 26,000 mg/L (Al Kholif et al., 2020; Wardani et al., 2020). The release of untreated tofu wastewater into water bodies

leads to pollution, eutrophication, and adverse impacts on aquatic ecosystems (Al Kholif et al., 2021a,b; Putri et al., 2024). Additionally, this wastewater is highly acidic, often with a pH of about 3–4, further adding to its detrimental effect on the environment (Hardyanti and Nurandani, 2023; Widiyanto, 2023). Different wastewater treatment processes, including anaerobic digestion and microbial fuel cells, have been explored, yet they generally require complicated systems and high operational costs (Permana, 2024; Permana and Djaenudin, 2019).

Fermentation is a practical, cost-effective, and eco-friendly solution for transforming tofu wastewater into liquid organic fertilizer. It uses microorganisms to mineralize organic compounds into nutrients easily absorbed by plants while degrading contaminants (Rasmito et al., 2023). EM4 is a consortium of beneficial microorganisms that promotes fermentation, improves organic matter's decomposition rate, and increases organic nutrient availability (Adiyaksa Fazrian et al., 2025; Al-Hadi and Masjud, 2021). Rich in sugars and minerals, coconut water provides favorable conditions for microbial growth and metabolic activities (Gustiari, 2023). The transformation of Tofu wastewater into organic fertilizer solves pollution and agricultural production problems through controlled fermentation. Previous studies have confirmed that tofu wastewater could be an organic fertilizer due to its nutrient-rich composition. The high concentration of N in wastewater could range from 161.5 mg/L to 188.34 mg/L (Hadiyanto, 2018; Hadiyarto et al., 2018). Wastewater can be utilized as a source of plant nutrients. N, P, and K content must be considerable, as these nutrients are crucial for root prosperity and plant well-being (Hardyanti and Nurandani, 2023; Sugiharti et al., 2022). Industrial tofu wastewater can have complex organic molecules as its natural structure, which need to be broken down with microbes before it can be bioavailable (Budiastuti, 2024).

Decomposing complex compounds and minimizing environmental risks occur through fermentation, which maximizes nutrient bioavailability. Using a microbial mixture like EM4 significantly increases the breakdown of proteins, carbohydrates, and lipids into bioavailable nutrient sources, delivering a more balanced fertilizer (Indrawati et al., 2020). EM4's ability to enhance organic matter degradation has led to its extensive use in organic waste processing, aiding in releasing N, P, and K in plant-available forms (Al-Hadi and Masjud, 2021). Coconut water is an effective fermentation medium due to its mineral content and growth factors that stimulate microbial action. Its addition increases organic matter decomposition efficiency and enriches liquid fertilizer with micronutrients (Gustiari, 2023). While the benefits of tofu wastewater conversion to liquid organic fertilizers are recognized, several aspects need further study. First, studies show fermentation could enrich nutrient content and improve tofu wastewater quality (Rasmito et al., 2019; Sugiharti et al., 2022), but no comprehensive studies determine the power of EM4 required for nutrient availability. Research must identify the ideal EM4 ratio for fermenting clean fertilizer. Second, although coconut water is acknowledged as a fermentation enhancer, the role of its bioactive compounds in microbial metabolism during tofu wastewater fermentation is not adequately clarified (Gustiari, 2023). A systematic review of the interplay between coconut water and EM4 that alleviates microbial activity and nutrient transformation is needed. Finally, while prior research has explored fermented tofu wastewater application on crops, little is known about the time-dependent nutrient release or its impact on soil health. This helps establish targets in the fermented product after processing and is relevant for nutrient content stability in the fermented product as a sustainable agricultural input. Filling these knowledge gaps will aid in optimizing tofu wastewater fermentation to utilize its potential as an eco-friendly liquid organic fertilizer.

This study introduces a novel fermentation strategy combining coconut water and graded concentrations of EM4 under anaerobic conditions to convert tofu wastewater, a major agro-industrial pollutant, into liquid organic fertilizer. The optimization of EM4 dosage (10%, 25%, and 50%) and the innovative use of coconut water as a microbial growth enhancer contribute to a more nutrient-rich, regulatory-compliant, and environmentally sustainable fertilizer production process. The study aims to quantify the product's N, P_2O_5, K_2O, C-organic matter, and C/N ratio content after 14 days of fermentation.

2. EXPERIMENTAL SECTION

2.1 Materials

The main ingredient is tofu wastewater from a small home industry on Jl. Kedung Tarukan No. 12, Surabaya, East Java. Secondary fermentation supplements include coconut water as the primary fermentation and EM4, a decomposing microorganism used at different concentrations. Chemical reagents for analysis include sulfuric acid (H_2SO_4, MERCK), pp indicator, sodium hydroxide (NaOH, MERCK), distilled (DI) water, boric acid (H_3BO_3, Sigma-Aldrich), Conway indicator, perchloric acid ($HClO_4$, MERCK), nitroxyl (HNO_3, Sigma-Aldrich), Ammonium Heptamolybdate, potassium dichromate (K_2CrO_7, Sigma-Aldrich), and iron (II) sulfate ($FeSO_4$, MERCK). 1 L glass bottles and dark plastic are used for anaerobic sealing during fermentation. Sample analysis uses a spectrophotometer and an Atomic Absorption Spectrophotometer (AAS) OPTIZEN POP, Germany.

2.2 Experiment Design

In three treatments, a 4:1 ratio of tofu liquid waste to fermentation material was used (coconut water and EM4 at various concentrations). Treatment A used 10% EM4 (10 mL EM4 + 90 mL coconut water); treatment B, 25% EM4 (25 mL EM4 + 75 mL coconut water); and treatment C, 50% EM4 (50 mL EM4 + 50 mL coconut water). Anaerobic fermentation was performed for 14 days in sealed bottles as follows: (a) fresh tofu liquid waste was taken after tofu

production; (b) the fermentor, coconut water + EM4, was prepared according to each treatment's concentration; (c) ferment was mixed with tofu liquid waste at 1:4 ratio; (d) fermentation occurred in tightly sealed 1 L bottles for anaerobic conditions; (e) samples were analyzed after 14 days to assess nutrient composition changes.

2.3 Data Collection

After 14 days of fermentation, samples of the produced liquid organic fertilizer underwent laboratory analysis to determine nutrient composition. The quality analysis followed provisions by the Minister of Agriculture No. 70/Permen/Tani/SR.140/10/2011 (Menteri Pertanian, 2011). Major nutrients evaluated included N, P_2O_5,K_2O, C-organic, and C/N ratio. N, P_2O_5, and K_2O parameters were analyzed using the Kjedahl method Latimer Jr (2016), and organic C parameters using the SNI 02-4958-2006 method (Badan Standarisasi Nasional, 2006). The C/N ratio was estimated by comparing C-organic levels to total N. Three tests were performed for each sample, with the mean value used as the final result for data comparison.

2.4 Data Analysis

The study results were presented as mean ± standard deviation, then using tables and charts. Fermentation product quality was compared to the standard requirements for qualified liquid organic fertilizer regulated by Minister of Agriculture No. 70/Permentan/SR.140/10/2011 (Menteri Pertanian, 2011), which stipulates N (3-6%), P_2O_5 (3-6%), K_2O (3-6%), and C-organic minimum of 6%. The carbon-to-nitrogen (C/N) ratio reflects the balance of carbon and nitrogen in the fertilizer. The C and N test results were compared according to Equation (1).

$$\text{C/N ratio} = \frac{\text{C-organic content}}{\text{N content}} \quad (1)$$

3. RESULTS AND DISCUSSION

3.1 Initial Characteristic

This research aims to ferment tofu waste into liquid organic fertilizer using coconut water and EM4. Anaerobic fermentation was used with EM4 concentrations of 10%, 25%, and 50% for 14 days of coconut milk. The study investigated N, P_2O_5, K_2O, C-organic content, and C/N ratio parameters. These were compared to liquid organic fertilizer quality standards based on Minister of Agriculture No. 70/Permentan/SR.140/10/2011 (Menteri Pertanian, 2011). Before the main investigation, targeted parameter characteristics were inspected by analyzing wastewater and coconut water samples from the tofu industry. Table 1 shows the initial characterization of tofu industry wastewater samples.

Based on Table 1, early examination of liquid waste tofu showed N of 0.28%, P_2O_5 of 0.01%, K_2O of 0.10%, and C-organic of 0.54%, with a C/N ratio of 1.92. Coconut water had N at 0.22%, no P_2O_5, K_2O at 0.40%, and C-organic at 7.57%, giving a C/N ratio of 34.40. Nutrient levels are below the quality standard of the Minister of Agriculture regulation. The method that was tried shows how to improve nutrient quality within the manures.

3.2 Nitrogen (N) Analysis

A by-product of tofu production, wastewater from the tofu industry is a nutrient-rich resource with high organic matter (including proteins, carbohydrates, and fats). This composition makes it a potential N source for agriculture (Faisal et al., 2014; Hadiyarto et al., 2018; Rasiska et al., 2022). Previous studies reported that the N content in tofu wastewater was between 161.5 mg/L and 188.34 mg/L (Hadiyanto, 2018; Hadiyarto et al., 2018), suggesting that N can serve as the primary organic material in organic fertilizers. The N content markedly increased after a 14-day fermentation period, as shown in Figure 1. The increase is due to microorganisms in EM4 decomposing proteins in the tofu wastewater.

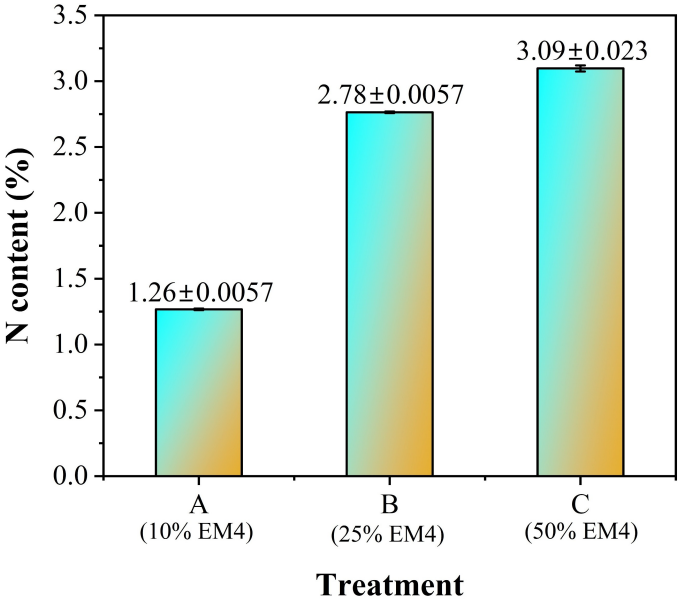

Figure 1. The Increased N Content After Fermentation

The results show that learned abstract distributions of EM4 as a fermentation agent correlated to liquid organic fertilizer N contents. Treatment A (10% EM4) recorded an N content of 1.26 ± 0.0057%, Treatment B (25% EM4) had 2.78 ± 0.0057%, and Treatment C (50% EM4) achieved the highest N content at 3.09 ± 0.023%. Based on the 3–6% N content, liquid organic fertilizer quality would represent a minimum standard requirement (Minister of Agriculture No. 70/Permentan/SR.140/10/2011) (Menteri Pertanian, 2011). Therefore, treatment C could meet this requirement. This positive correlation indicates that increased EM4 concentrations could promote microbial activity that is beneficial for transforming N compounds to become more accessible to plants. The small standard deviation values support the

Table 1. Initial Results of Tofu Wastewater and Coconut Water Samples

Sample	N content (%)	P_2O_5 content (%)	K_2O content (%)	C-organic (%)	C/N ratio
Tofu wastewater	0.28	0.01	0.10	0.54	1.92
Coconut water	0.22	0.00	0.40	7.57	34.40
Quality standard	3-6	3-6	3-6	min 6	-

reliability and homogeneity of the results. Thus, Treatment C (50% EM4) is the most effective approach to producing N-rich liquid organic fertilizer.

The improved nutritional value of EM4 is evidenced by increased N content in each treatment, as fermentation breaks down complex organic compounds into simple materials. This aligns with earlier works showing significantly higher N, P, and K concentrations when using fermented EM4, especially with organic additives like cabbage and banana peels, improving fertilization (Rasmito et al., 2019, 2023). Implementing vermifilters in fertilizer production can increase N content by 1.19% from tempe industry waste (Nurhayati et al., 2024). Using tofu wastewater for fertilizer addresses the environmental issue of its disposal. Untreated wastewater pollutes surface water with organic density, but fermentation can convert this waste into sustainable agrarian support (Nugroho et al., 2019; Rasiska et al., 2022). Tofu wastewater utilization thus offers both nutrient-adding and pollution-mitigating benefits, demonstrating its significance in agriculture and the environment. Consequently, Treatment C (50% EM4) results indicate efficient N enhancement and align with environmentally friendly, sustainable strategies (Sefia, 2024).

Phosphorus (P_2O_5) Analysis Tofu manufacturing generates wastewater containing large quantities of proteins, carbohydrates, and fats, as well as considerable amounts of N and (P_2O_5) suitable for nutrient recovery (Faisal et al., 2014; Zaman et al., 2022). (P_2O_5) increased during fermentation but did not meet liquid organic fertilizer quality parameters. This deficit likely stems from a lack of degrading microorganisms like *Bacillus megaterium* and *Aspergillus sp*, absent in EM4 and coconut water. Figure 2 displays the analysis results, showing higher (P_2O_5) content with increased EM4 concentrations: 1.65 ± 0.017% from treatment A (10% EM4), 1.98 ± 0.0057% from treatment B (25% EM4), and 2.22 ± 0.0057% from treatment C (50% EM4). However, the (P_2O_5) produced was still below the 3–6% requirement for liquid organic fertilizers (Menteri Pertanian, 2011).

Limited P_2O_5 results from few P_2O_5-solubilizing microorganisms like *Bacillus megaterium* or *Pseudomonas fluorescens* and low initial P_2O_5 concentrations in tofu wastewater, which mainly contain organic P_2O_5 forms requiring microbial activity for solubilization (Faisal et al., 2014; Putri and Waluyo, 2022; Widayat et al., 2018; Zaman et al., 2022). Research shows that organic matter decomposition by microbial inoculants, such as EM4, can enhance nutrient availability (Musa et al., 2021; Rasmito et al., 2023). Fermentation can increase the P_2O_5 profile by up to 75%, especially with organic supplements like banana peels or cabbage as extra nutrient sources (Rasmito et al., 2023, 2019). Even if P_2O_5 levels did not reach the standard, applying tofu wastewater as fertilizer has broader significance. It reduces environmental pollution from high-organic-load untreated effluent and is an eco-friendly disposal technique for recycling agricultural waste (Musa et al., 2021; Rasiska et al., 2022; Wardani et al., 2020). To increase P_2O_5 content further, future studies can add P_2O_5-containing materials like rock P_2O_5, bone meal, or P_2O_5-solubilizing microorganisms (Aditya and Kartohardjono, 2018; Taufikurahman, 2024). While the fermentation of tofu wastewater with EM4 has excellent potential for nutrient recovery, optimization is needed to increase the P_2O_5 amount. This work aligns with the literature noting the environmental and agricultural benefits of tofu waste as a sustainable fertilizer (Faisal et al., 2014; Putri and Waluyo, 2022; Rasmito et al., 2023; Zaman et al., 2022). Another author found that the P content was raised from 0.78 ± 0.01 to 1.46 ± 0.03% due to tempeh wastewater fermentation at day 32 employing vermi composting (Nurhayati et al., 2024).

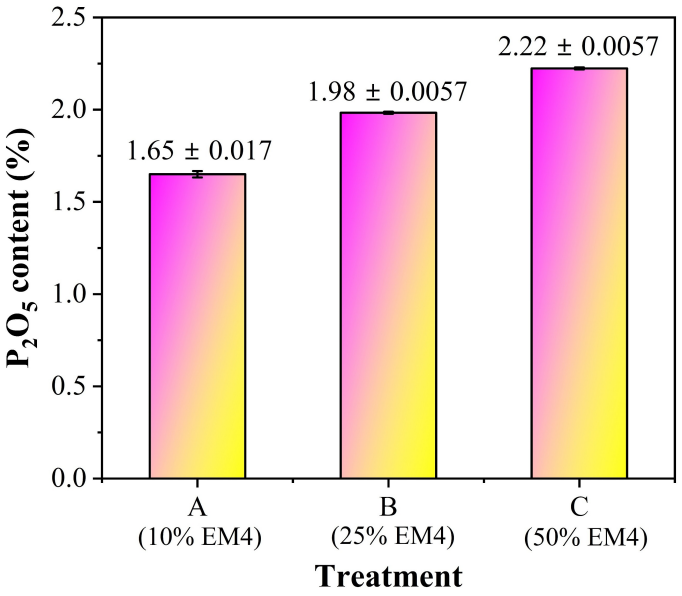

Figure 2. The Increased P_2O_5 Content After Fermentation

3.3 Potassium (K_2O) Analysis

As shown in Figure 3, K_2O content in liquid organic fertilizer from tofu wastewater increased with EM4 concentration. K_2O analysis revealed values of 2.28 ± 0.026% (treat A: 10% EM4), 2.70 ± 0.035% (treat B: 25% EM4), and 3.28 ± 0.025% (treat C: 50% EM4). Treatment C's K_2O content meets the minimum 3-6% requirement for liquid organic fertilizers according to Minister of Agriculture No. 70/Permentan/SR.140/10/2011 (Menteri Pertanian, 2011). Increased K_2O availability during fermentation suggests EM4, as a microbial inoculant, improves K_2O bioavailability through organic material decomposition and nutrient solubilization. A study using tempeh wastewater for vermicomposting fertilizer found K increase from 0.31 ± 0.03 to 0.37 ± 0.08 over 32 days (Nurhayati et al., 2024). Higher K content has been reported in organic fertilizers with a 35:65 ratio of cow rumen to straw (Sugito et al., 2023)

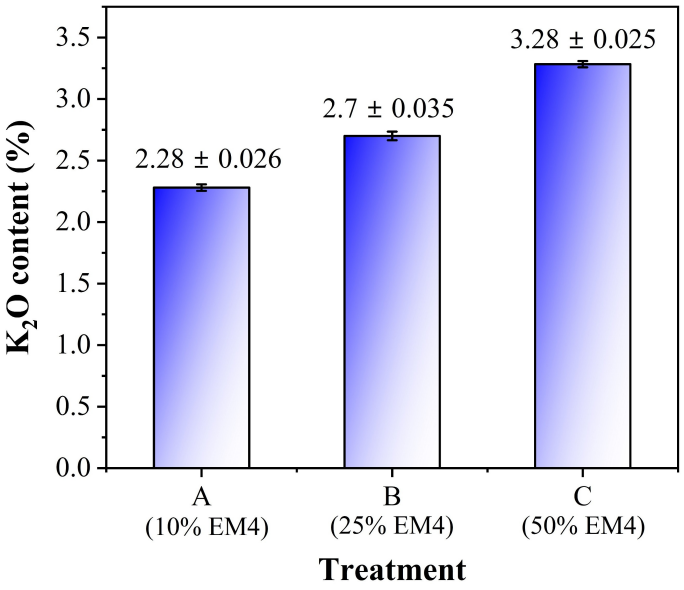

Figure 3. The Increased K_2O Content After Fermentation

The results demonstrate EM4 fermentation's effectiveness in increasing K_2O availability from organic matter decomposition in tofu wastewater, a proteinaceous waste product from tofu production containing carbon, lipids, and important nutrients, including K_2O (Hardyanti and Nurandani, 2023; Zaman et al., 2022). Tofu and tempeh wastewater show high COD levels (7,000 to 26,000 mg/L), indicating high organic content (K_2O can be extracted during fermentation) (Aditya and Kartohardjono, 2018; Sutrisno et al., 2022). The nutrients in tofu wastewater can be recovered and reused as nutrient-rich NPK liquid fertilizer (Ajijah et al., 2020; Rasmito et al., 2023). Nutrient-dense tofu wastewater improves plant growth in hydroponic systems and provides a substrate for microalgae cultivation, supporting its use as a K_2O source (Chaorlina et al., 2021; Gustiari, 2023). This method mitigates the environmental risks of tofu waste disposal and produces nutrient-rich fertilizer, aligning with sustainable agroecosystem management and utilizing a cost-effective resource (Li et al., 2021; Rasmito et al., 2023). These results indicate that EM4 fermentation can efficiently recover K_2O from tofu wastewater, contributing to environmental conservation and agricultural productivity.

3.4 C-Organic Analysis

Tofu production generates significant amounts of high organic content wastewater, presenting environmental concerns and resource usage possibilities. This wastewater contains high BOD and COD, indicating an organic load. Literature shows BOD concentrations of 5,000 – 10,000 mg/L and COD of 7,000 - 26,000 mg/L (Aditya and Kartohardjono, 2018; Al Kholif et al., 2020; Wardani et al., 2020). A high organic load suggests that tofu effluents can enrich fertilizers' organic quality, improving soil quality and yields. Figure 4 demonstrates C-organics' increase in organic fertilizer from tofu industry waste by adding EM4 and coconut water. Cultivated at the University, results showed C-organic content increases with rising EM4 concentration in liquid organic fertilizer. Treatment A (10% EM4), Treatment B (25% EM4), and Treatment C (50% EM4) results were 4.07 ± 0.01%, 8.90 ± 0.22%, and 10.5 ± 0.094% respectively, exceeding the 6% C-organic minimum for liquid organic fertilizers in Minister of Agriculture No. 70/Permentan/SR.140/10/2011 (Menteri Pertanian, 2011). This demonstrates EM4's ability to determine organic matter in tofu effluent and decompose it into bioavailable carbon compounds. It offers a beneficial way to utilize tofu effluents in creating high-grade organic fertilizer, supporting sustainable agriculture (Faisal et al., 2014; Putri and Waluyo, 2022; Rasmito et al., 2023).

The results align with earlier findings showing a 7-24% increase in SOC content when organic fertilizers were added to soils, including those from tofu wastewater (Ermadani et al., 2019). Fermenting tofu wastewater using EM4 produced high organic matter content that stimulated soil microbial activity. This facilitated organic matter decomposition to produce labile organic carbon (LOC) fractions vital for plant growth (He et al., 2021; Hu et al., 2014). Tofu wastewater-derived fertilizers have also improved soil properties like nutrient availability and microbial biomass, which are crucial for sustainable agriculture (Meng and Liu, 2021; Wijayanto et al., 2022). These findings highlight tofu wastewater's potential to enhance soil fertility and promote sustainable farming practices (Angui et al., 2018; Randa, 2023).

3.5 C/N Ratio Analysis

The tofu industry generates large volumes of wastewater, which can be transformed into organic fertilizer with an improved C/N ratio. The C/N ratio is one of the most important factors determining microbial activity and nutrient availability to plants in composting and organic fertilizer production. Figure 5 shows the C/N ratio after fermen-

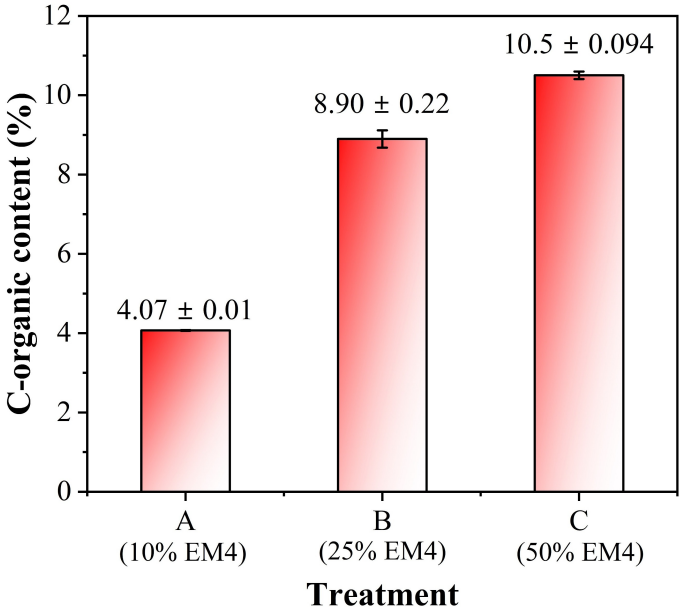

Figure 4. The Increased C-Organic Content After Fermentation

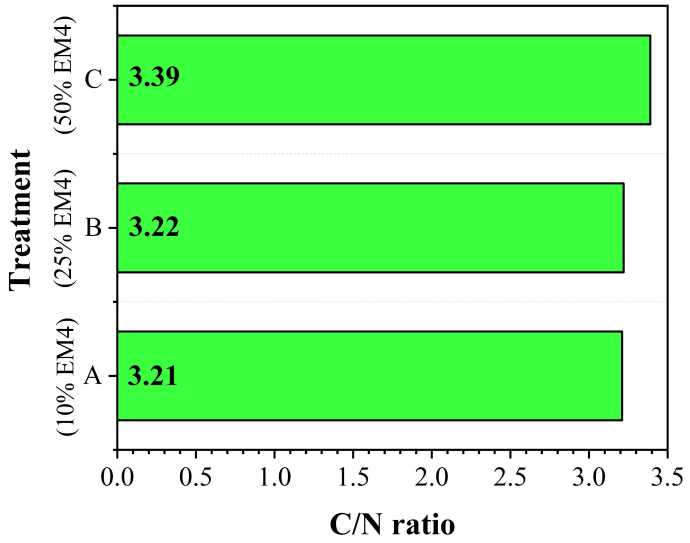

Figure 5. C/N Ratio in Organic Fertilizer Made from Tofu Industry Wastewater Processed with EM4 and Coconut Water

tation using tofu wastewater with EM4 addition. Many studies have investigated the C/N of organic fertilizers from tofu wastewater and its mixtures with other organic materials. All treatments resulted in low C/N ratios of the liquid organic fertilizer from tofu wastewater fermentation: treatment A (10% EM4) at 3.21, treatment B (25% EM4) at 3.22, and treatment C (50% EM4) at 3.39. This suggests a balanced C and N proportion, indicating N-rich fertilizers with quick availability and rapid release for plants and demonstrating effective fermentation in decaying organic materials and promoting soil microorganism growth. This aligns with previous studies highlighting the benefits of balanced C/N ratios for improving soil fertility and sustainable agricultural practices (Faisal et al., 2014; He et al., 2021; Rasmito et al., 2023).

The findings align with research emphasizing the critical role of C/N ratio management during fermentation to optimize organic fertilizer benefits. Rasmito et al. (2023) indicated that a balanced C/N ratio should support root growth, and Budiastuti (2024) proved that adding co-substrate water hyacinth extract improved the nutrient composition of tofu wastewater, forming a C/N ratio of 10.49. Yuliany (2024) stated that mixing tofu wastewater with high C/N ratio striker materials (dry leaves) may equal that C/N ratio for good composting. Organic fertilizer production from cow rumen and straw produced a C/N ratio of 13.25 (Sugito et al., 2023)). These studies support tofu wastewater's potential as an effective nitrogen-rich fertilizer while highlighting the importance of co-substrates and fermentation process control for enhancing nitrogen fertilizer efficacy and its use in farm fields for increased environmental sustainability.

4. CONCLUSIONS

This study tests fermentation with EM4 microorganisms and coconut water in fermented tofu wastewater to convert it into liquid organic fertilizer. The findings show that fermentation improves the nutrient quality of the obtained fertilizer, especially N, K_2O, and C-organics. Treatment C (50% EM4) was the most effective, producing the highest concentrations of these nutrients and meeting minimum quality requirements as a liquid organic fertilizer, as cited in Permentan No.70/Permentan/SR.140/10/2011. However, P_2O_5 levels were too low to comply with the standard, suggesting future studies could include phosphate-solubilizing bacteria or inorganic fractions rich in phosphate. This process can reduce organic waste pollution and promote sustainable agriculture by transforming tofu wastewater into valuable fertilizers. Using a mixture of tofu wastewater, EM4, and coconut water is an environmentally friendly technology for organic fertilizer production. Further studies were conducted on optimal concentrations of fermentative microorganisms, such as de biogás microorganisms, which increased fermented treatment efficiency and the influence of the fermentation process in the soil.

5. ACKNOWLEDGEMENT

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