COGNITIA
INTERNATIONAL ENGINEERING JOURNAL

e-ISSN : 3090-7403
DOI : 10.63288/ciej.v1i1.3

Reseach Paper

Effect of Fermentation Duration on the Carbon-to-Nitrogen (C/N) Ratio of Liquid Organic Fertilizer Produced from Dami Jackfruit Waste Using Coconut Husk-Based Bioactivator

Fitra Fitriah*, Sitti Saleha

Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Muslim Indonesia, Indonesia

Received *8 Feb 2025,* ***Revised*** *24 March 2025,* ***Accepted*** *11 April 2025*

Abstract: Market and household waste are significant contributors to urban pollution, leading to health issues and a decline in city aesthetics. One of the most commonly found market wastes is jackfruit dami waste. This study aims to evaluate the effect of bioactivator addition on the carbon-to-nitrogen (C/N) ratio and to determine the optimal composting duration for achieving a favorable C/N value. The bioactivator (MOL) was prepared using 300 g of coconut fiber and 5 L of coconut water, fermented for two weeks with stirring every three days to release gas. Molasses was prepared by dissolving 1 kg of granulated sugar in 1000 mL of distilled water (1:1 ratio). The jackfruit dami waste was shredded, weighed, and mixed with distilled water, molasses, and MOL at varying concentrations (5%, 11%, and 17% v/w). The composting process was carried out in sealed plastic containers for 9 to 24 days, with stirring every three days. The composted materials were then analyzed for organic carbon and nitrogen content to determine the C/N ratio. The results showed that the highest C/N ratio of 7.18% was obtained on day 24 with a 11% MOL concentration. However, based on the standards set by the Ministry of Agriculture for liquid organic fertilizers, the C/N ratio obtained in this study did not meet the required specifications.

Keywords: Keywords: Jackfruit dami waste; bioactivator; coconut fiber MOL; C/N ratio; liquid organic fertilizer.

1. Introduction

Urban pollution is increasingly driven by the accumulation of market and household waste. These types of waste contribute significantly to environmental degradation, health problems, and a decline in the aesthetic value of cities. Waste is generally defined as any unused or discarded material resulting from a process [1]. The limited availability of final disposal sites (TPA) and the lack of public awareness regarding waste management have exacerbated the problem. Organic waste, whether from households or tourist areas, has the potential to be converted into economically valuable products through appropriate treatment methods. In Makassar City, for instance, daily waste production is estimated at 600–700 tons [2], underscoring the urgency for sustainable waste management solutions.

One of the most common forms of market waste is jackfruit peel and dami (the fibrous inner part of the fruit). While the flesh and seeds of jackfruit are typically utilized, the peel and dami are often discarded without further processing. Dami jackfruit constitutes approximately 40–50% of the waste from the fruit and contains a significant proportion of coarse fiber, protein, glucose, fructose, sucrose, starch, and pectin [3]. Despite its high carbon content, jackfruit dami contains relatively low levels of nitrogen. To optimize its use in composting, it is necessary to supplement the material with nitrogen-

* *Corresponding author:* *ftrftriah06@gmail.com*

rich components to achieve a favorable carbon-to-nitrogen (C/N) ratio for the production of high-quality organic fertilizer [4].

Nitrogen enrichment can be achieved by introducing local microorganisms (MOL), which are derived from the fermentation of locally available materials. MOL solutions contain macro- and micronutrients as well as beneficial bacteria that act as decomposers, plant growth promoters, and biocontrol agents against pests and diseases. These microorganisms can therefore function not only as decomposers but also as biofertilizers and organic pesticides, especially fungicides. A key advantage of MOL is its low cost, as it utilizes materials readily found in the surrounding environment [5]. Previous studies have shown that composting with MOL bioactivators within a period of 10–13 days can produce an optimal C/N ratio [6].

In this study, coconut fiber-based MOL is used as the bioactivator. Coconut fiber, a readily available agricultural by-product, contains essential nutrients such as nitrogen (0.44%), phosphorus (119 mg/kg), potassium (67.20 me/100g), calcium (7.73 me/100g), and magnesium (11.03 me/100g). Moreover, coconut fiber hosts beneficial microbial species such as Klebsiella sp., Pseudomonas sp., Bacillus circularis, Bacillus megaterium, and Bacillus firmus [7]. These properties make coconut fiber a viable raw material for producing MOL that enhances the composting process and improves the quality of the final organic fertilizer product.

Based on the above background, this research seeks to address the issue of urban waste pollution by exploring the potential of jackfruit dami as a raw material for liquid organic fertilizer production using coconut fiber-based bioactivators. The novelty of this study lies in the utilization of jackfruit dami, a waste material that has not been optimally processed, in combination with a locally sourced and nutrient-rich MOL derived from coconut fiber. The objective of this study is to determine the effect of MOL addition on the C/N ratio and to identify the optimal composting duration required to achieve a C/N ratio that meets the standard for liquid organic fertilizers.

2. Research and Methodology

2.1 Materials

The materials used in this study consisted of jackfruit dami waste as the primary organic substrate and a coconut fiber-based bioactivator (MOL) made from coconut fiber and coconut water. The MOL served as a microbial inoculum to accelerate the composting process. A molasses solution was also prepared using granulated sugar and distilled water in a 1:1 ratio to serve as an energy source for microbial growth. Additional chemical reagents used for analytical purposes included potassium dichromate ($K_2Cr_2O_7$) 1 N, concentrated sulfuric acid (H_2SO_4), concentrated phosphoric acid (H_3PO_4), sodium fluoride (NaF) 2%, and diphenylamine indicator for organic carbon (C-organic) analysis. For nitrogen analysis, selenium mixture and concentrated H_2SO_4 were used in the Kjeldahl digestion process, while sodium hydroxide (NaOH) 40%, 1% boric acid with Conway indicator, and 0.05 N sulfuric acid were employed for distillation and titration steps. All materials and reagents were of analytical grade and used according to standard laboratory protocols.

2.2 Preparation of Bioactivator and Composting Process

The preparation of the local microorganism (MOL) bioactivator was carried out by mixing 300 grams of coconut fiber with 5 liters of coconut water, followed by thorough stirring. The mixture was placed in a closed container and allowed to ferment at room temperature for two weeks. To support optimal microbial activity, the mixture was stirred and degassed every three days. The fermentation process was monitored until a distinctive odor, indicative of successful fermentation, was detected.

Molasses solution was prepared separately by dissolving 1 kg of granulated sugar in 1 liter of distilled water in a 1:1 ratio. This solution functioned as an energy source and nutrient enhancer for bacterial proliferation.

The composting process began by weighing the jackfruit dami waste according to the treatment variations. The composting substrate was then combined with distilled water, molasses solution, and the prepared MOL. The mixture was transferred into tightly sealed plastic containers and subjected to anaerobic fermentation for a period ranging from 9 to 24 days. During this period, the compost was stirred every three days to maintain homogeneity and enhance microbial activity.

Upon completion of the fermentation period, the resulting compost was analyzed for its organic carbon (C-organic) and total nitrogen content to evaluate the quality and maturity of the compost.

2.3 Analysis of C-Organic and Nitrogen Content

The analysis of organic carbon (C-organic) was carried out using the Walkley and Black method. Approximately 0.1 g of the compost sample was weighed and transferred into a 250 mL Erlenmeyer flask. Then, 5 mL of 1 N potassium dichromate ($K_2Cr_2O_7$) and 5 mL of concentrated sulfuric acid (H_2SO_4) were added carefully, and the mixture was gently shaken. After cooling, 50 mL of deionized water, 5 mL of concentrated phosphoric acid (H_3PO_4), and 5 mL of 2% sodium fluoride (NaF) were added to the solution. A blank solution was prepared using 5 mL of 1 N $K_2Cr_2O_7$, 5 mL of concentrated H_2SO_4, and 50 mL of deionized water. Three drops of diphenylamine indicator were added, and the solution was titrated with 0.2 N ammonium iron (II) sulfate until a color change was observed, indicating the endpoint of the reaction.

The total nitrogen content was determined using the Kjeldahl method. A total of 0.250 g of finely ground compost sample was weighed and placed in a Kjeldahl flask. A selenium mixture (0.25–0.50 g) and 3 mL of concentrated H_2SO_4 were added. The mixture was left to pre-digest for 2–3 hours before being fully digested at increasing temperatures, starting from 150°C and gradually rising to a maximum of 350°C, until a clear solution was obtained (within 3–3.5 hours). After cooling, the digest was diluted with a small amount of distilled water to prevent crystallization and transferred into a 250 mL distillation flask. Deionized water was added to fill half of the flask volume, and boiling stones were included. The receiving flask contained 10 mL of 1% boric acid with three drops of Conway indicator. Distillation was initiated by adding 20 mL of 40% sodium hydroxide (NaOH). The distillation process continued until approximately 75 mL of distillate was collected. The collected distillate was titrated with 0.05 N sulfuric acid (H_2SO_4) until a color change from green to light pink was observed, indicating the endpoint.

3. Results and Discussion

3.1 Effect of Fermentation Time and Bioactivator Concentration on C-Organic Content

Organic carbon (C-organic) is a critical parameter in determining the quality of mineral soil, as it serves as a primary energy source for soil microorganisms and plays an essential role in soil structure and fertility. Figure 4.1 illustrates the effect of fermentation time and varying concentrations of coconut husk-based local microorganism (MOL) bioactivator on the percentage of C-organic content in liquid organic fertilizer derived from jackfruit waste (dami nangka).

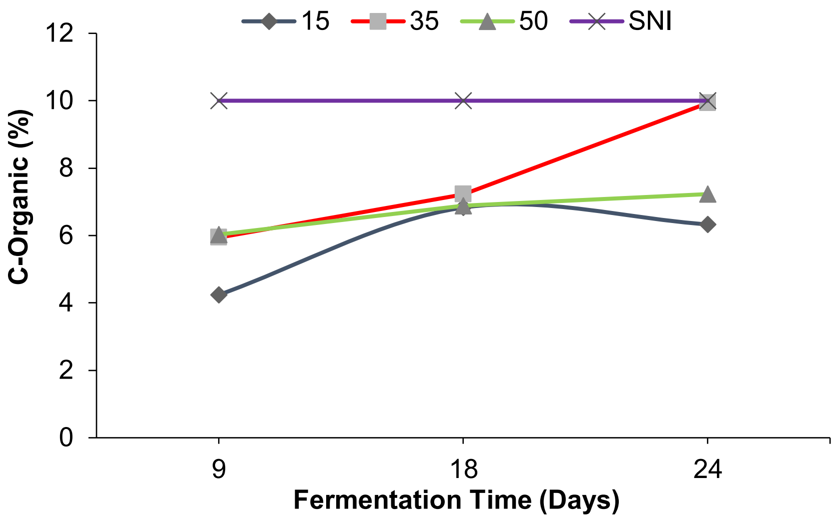

Figure 1. The effect of fermentation duration on C-organic content (%)

As shown in Figure 4.1, the addition of bioactivator and the duration of fermentation influenced the C-organic content significantly, though the overall values remained within a moderate range. At a 5% MOL concentration (mL/g), the C-organic content increased from 4.25% on day 9 to 6.83% on day 18, but slightly decreased to 6.33% on day 24. Similarly, at an 11% MOL concentration, the values were 5.94% (day 9), 7.22% (day 18), and peaked at 9.93% (day 24). Meanwhile, at the highest MOL concentration of 17% (mL/g), the C-organic content was recorded at 6.03% (day 9), 6.88% (day 18), and slightly increased to 7.23% (day 24).

These variations suggest that higher MOL concentrations generally contribute to an increase in C-organic levels during fermentation. However, the slight decline observed in some treatments toward the end of the fermentation period may be attributed to microbial metabolic activity. The bioactivator, which stimulates microbial growth, promotes biochemical reactions such as the conversion of carbohydrates into CO_2 and H_2O. This ongoing mineralization process can lead to the reduction of organic carbon content as microorganisms utilize carbon compounds for energy and cellular processes [8][9][10].

The data indicate that an 11% MOL concentration yields the highest C-organic content at 24 days of fermentation, suggesting this as the optimal combination of concentration and duration for enhancing organic carbon in liquid organic fertilizer.

3.2 Effect of Fermentation Time and Bioactivator Concentration on Nitrogen Content

Nitrogen is one of the essential macronutrients required for optimal plant growth. It plays a fundamental role in chlorophyll formation, protein synthesis, and enzymatic activities. A deficiency in nitrogen can lead to stunted growth, chlorosis (yellowing of leaves), and underdeveloped root systems. The nitrogen content in the liquid organic fertilizer derived from jackfruit waste (dami nangka) with the addition of local microorganisms (MOL) using coconut husk bioactivator is presented in Figure 4.2.

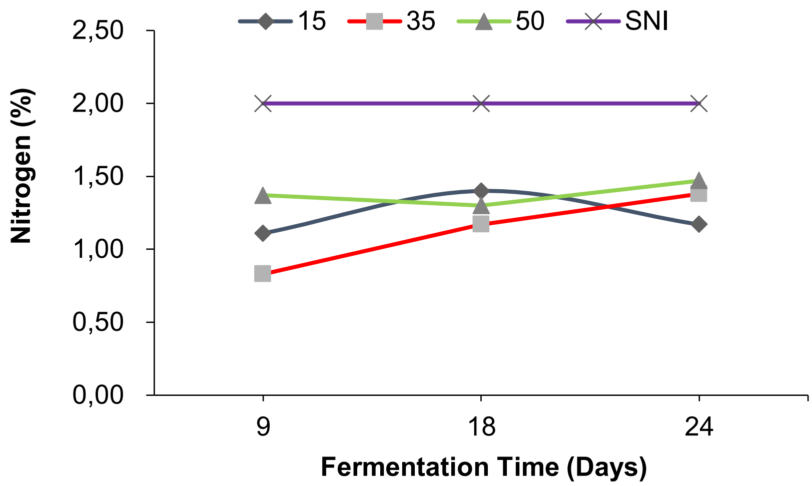

Figure 2. Effect of fermentation duration on nitrogen content (%)

As shown in Figure 4.2, the nitrogen content varied across different MOL concentrations and fermentation periods, indicating that the optimization of nitrogen enrichment through microbial activity is still a challenge. At a MOL concentration of 5% (mL/g), nitrogen content increased from 1.11% on day 9 to 1.40% on day 18, followed by a slight decrease to 1.17% on day 24. In contrast, the 11% MOL treatment showed a relatively modest increase, from 0.83% (day 9) to 1.17% (day 18), and peaked at 1.38% on day 24. Interestingly, the highest MOL concentration (17%) yielded a nitrogen content of 1.37% on day 9, decreased slightly to 1.30% on day 18, and rose again to 1.47% on day 24.

These results suggest that nitrogen dynamics during fermentation are influenced not only by the concentration of bioactivator but also by the metabolic rate of the microbial population present. Microorganisms decompose organic substrates by breaking down complex organic molecules into simpler forms through enzymatic activity. This process is highly dependent on the availability of nitrogenous compounds in the substrate and the efficiency of microbial assimilation and mineralization [9][11][12].

The highest nitrogen content (1.47%) was recorded in the 17% MOL treatment on day 24, indicating that higher concentrations of bioactivator may enhance microbial decomposition and nitrogen release over prolonged fermentation periods. However, the fluctuations observed in other treatments underscore the need for further investigation to determine the most stable and effective conditions for nitrogen enrichment in organic fertilizer production.

3.3 Effect of Moisture Content on Capsules

The carbon to nitrogen (C/N) ratio is a critical parameter for assessing the maturity and quality of organic fertilizers. Plants can effectively absorb nutrients when the C/N ratio of organic fertilizer closely resembles that of natural soil. A high C/N ratio indicates nutrient imbalance, while a low ratio may reflect incomplete decomposition. The results of C/N ratio analysis of liquid organic fertilizer made from jackfruit rind with the addition of local microorganisms (MOL) derived from coconut husk bioactivator are presented in Figure 4.3.

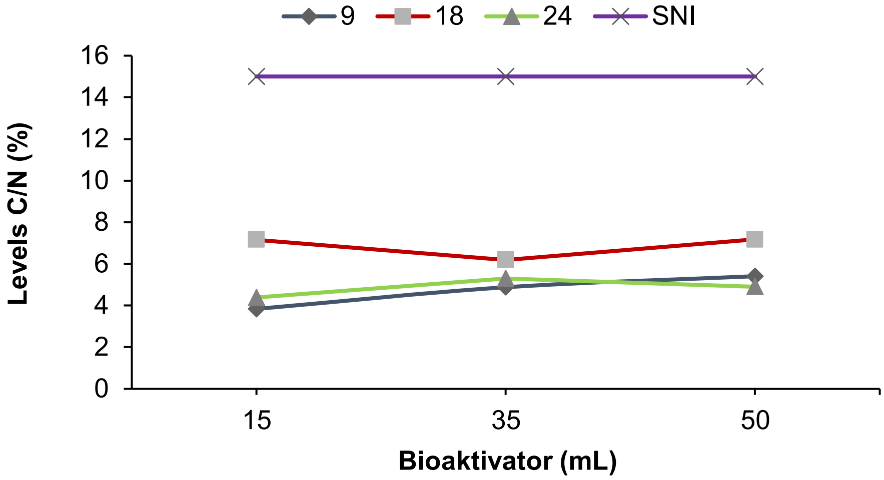

Figure 3. Effect of MOL bioactivator addition and fermentation time on C/N ratio (%)

As shown in Figure 4.3, the variation in MOL concentrations and fermentation durations did not significantly affect the C/N ratio values. At 5% MOL concentration (ml/g), the C/N values were recorded at 3.84% on day 9, 4.88% on day 18, and 5.41% on day 24. The treatment with 11% MOL concentration resulted in values of 7.16%, 6.19%, and 7.18% on days 9, 18, and 24, respectively. Meanwhile, the 17% MOL concentration yielded C/N values of 4.39%, 5.30%, and 4.91% for the same respective days.

These findings indicate that all treatments produced C/N ratios below 10%, the minimum threshold required by the Regulation of the Minister of Agriculture of the Republic of Indonesia concerning the quality standard for liquid organic fertilizer [10][13]. Consequently, the resulting liquid organic fertilizer cannot yet be classified as a proper organic fertilizer and is more appropriately categorized as a soil amendment. The relatively low C/N ratios may be attributed to the relatively high nitrogen content resulting from rapid microbial decomposition of organic matter, whereas the carbon content had not yet undergone complete mineralization [14][15][16][17].

This outcome highlights the need for further optimization, including adjustment of substrate ratios, bioactivator types and concentrations, and fermentation durations, to achieve a liquid organic fertilizer with a C/N ratio that complies with the established quality standards.

4. Conclusion

Based on the research findings, it can be concluded that the addition of coconut husk-based local microorganism (MOL) bioactivator at concentrations of 5%, 11%, and 17% with fermentation durations of 9, 18, and 24 days produced varying effects on the organic carbon (C-organic), nitrogen content, and C/N ratio of liquid organic fertilizer made from jackfruit waste (dami nangka). The highest C-organic content was observed with 11% MOL on the 24th day at 9.93%, while the highest nitrogen content was found with 17% MOL on the 24th day at 1.47%. However, the resulting C/N ratios remained below the minimum standard of 10% as stipulated by the Indonesian Ministry of Agriculture, indicating that the product can only be classified as a soil conditioner rather than a standard liquid organic fertilizer. Therefore, future research is recommended to optimize the raw material composition, MOL concentration, and fermentation time to enhance the decomposition process and achieve quality parameters that meet the official standards for liquid organic fertilizer.

5. References

[1] D. N. Afiyah, E. Uthari, D. Widyabudiningsih, and R. D. Jayanti, "Production and Testing of Liquid Organic Fertilizer (LOF) from Market Waste Using EM4 Bioactivator," Fullerene Journal of Chemistry, vol. 6, no. 2, pp. 89–95, 2021, doi: 10.37033/fjc.v6i2.325.

[2] A. C. Malina, Suhasman, A. Muchtar, and Sulfahri, "Environmental Study of Waste Sorting Sites in Makassar City," Journal of Innovation and Public Service Makassar, vol. 1, no. 1, pp. 14–27, 2017.

[3] Z. N. Hidayat, A. Z. Arifin, and S. H. Pratiwi, "Utilization of Rice Straw (Oryza sativa) and Jackfruit Peel (Artocarpus heterophyllus) as Organic Fertilizer with Goat Urine and Effective Microorganism 4 (EM4) Application," Agrotechnology Merdeka Pasuruan Journal, vol. 5, no. 1, pp. 16–22, 2021.

[4] R. A. Hadi, "Utilization of Local Microorganisms (MOL) from Materials Available in the Surrounding Environment," Journal of Agricultural Science, vol. 9, no. 1, pp. 93–104, 2019.

[5] A. Kurniawan, "Production of Local Microorganisms (MOL) Utilizing Organic Materials Available in the Surroundings," Hexagro Journal, vol. 2, no. 2, pp. 36–44, 2018, doi: 10.36423/hexagro.v2i2.130.

[6] H. Setyawati, E. J. Sinaga, and Jimmy, "Production of Bioethanol Base Material as an Effort to Utilize Jackfruit Peel Waste at CV. Kajeye Food Malang," Journal of Applied National Science and Technology, vol. 1, no. 1, pp. 7–13, 2020.

[7] P. A. W. Dharma, A. A. N. G. Suwastika, and N. W. S. Sutari, "Study on the Utilization of Coconut Husk Waste into Local Microorganism Solution," Tropical Agrotechnology, vol. 7, no. 2, pp. 200–210, 2018.

[8] L. Trivana and A. Y. Pradhana, "Optimization of Composting Time and Quality of Goat Manure Compost with Coconut Husk Dust Using PROMI and Orgadec Bioactivators," Veterinary Science Journal, vol. 35, no. 1, p. 136, 2017, doi: 10.22146/jsv.29301.

[9] R. Syafri, Chairil, and D. Simamora, "Analysis of Macro Nutrient Elements in Liquid Organic Fertilizer (LOF) from Pineapple and Jackfruit Chip Industry Waste in Kualu Nenas Village with the Addition of Cow Urine and EM4," Journal of Photochemistry, vol. 8, no. 1, pp. 4–9, 2017.

[10] Ministry of Agriculture, "Minimum Technical Requirements for Organic Fertilizers, Biofertilizers, and Soil Conditioners," Decree of the Minister of Agriculture of the Republic of Indonesia No. 261/Kpts/SR.310/M/4/2019, 2019. [Online]. Available: http://psp.pertanian.go.id/index.php/page/publikasi/418.

[11] S. Yanti, I. Ibrahim, M. Masrullita, and M. Muhammad, "Production of Liquid Organic Fertilizer from Vegetable Waste Using EM4 Bioactivator," Journal of Chemical Technology Unimal, vol. 10, no. 2, pp. 45–52, 2020.

[12] R. Andesta, N. ZA, N. Sylvia, A. Muarif, and R. Nurlaila, "Production of Liquid Organic Fertilizer from Kepok Banana Peel Waste and Rice Washing Water Using EM4 Bioactivator," Chemical Engineering Journal Storage (CEJS), vol. 3, no. 4, pp. 581–595, 2023.

[13] D. Amalia and P. Widiyaningrum, "Use of EM4 and Tomato Waste MOL as Bioactivators in Compost Production," Life Science, vol. 5, no. 1, pp. 18–24, 2016.

[14] N. K. Budiyani, N. N. Sonari, and N. W. S. Sutari, "Analysis of Local Microorganism (MOL) Quality from Banana Corm," E-Journal of Tropical Agrotechnology, vol. 5, no. 1, pp. 63–72, 2016.

[15] R. Y. Cesaria, R. Wirosoedarmo, and B. Suharto, "Effect of Starter Use on Fermentation Quality of Tapioca Waste as an Alternative Liquid Fertilizer," Journal of Natural Resources and Environment, pp. 8–14, 2014.

[16] M. Febrianna, S. Prijono, and N. Kusumarini, "Utilization of Liquid Organic Fertilizer to Increase Nitrogen Uptake and Growth of Mustard (Brassica juncea L.) in Sandy Soil," Journal of Soil and Land Resources, vol. 5, no. 2, pp. 1009–1018, 2018.

[17] L. M. Gaol and I. D. A. A. Wamadewanthi, "Environmental Impact Prediction of Waste Management at Jabon Landfill, Sidoarjo Regency," Journal of Environmental Science and Technology, vol. 5, no. 1, pp. 25–32, 2017.