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The Effect of Green Phoskko and Em4 Activators on Compost Making from a Mixture of Goat Manure and Tapioca Industrial Solid Waste Using the Windrow Method

Shela Septiyani[1], Natalina[2]
[1]Environmental Engineering Study Program, Faculty of Engineering, Malahayati University, Bandar Lampung
[2]Environmental Engineering Study Program, Faculty of Engineering, Malahayati University, Bandar Lampung
Corresponding Author e-mail:shelaseptiyani20@gmail.com

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Abstract: *Organic waste from cassava peels and goat manure in Lampung, Indonesia's cassava hub producing 39.74 million tons in 2022, pollutes via open dumping due to high initial CN ratio (~33) slowing natural composting. This quantitative true experimental study aimed to analyze Green Phoskko and EM4 activators' effects on windrow composting of goat manure-cassava peel (1:1 ratio). The population comprised all potential mixtures in Lampung; purposive total sampling yielded 9 units (3 treatments x 3 replications, 6 kg/unit). Instruments included thermometer, pH meter, and spectrophotometer for N/C-organic; data analyzed descriptively and via ANOVA/t-test in Excel/SPSS. Results showed Green Phoskko superior: N rose to 2.80%, C-organic fell to 15.55%, CN ratio to 10.50, pH 6.5-7, temperature 28-32°C (mesophilic) by day 28, meeting SNI 7763:2018 standards; EM4 achieved CN 11.50. Green Phoskko accelerates lignocellulosic waste composting more effectively than EM4 due to superior microbes like Trichoderma sp.*

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Introduction

Organic waste, including solid waste from the tapioca industry such as cassava peels and livestock waste such as goat manure, is often disposed of in open dumps without adequate management, causing environmental disturbances, unpleasant odors, and land degradation (Sholihah Nurhidayati, 2018; Elamin et al., 2018;). In Lampung Province, a major center for cassava production with 39.74 million tons in 2022, cassava peel waste reaches a significant volume that has the potential to pollute the environment if left untreated, while nitrogen-rich goat manure remains wasted (Putih et al., 2022; Indra Dwi Faturahman, 2023). The volume of organic waste continues to increase with population growth and industrial activity, emphasizing the need for sustainable recycling technologies such as composting (Cahyani, 2013; Purwaningrum Kusbiantoro, 2021).

Composting is considered a sustainable solution because it converts organic waste into high-value compost, supporting environmental conservation, human safety, and economic value by reducing chemical fertilizers (Ayilara et al., 2020; Rastogi et al., 2020). This process involves aerobic decomposition by microorganisms, which lowers the C/N ratio to approximately 10-12, similar to soil, allowing optimal plant uptake (Rahmawati et al., 2017; Trivani Dwi Kurniawati et al., 2021).

The natural composting process is slow due to the high C/N ratio in materials such as cassava peels (rich in carbon) and goat manure (CN ratio >30), hindering efficiency and requiring acceleration through biological activators (Siboro et al., 2013; Linda Trivana et al., 2017;). Tapioca industrial waste in Lampung often rots and produces a pungent odor, while goat manure containing N, P, and K has not been optimally utilized, causing the loss of organic fertilizer potential and environmental pollution (Hapsari, 2013; Pipid Ari Wibowo et al., 2023).

The simple and inexpensive windrow method is suitable for large-scale composting, but requires periodic turning for optimal aeration, controlled temperature, and reduced humidity to achieve compost maturity (Khater, 2015; Hemidat et al., 2018; Vaneza Citra Kurnia et al., 2017). The use of activators such as EM4 (containing Lactobacillus sp., Saccharomyces sp.) and Green Phoskko (containing Actinomyces sp., Trichoderma sp.) is necessary to accelerate the decomposition of cellulose and lignin, but their effects on parameters such as N, C-organic, C/N ratio, pH, and temperature are unclear in this mixture (Pangaribuan & Pujisiswanto, 2008; Shafiyah Setianingsih & Harmin Sulistiyaning Titah, 2020).

Although windrow composting is efficient for organic waste, the lack of specific studies on the combination of goat manure and cassava peel with the activator causes uncertainty in the quality of the compost according to SNI 7763:2018 (Retno Wulandari Sekarsari et al., 2020; Trivana Dwi Kurniawati et al., 2021).

This study aims to determine the effect of EM4 and Green Phoskko activators on composting from a mixture of goat manure and tapioca industrial solid waste using the windrow method, with parameters N, C-organic, C/N ratio, pH, and temperature. The urgency of this research lies in the massive reduction of organic waste in Lampung, pollution prevention, and the production of affordable organic fertilizer to support sustainable agriculture in accordance with Law No. 18 of 2008 concerning Waste Management (Azim et al., 2018; Putih et al., 2022). The novelty of this study is the comparative evaluation of EM4 versus Green Phoskko on this specific mixture using the windrow method, filling the gap in previous studies that were limited to one activator or single material (Pipid Ari Wibowo et al., 2023; Shafiyah Setianingsih & Harmin Sulistiyaning Titah, 2020).

Research Methods

Types and Methods of Research

This research is a quantitative true experiment designed to test the effect of independent variables in the form of Green Phoskko and EM4 activators on dependent variables such as nitrogen content, organic C, C/N ratio, pH, and compost temperature from a mixture of goat manure and cassava peel waste using the windrow method (Sugiyono, 2021; Septiyani, 2025). The quantitative approach was chosen because it allows strict control of control variables such as fermentation time (days 0, 7, 14, 21, 28), material composition (3 kg goat manure: 3 kg cassava peel: 12 ml activator), and the windrow procedure to produce objective and statistically testable numerical data (Creswell & Creswell, 2023; Purwaningrum Kusbiantoro, 2021). The quasi-experimental design with three treatments (without activator, +Green Phoskko, +EM4) ensures replication and randomization for internal validity, in accordance with the principles of the experimental method which emphasizes controlled conditions to avoid external bias (Sugiyono, 2022; Vaneza Citra Kurnia et al., 2023).

Data Analysis Instruments and Techniques

Research instruments included measuring instruments such as thermometers for temperature, pH meters for acidity, spectrophotometers for nitrogen and organic carbon, and laboratory analysis for the C/N ratio, with the main materials being fresh goat manure from local farmers and cassava peels from the Lampung tapioca industry (Septiyani, 2025; Linda Trivana et al., 2017). Quantitative data analysis techniques used descriptive statistics (averages, change trend graphs) and inferential (ANOVA

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or t-test for treatment comparisons) through software such as Excel or SPSS, allowing interpretation of significant effects between treatments at each time interval (Sugiyono, 2021; Emzir, 2022). This approach aligns with experimental data analysis that emphasizes hypothesis testing (H0: no effect; Ha: effect) based on the SNI 7763:2018 compost quality standard, with validation through triangulation of primary laboratory data and secondary literature (Sudaryono, 2021; Ayilara et al., 2020).

Population and Sample

The study population was all possible mixtures of goat manure and cassava peel waste that can be processed into compost using the windrow method in the Lampung region, with an initial C/N ratio characteristic of approximately 37.34:1.11 (Septiyani, 2025; Pipid Ari Wibowo et al., 2023). Samples were taken purposively with a total sampling technique from one livestock location (Jl. Sultan Agung, Kedaton, Bandar Lampung) and a tapioca industry, resulting in three treatment sample units (P1: without activator; P2: +Green Phoskko 12 ml; P3: +EM4 12 ml), each 6 kg of material with three replications for a minimum sample size of 9 total units to be representative and support statistical tests (Sugiyono, 2022; Creswell & Creswell, 2023). This sample selection ensures homogeneity and relevance to the local industry population, avoiding bias with the criteria of fresh material quality and uniform chopped size (Putih et al., 2022).

Research Procedures

The procedure begins with literature study and material collection (goat manure and finely chopped cassava peel), followed by windrow land preparation with sack-lined holes, material mixing (1:1 ratio), activator application to P2 and P3, and long pile formation for optimal aeration (Septiyani, 2025; Purwaningrum Kusbiantoro, 2021). Furthermore, weekly stirring is carried out to maintain mesophilic temperature (30-60°C), humidity of 50-60%, and random sampling on days 0, 7, 14, 21, and 28 for laboratory analysis, ending with drying of mature compost (black, odorless, and not muddy) (Khater, 2015; Sumiyati et al., 2025). This flow follows the standard aerobic composting protocol with variable control for reliability, validated through photo documentation and daily records (Sugiyono, 2021; Emzir, 2022).

Results and Discussion

Implementation of research

Research on composting organic waste (cassava peel and goat manure) using the windrow method. The parameters measured were C/N ratio, nitrogen, organic carbon, pH, and temperature.

1. Comparison of Changes in Nitrogen Values from 3 (three) Types of Treatment During the Composting Process

The addition of goat manure and cassava peels as nitrogen sources improves nitrogen levels and increases macronutrient content, thus supporting more efficient organic material decomposition and producing good compost. The following table compares changes in nitrogen values across the three treatments during the composting process.

Table 1. Comparison of Changes in Nitrogen Values from 3 Types of Treatment During the Composting Process.

Day	N concentration (%) Treatment 1	N concentration (%) Treatment 2	N concentration (%) Treatment 3
0	1.11	1.11	1.11
7	1.30	1.40	1.25
14	1.54	1.71	1.62
21	1.80	2.25	2.02
28	2.01	2.80	2.50

Source: Research Results, 2025

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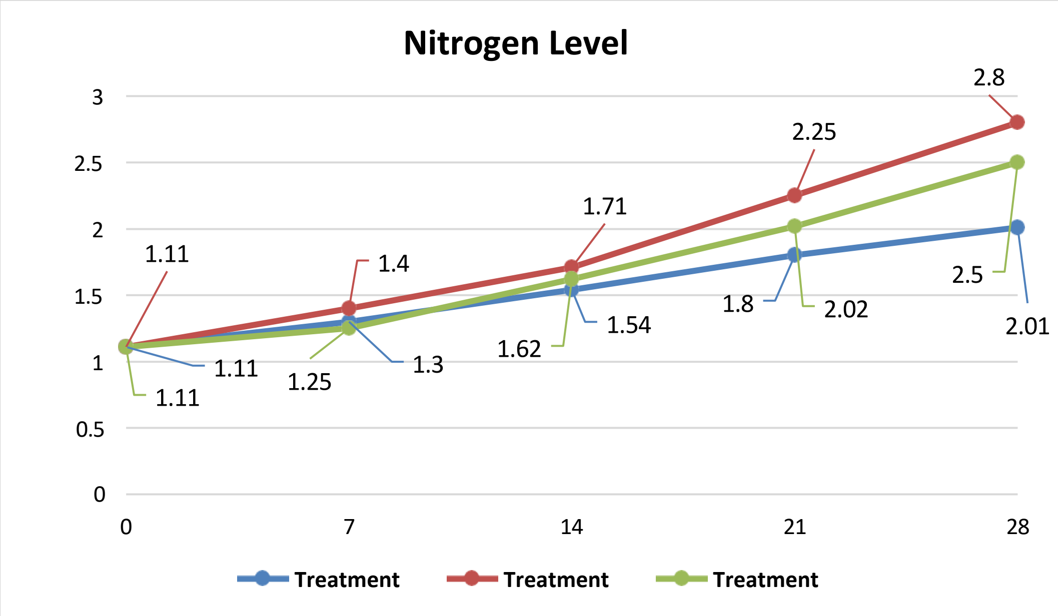
The conditions in this experiment consist of 3 treatments with an aerobic process using the windrow method as a medium for making compost, namely:

a. Treatment 1 : goat dung + skincassava
b. Treatment 2 : dirt goat + cassava skin + Green Phoskko
c. Treatment 3 : goat droppings + cassava peel + Em4



Graph 1. Comparison of Changes in Nitrogen Values from 3 Types of Treatment During the Composting Process.

Nitrogen is a nutrient that plants need in large quantities, absorbed by plants in the form of ammonium and nitrate. The highest nitrogen content in this study was in treatment 2 at 2.80%. Green Phoskko contains microbes such as Actinomycetes, Pseudomonas sp., Lactobacillus sp., Trichoderma sp., Acetobacter sp. and Rhizobium sp. These microbes function to accelerate and improve the fermentation process because they produce enzymes that can degrade lignin and cellulose, and are antagonistic to cassava peels (Indra Dwi Fathurrahman, 2023). Research conducted by Hapsari (2013), explains that the higher the N nutrient content will increase the number of microorganisms so that the decomposition rate is faster. Based on research conducted by Akanbi (2007) cassava peels have a high carbon content of 59.31% and a nitrogen content of 2.06% causing microorganisms to be unable to reproduce optimally due to the low N content in cassava peels. According to Amnah and Friska (2019), microorganisms require large amounts of N during the composting process for cell multiplication and to consume C as an energy source for microorganisms.

The windrow method can increase the nitrogen content in compost by maintaining aerobic conditions through regular turning, thereby reducing nitrogen loss due to ammonia evaporation and accelerating the mineralization process by microorganisms. The higher the nitrogen content, the faster the organic matter will decompose, because microorganisms decomposing organic matter in compost require nitrogen for their activity (Liu D, 2011).

2. Comparison of Changes in Organic C Values from 3 Types of Treatment During the Composting Process

The addition of goat manure is expected to accelerate the decomposition of organic matter, reduce organic carbon levels through microbial activity, and produce compost with organic carbon levels that meet compost quality standards. The following table compares changes in organic carbon values across three treatments during the composting process.

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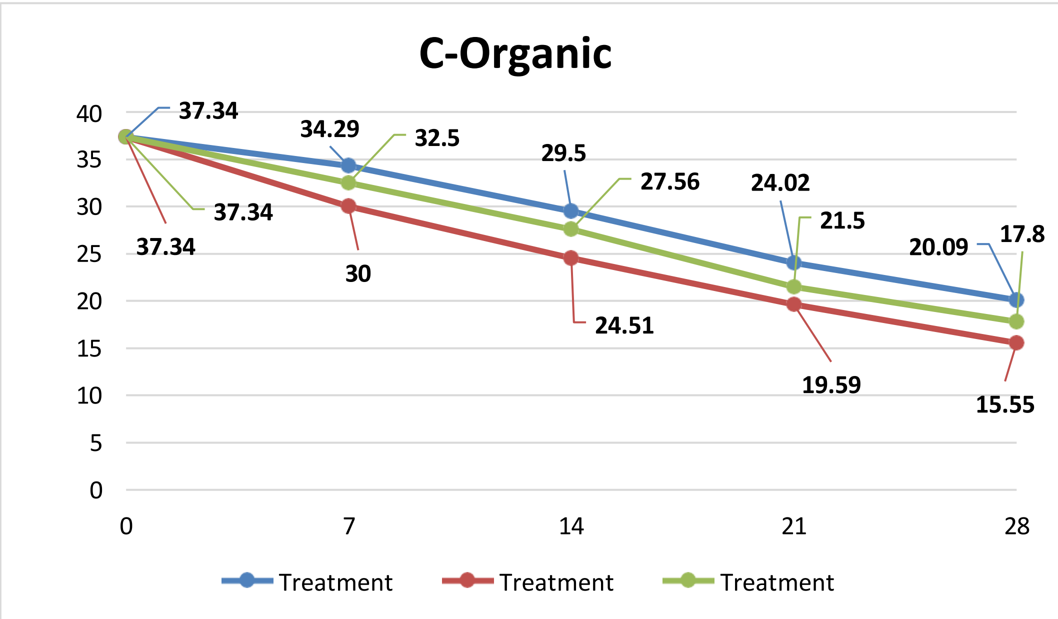
Table 2. Comparison of Changes in Organic C Values from 3 Types of Treatment During the Composting Process.

Day	Concentration C (%) Treatment 1	Treatment 2	Treatment 3
0	37.34	37.34	37.34
7	34.29	30.00	32.50
14	29.50	24.51	27.56
21	24.02	19.59	21.50
28	20.09	15.55	17.80

Source: Research Results, 2025

The conditions in this experiment consist of 3 treatments with aerobic processes.using the windrow method as a medium for making compost, namely:

a. Treatment 1 : goat manure + cassava peel
b. Treatment 2 : goat manure + cassava peel + Green Phoskko
c. Treatment 3 : goat manure + cassava peel + Em4



Graph 2. Comparison of Changes in Organic C Values from 3 Types of Treatment During the Composting Process.

It can be seen from graph 4.2 that increasing fermentation time causes the concentration of organic C to decrease. This occurs due to the activity of microorganisms where organic C is used as an energy source for the activity of microorganisms in addition to the organic C content will also decompose in the form of CO2 into the air, Marlina (2016). According to Pradiksa (2022) where the more compost decomposes, the organic C value will decrease while the nitrogen (N) content will increase. This is supported by the statement from Purnomo et al. (2017) which states that the decrease in organic C content occurs because compost that has experienced maturity will continue to decompose which results in the nitrogen content will increase with the formation of ammonia. The windrow composting method can accelerate the decrease in organic carbon levels because periodic turning of the pile increases aeration, so that the activity of aerobic microorganisms in decomposing organic matter into carbon dioxide (CO_2) takes place more optimally.

The organic C level was indicated by treatment 2 because it had the largest decrease in organic

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C up to 15.55% on the 28th day. One of the bacteria that can accelerate the degradation process is Trichoderma sp. Trichoderma sp. has benefits as a decomposer, which encourages the acceleration of the decomposition process of organic materials. The decomposing enzymes found in these fungi result in the process of organic materials in the form of cellulose becoming faster (Adhi & Muda, 2014). Trichoderma sp. is a mold that has a fairly high cellulolytic activity, this mold has a cellulase enzyme consisting of an exogluconase enzyme (Suyanto & Irianti, 2015), so it can decompose organic compounds into compost.

Meanwhile, in treatment 3, organic C decreased from an initial level of 37.34% to 17.80%. Em4 contains Lactobacillus sp. microbes, yeast, Lactobacillus sp. microbes that work quickly at the beginning of fermentation. Yeast produces cellulase enzymes to break down cassava peel cellulose. However, Em4 does not contain as much lignin-rotting fungi as Green Phoskko, so the lignin component in the cassava peel remains more, causing the final Organic C value to be slightly higher (17.8%) than Green Phoskko (15.55%).

3. Comparison of Changes in C/N Ratio Values from 3 Types of Treatment During the Composting Process

The addition of goat manure as a nitrogen source aims to reduce the C/N ratio of the starting material by increasing the availability of nitrogen, thereby accelerating the decomposition process and producing compost with characteristics that meet the quality standards of mature compost.

Table 3. Comparison of changes in C/N ratio values in 3 types of treatment during the composting process.

Day	C/N concentration Treatment	C/N concentration Treatment	C/N concentration Treatment
	1	2	3
0	33.74	33.74	33.74
7	25.00	23.50	24.50
14	23.50	17.00	18.00
21	20.65	12.50	14.00
28	17.00	10.50	11.50

Source: Research Results, 2025

The conditions in this experiment consist of 3 treatments with an aerobic process using the windrow method as a medium for making compost, namely:

a. Treatment 1: goat manure + cassava peel
b. Treatment 2: goat manure + cassava peel + Green Phoskko
c. Treatment 3: goat manure + cassava peel + Em4

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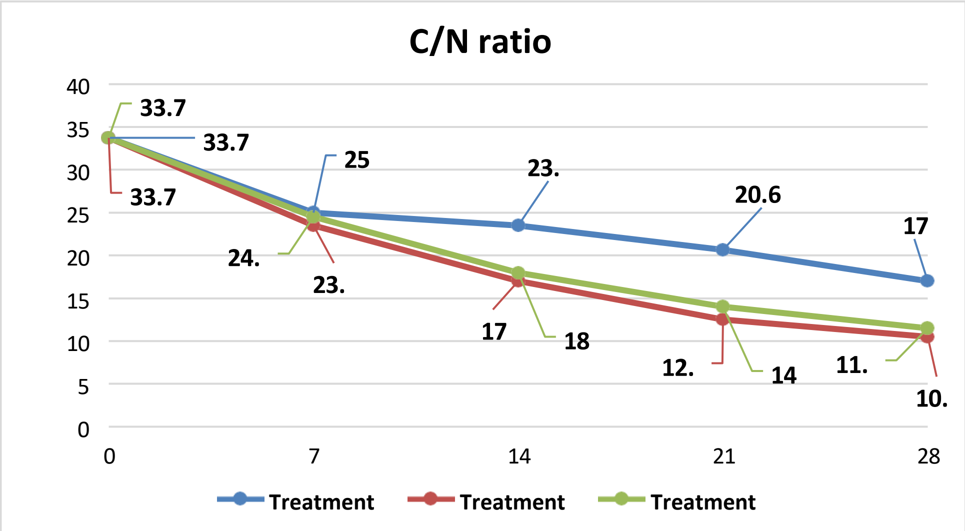

Graph 3. Comparison of Changes in C/N Ratio Values from 3 Types of Treatments During the Composting Process.

Based on graph 3, it can be concluded that all three treatments experienced a decrease in the C/N ratio. The decrease in the C/N ratio occurred due to a decrease in the organic C content and an increase in the nitrogen content in the compost. The decrease in C/N that occurred in all treatments was caused by microbial activity, because microbes use organic matter as a carbon source, which is utilized for their growth and development. This is in accordance with the opinion of Rajesh et al., (2016), composting depends on microbial activity that requires carbon as an energy source and cell formation, as well as nitrogen for the formation of cell proteins. Windrow composting supports the growth of aerobic microorganisms that play an important role in accelerating the process of organic material decomposition. With regular turning, oxygen remains available so that the decomposition process by microbes takes place effectively and efficiently, and accelerates the reduction of the C/N ratio during the composting process.

Composting time affects the composting process; the longer the composting process, the lower the C/N ratio. This is because the C content in the compost material has decreased significantly due to its use by microorganisms as a food and energy source, while the nitrogen content has increased due to the decomposition process of the compost material by microorganisms that produce ammonia and nitrogen, thus decreasing the C/N ratio (Trivana and Pradhana, 2017).

Of the three treatments, treatment 2 showed that treatment 2 reduced the C/N ratio quickly and stably, having a final value of 10.50, approaching the optimal ratio for compost, indicating that organic matter had been completely decomposed. Green phoskko contains lignin and cellulose-decomposing microbes (Trichoderma, Aspergillus, Prnicillium) that are capable of decomposing complex organic matter. High levels of cellulose and lignin will cause the rate of decomposition of organic matter into compost to be quite long, so an activator is needed to speed up the composting time. Green phoskko has the availability of supporting nutrients, namely NPK, to accelerate microbial growth, increase enzymatic activity, accelerate the decomposition of organic matter so that the C/N ratio decreases quickly.

Meanwhile, in treatment 3, the results on the 28th day showed a value of 11.50. EM4 is effective in composting, especially for easily decomposed materials, but for fibrous materials such as cassava peels, EM4 is less than optimal because it does not contain lignocellulose-decomposing microbes or supporting nutrients.

Percentage (%) reduction in C/N ratio with 3 (three) treatments during 28 days of fermentation. Calculation formula for percentage reduction in C/N content:

$$\text{Percentage decrease (\%)} = \frac{\text{C/N awal} - \text{C/N akhir}}{\text{C/N awal}} \times 100\%$$

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In treatment 1 from day 0 to day 7 there was a decrease of 0.26%, on day 7 to day 14 there was a decrease of 0.06%, on day 14 to day 21 there was a decrease of 0.12%, on day 21 to day 28 there was a percentage decrease of 0.18%. In treatment 2 from day 0 to day 7 there was a decrease of 0.30%, on day 7 to day 14 there was a decrease of 0.28%, on day 14 to day 21 there was a decrease of 0.26%, on day 21 to day 28 there was a percentage decrease of 0.16%. In treatment 3 from day 0 to day 7 there was a decrease of 0.27%, on day 7 to day 14 there was a decrease of 0.26%, on day 14 to day 21 there was a decrease of 0.22%, on day 21 to day 28 there was a percentage decrease of 0.19%.

4. Comparison of pH Value Changes from 3 Types of Treatment During the Composting Process

pH observations were carried out every 5 days with a time span of 28 days using a soil analyzer.

Table 4. Results of pH observations

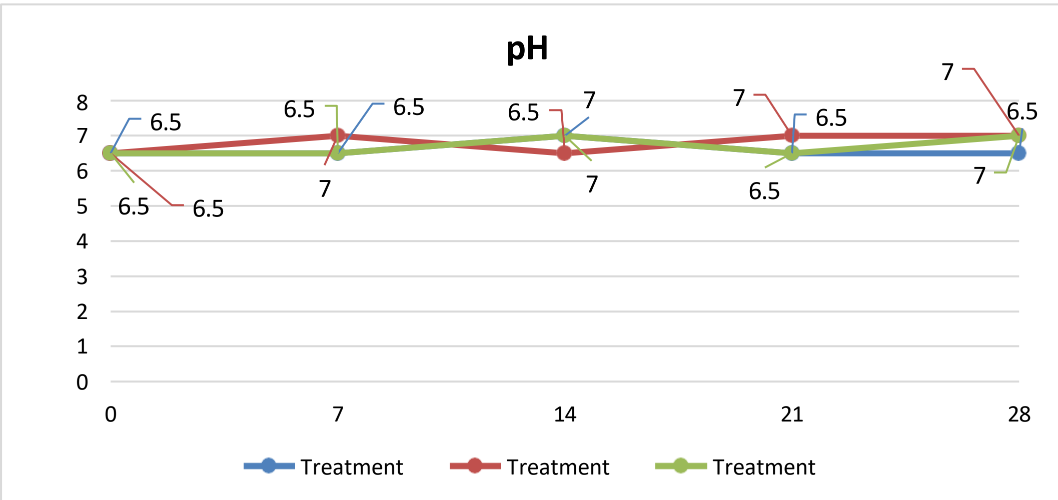
Day	Treatment 1	Treatment 2	Treatment 3
0	6.5	6.5	6.5
7	6.5	7	6.5
14	7	6.5	7
21	6.5	7	6.5
28	6.5	7	7

Source: Research Results, 2025

The conditions in this experiment consist of 3 treatments with an aerobic process using the windrow method as a medium for making compost, namely:

a. Treatment 1: goat manure + cassava peel
b. Treatment 2: goat manure + cassava peel + Green Phoskko
c. Treatment 3: goat manure + cassava peel + Em4

Based on the fermentation process that has been carried out on samples on days 0, 7, 14, 21, and 28. The results of laboratory tests for pH measurements using cassava peel and goat feces as raw materials with Green phoskko and Em4 activators are presented in Graph 4 as follows:



Graph 4. Comparison of changes in pH values from 3 types of treatment During the Composting Process.

The degree of acidity (pH) is one of the composting indicators that affects microbial activity during the composting process. The pH in this study ranged from 6-7. From day 0 to day 28, the pH

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values of the three treatments were around 6.5 to 7. Increases and decreases in pH indicate that microorganism activity is occurring in decomposing organic matter (Amalia and Widiartika, 2016). Furthermore, according to Ole (2013), the composting process itself will cause changes in the organic matter and the pH of the material itself.

The pH of mature compost is usually close to neutral. In treatment 1, pH changes were slower because it didn't contain a bioactivator. However, in treatments 2 and 3, changes were faster because microbes accelerated decomposition. The microbes in the bioactivator accelerated the decomposition of organic matter (carbohydrates and proteins), resulting in more intensive and earlier fermentation and formation of pH-active compounds (organic acids and ammonia), and faster decomposition.

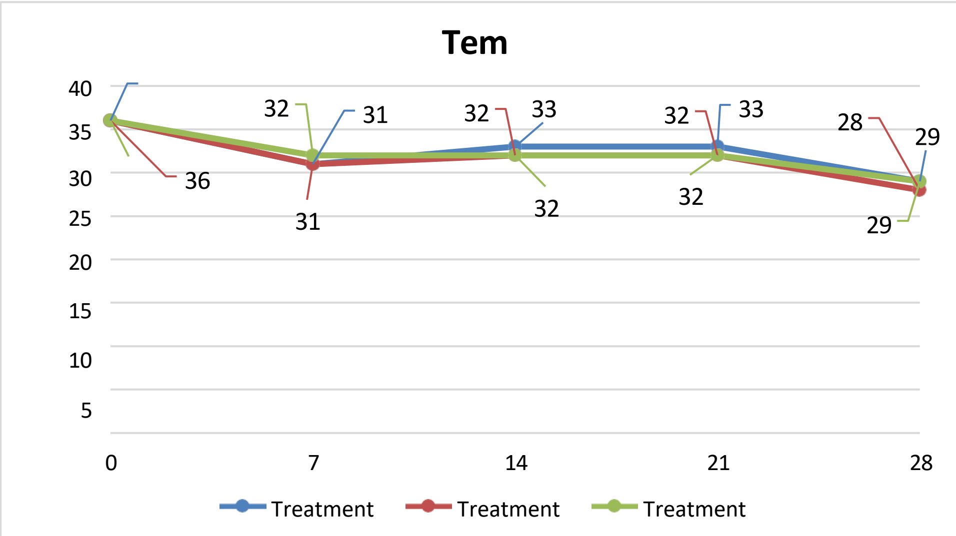
5. Comparison of Temperature Changes from 3 Types of Treatment During the Composting Process

Temperature observations were conducted every five days over a 28-day period using a soil analyzer. The following table compares temperature changes across the three treatments during the composting process.

Table 5. Comparison of Changes in Temperature Values from 3 Types of Treatment During the Composting Process.

Day	Treatment 1	Treatment 2	Treatment 3
0	36	36	36
7	31	31	32
14	33	32	32
21	33	32	32
28	29	28	29

Source: Research Results, 2025



Graph 5. Comparison of Changes in Temperature Values, from 3 Types Treatment During the Composting Process.

The conditions in this experiment consist of 3 treatments with an aerobic process using the windrow method as a medium for making compost, namely:

a. Treatment 1: goat manure + cassava peel
b. Treatment 2: goat manure + cassava peel + Green Phoskko
c. Treatment 3: goat manure + cassava peel + Em4

From the table and graph data above on day 0 to day 28 in the control tank decreased from 36oC

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to 29oC. In the green phoskko treatment the temperature on day 0 to day 28 decreased from 36oC to 28oC, and in the Em4 treatment the temperature on day 0 to day 28 decreased from 36oC to 29oC. During the composting process, it cannot reach the thermophilic temperature (40oC) but only reaches the mesophilic temperature (30oC), possibly the low pile height causes the heat generated to not be retained for long in the pile and immediately escapes (IndrastidanWimbanu, 2006). The increase in temperature occurs due to microbial activity, but during aerobic decomposition the temperature will slow down to decrease. After all this happens, the composting has been windrow completed (Couth & Trois, 2012).

Conclusion

This study showed that Green Phoskko and EM4 activators significantly accelerated the windrow composting process of a mixture of goat manure and cassava peel waste, with Green Phoskko excelling in reducing the C/N ratio to 10.50, increasing nitrogen to 2.80%, and reducing organic C to 15.55% on day 28. All three treatments achieved a neutral pH (6.5-7) and mesophilic temperature (28-32°C) which are optimal for aerobic decomposition, meeting SNI 7763:2018 standards. Green Phoskko is effective thanks to lignocellulose-degrading microbes such as Trichoderma sp. and Actinomycetes that decompose the complex material of cassava peel, while EM4 (C/N ratio 11.50%) is better for initial fermentation via Lactobacillus sp. These findings demonstrate the potential of both activators to convert Lampung organic waste into high-quality fertilizer in 28 days, addressing the problem of high initial C/N ratio (>33) that inhibits natural composting.

Despite optimal results, limitations include the small laboratory scale (6 kg/treatment), a limited fermentation time of 28 days without field plant testing, and the absence of quantitative microbiological analysis and secondary parameters such as P, K, or pathogens. Suggestions for further research include industrial scale (>100 kg), activator dosage comparison, plant bioassay tests, and cost-benefit economic analysis. Practically, Lampung tapioca farmers and industries can adopt Green Phoskko for rapid composting, reducing open dumping pollution in accordance with Law No. 18/2008, saving chemical fertilizers, and increasing income from sustainable organic fertilizers, supporting green farming in the cassava center of 39.74 million tons/year.

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