The Application of Liquid Organic Fertilizer Resulting From the Anaerobic Fermentation Process of *Trichoderma sp* Spores and Banana Peel Waste (*Musa paradisiaca l.*) to Plants

Sofiah[1],* Siti Chodijah[2], Adi Syakdani[3], Melantina Oktriyanti[4], Liana Aprilayondra[5], Nadia Yulianti[6], Nova Humairoh[7], Hari Chandra[8]

[123456]*Chemical Engineering Department, Politeknik Negeri Sriwijaya, Palembang, Indonesia*
[7]South Sumatra Province Food Security and Livestock Service
[8] UPTD Plantation Plant Protection Center, South Sumatra Province
sofiahzainal_sofie@yahoo.com

Abstract. Liquid organic fertilizer is produced through the fermentation of plant waste. This study aims to determine the optimal fermentation time, the effect of Trichoderma sp addition on NPK content, and whether the fertilizer meets the standards set by Minister of Agriculture Regulation No. 261/KPTS/SR.310/M/4/2019[1]. The fertilizer was made using an anaerobic fermentation process with banana peels, cassava leaves, and EM4 as a bioactivator. The independent variables were fermentation durations of 0, 7, 14, 21, and 28 days, along with Trichoderma sp additions of 10g and 30g. Constant variables included 2 kg banana peel waste, 4000 ml coconut water, 1 kg cassava leaves, 75 ml EM4, and 250 g brown sugar. The results showed that the best fermentation occurred on day 28 with the addition of 30g Trichoderma sp. However, Trichoderma sp did not significantly influence NPK levels. The analysis revealed that the NPK content of the fertilizer, derived from banana peel waste, coconut water, and cassava leaves, did not meet the minimum technical quality standards for organic fertilizers, which require an NPK content of 2-6% as per the Minister of Agriculture's Decree No. 261/KPTS/SR.310/M/4/2019[2]. This study highlights the need for further optimization to enhance the NPK levels in liquid organic fertilizer.

Keywords: Liquid organic fertilizer, banana peel waste, old coconut water, EM4, cassava leaves, Trichoderma sp.

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1. Introduction

The Trichoderma sp. fungus is a microorganism that lives in the soil and naturally decomposes organic matter, helping plants by attacking pathogenic fungi that can cause diseases. [6]. According to research results [1], the spore density of Trichoderma sp. can inhibit the growth of F. moniliformae or the disease-causing fungus for plants. Trichoderma sp is also known for its ability to enhance nutrient availability for plants by decomposing organic matter in the soil. This makes it a useful agent in improving soil quality and supporting plant growth. The specific composition of Trichoderma sp. content can vary depending on the species and its growth conditions. However, in general, these substances work together to provide various benefits for plants and soil. Trichoderma sp has several mechanisms of action, one of which is producing antifungal compounds that can inhibit the growth of pathogens in plants. It is also known for its ability to decompose organic matter and can produce beneficial enzymes.

Fig 1. *Trichoderma sp.* Fungus
Source : Plant Protection Plantation Bureau, Archive 2023[7]

Banana peels are one of the abundant organic wastes, with Indonesia producing around 2.5 million tons of banana peels each year. Banana peel waste is often discarded without any further processing, even though banana peel waste does not pose environmental problems because it can biodegrade. One way to process banana peel waste is by turning it into liquid organic fertilizer. On the other hand, the demand for fertilizers is increasing, and excessive use of chemical fertilizers can lead to soil degradation and environmental pollution. Liquid organic fertilizer (LOF) made from natural materials like banana peels can be an environmentally friendly and sustainable alternative solution.

Fig 2. Waste from Pisang Lilin Peels

Additives such as mature coconut water are rich in mineral elements like K, N, Ca, Mg, Fe, Cu, P, and S, which are often used as one of the ingredients in the production of liquid organic fertilizers in almost all manufactured fertilizer products.[8].

Fig 3. Mature Cocount Water

Effective Microorganisme 4 (EM4) is a solution containing a mixture of microorganisms that are beneficial for the environment. This mixture consists of three main types of microorganisms: bacteria, yeast, and fungi, which help accelerate the decomposition of organic materials, improve soil quality, support plant growth, enhance soil fertility, increase nutrient availability, and aid in the formation of humus.

Fig 5. EM4

The nitrogen content in cassava leaves ranges from 2-3%, phosphorus from 0.5-1%, and potassium from 1-2%, along with calcium and magnesium, which play important roles in plant growth. Iron, zinc, copper, and boron help enhance plants' resistance to diseases and pests. Amino acids, plant hormones, and carbohydrates in cassava leaves help improve soil fertility and provide energy for beneficial microorganisms.

Fig 6. Cassava leaves

Red sugar contains carbohydrates, which are an easily accessible energy source for microorganisms, as well as various important minerals such as potassium, magnesium, and phosphorus. Potassium plays a role in nutrient transportation and enhances plant resistance to diseases. Magnesium is a key component of chlorophyll that is essential for photosynthesis, as well as activating the enzymes necessary for plant growth. Phosphorus is important for strong root development, flower and fruit formation, and overall improvement in plant quality.

Fig 7. Red Sugar

2. Research Material and Method

2.1 Research Location

Research on the Production of Liquid Organic Fertilizer Using Trichoderma sp. Spores with Banana Peel and Pineapple Peel Waste, Utilizing EM-4 Bioactivator and Coconut Water, was conducted at the Plant Protection Laboratory of the Plantation Research Center located at Jl. Kenten Sako No. 607 Palembang and Chemical Engineering KAI Laboratories Sriwijaya State Polytechnic at Palembang.

2.2 Research Proposal

2.2.1 Experiment Proposal

In this research, banana peel waste, pineapple peel, and coconut water waste were used as raw materials in the production of liquid organic fertilizer (POC) through a fermentation process. The treatments applied include the effect of varying fermentation times, the addition of bioactivator volume (EM-4), and Trichoderma sp. on the nitrogen, phosphorus, and potassium content in the liquid organic fertilizer, ie:

1. The preparation process of the tools and materials used.
2. The production of liquid organic fertilizer from banana peel waste and coconut water waste.
3. Research on the production of liquid organic fertilizer through anaerobic fermentation, which includes several analyses such as the analysis of N, P, and K content in the liquid organic fertilizer, as well as physical observations like smell, color, and pH of the fertilizer product.

2.2.2 Experiment Variable

a. Independent Variables
   Raw material amounts : Banana peels wastes 1kg
   Carbohydrate source amount : Coconut water wastes 2500 ml.
b. Research Variables
   Fermentation time : 0, 7, 14, 21, and 28 days
   EM4 Bioactivator Volume : 75 ml
   Trichoderma sp. : 10 gr, 20 gr, 30 gr, and 40

2.3 Tools and Materials

2.3.1 Tools

1. Plastic Bottle 1,5 L
2. Spatula
3. Analytical Balance
4. Thermometer
5. Hose
6. Plastic Bottle
7. Scissors
8. Blender
9. Filter
10. Funnel
11. Petri Dish
12. Knife
13. Test Tube
14. Wooden Stirrer
15. Glove
16. Litmus Paper
17. Hemocytometer
18. Microscope
19. UV-Vis Spectrophotometry

2.3.2 Material

1.	Banana peels wastes	20kg
2.	Coconut water wastes	5litre
3.	Potatos	200 g
4.	White Sugar	20 g
5.	EM4 Bioactivator	150ml
6.	*Trichoderma sp.*	120 g
7.	Distilled water	1 liter
8.	Antibiotic meditation	

The Process of activating *Trichoderma sp*

Fig 8. The process of activating *Trichoderma*

Research flowchart

A. *Trichoderma sp.* Activation Flowchart

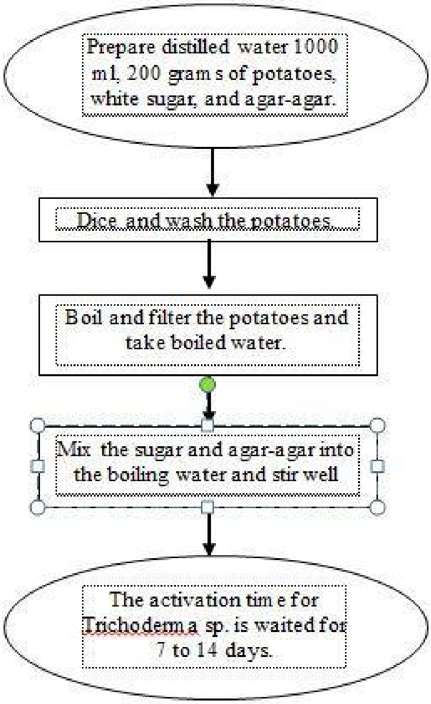

Fig. 9. *Trichoderma sp.* Activation Flowchart

B. Liquid Organic Fertilizer Production Flowchart

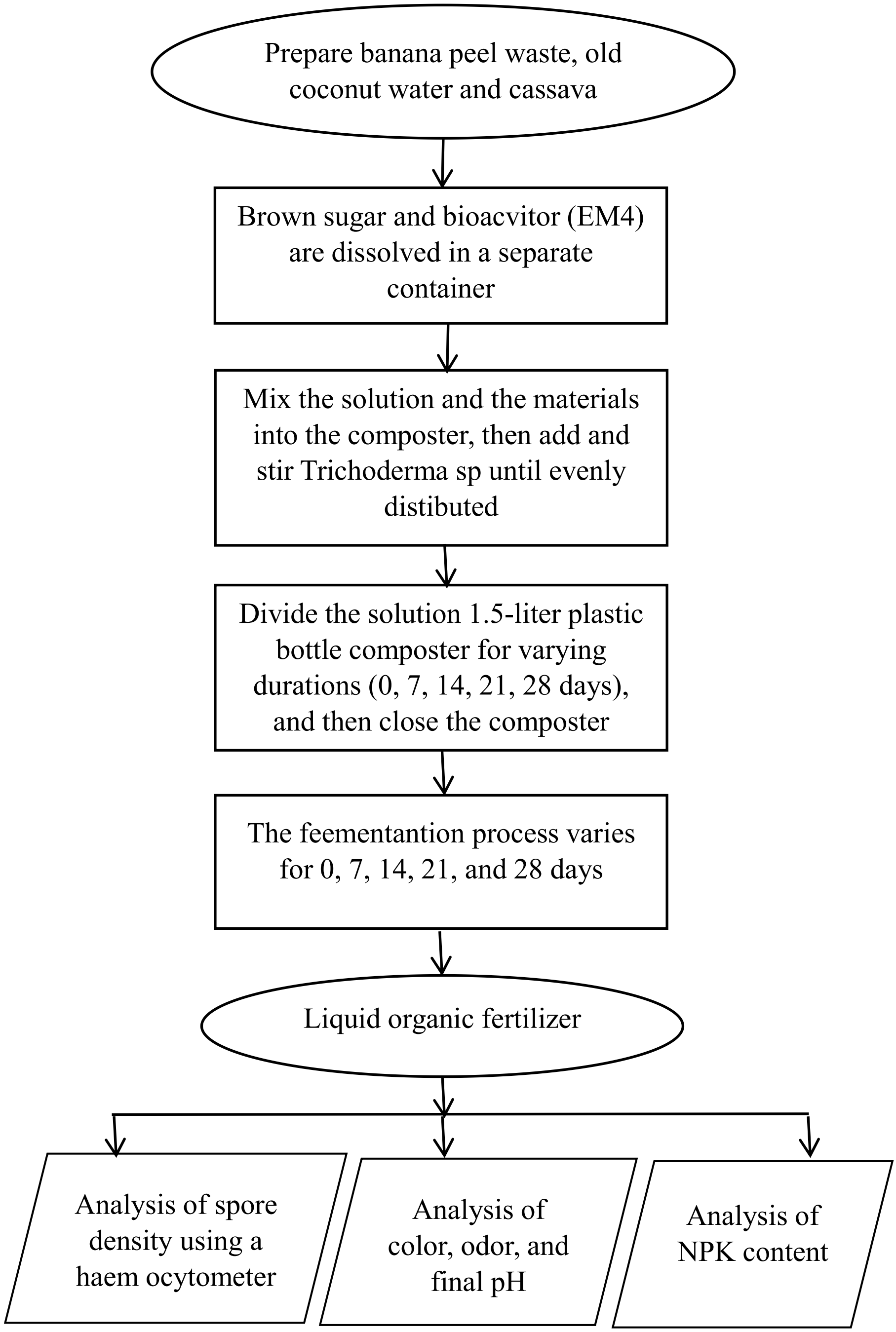

Fig. 10. Liquid Organic Fertilizer Production Flowchart

3. Result and Discussion

3.1 Result

The production of liquid organic fertilizer using banana peel waste and coconut water as raw materials. The implementation of this research on the production of liquid organic fertilizer was conducted from April 18, 2024, to May 18, 2024, at the UPTD Plant Protection Hall, Jl. RH. Amaluddin No. 607 Kenten Sako, Palembang, South Sumatra Province. The production of this liquid organic fertilizer is supplemented with the bioactivator EM4 and variations of Trichoderma sp. additions of 10 grams and 30 grams, with fermentation times varying (0, 7, 14, 21, 28) days. From the variable with the addition of 10 grams of Trichoderma sp., 5 samples were obtained, and from the 30 grams of Trichoderma sp., 5 samples were also obtained. The liquid organic fertilizer was then analyzed for the spore density of Trichoderma sp. and the NPK content of the fertilizer.

Table 3.1 Results of Physical Observation of Liquid Organic Fertilizer

***Trichoderma* Variation (gr)**	**Fermentation Time (Days)**	**pH**	**Colour**	**Odour**
10	0	6	Dark green	Not pungent
	7	5	Brownish green	Slightly pungent
	14	5	Brownish green	Very pungent
	21	4	Brownish green	Very pungent
	28	4	Yellowish green	Slightly pungent
30	0	5	Dark green	Not pungent
	7	5	Brownish green	Slightly pungent
	14	4	Brownish green	Very pungent
	21	4	Brownish green	Very pungent
	28	4	Yellowish green	Slightly pungent
PERMENTAN STANDARD 2019		4-9		

Table 3.2 Results of NPK Content Analysis of Liquid Organic Fertilizer

***Trichoderma* Volume (gr)**	**Fermentation Time (Days)**	**Spora Density (cfu/ml)**	**The Level of Nutrient Elements**		
			N (ppm)	**P_2O_5 (ppm)**	**K_2O (ppm)**
10	0	10,175 X 10^7	24,4668	17,35904	2675,38
	7	12,3 X 10^7	482,01	336,51710	3663,59
	14	16,75 X 10^7	562,92	236,59032	4338,46
	21	20,075 X 10^7	765,9	320,46194	3205,64
	28	23,8 X 10^7	754,29	331,50129	2820
30	0	24,35 X 10^7	26,22	24,72495	3482,82
	7	28,6 X 10^7	568,08	295,72645	2651,28
	14	31,275 X 10^7	611,12	509,84871	5332,69
	21	33,275 X 10^7	911,19	370,94065	3446,67
	28	35,275 X 10^7	778,92	385,00323	3398,46
PERMENTAN STANDARD 2019[2]		$\geq 1 \times 10^5$	20000-60000	20000-60000	20000-60000

Table 3.3 Conversion of NPK Content Analysis Results of Liquid Organic Fertilizer

***Trichoderma* Volume (gr)**	**Fermentation Time (Hari)**	**The Level of Nutrient Elements**			
		N (%)	**P_2O_5 (%)**	**K_2O (%)**	**NPK Total**
10	0	0,002447	0,00174	0,267538	0,27172
	7	0,048201	0,03365	0,366359	0,44821
	14	0,056292	0,02366	0,433846	0,5138
	21	0,07659	0,03205	0,320564	0,4292
	28	0,075429	0,03315	0,282	0,39058
30	0	0,002622	0,00247	0,348282	0,35338
	7	0,056808	0,02957	0,265128	0,35151
	14	0,061112	0,05098	0,533269	0,64537
	21	0,091119	0,03709	0,344667	0,47288
	28	0,077892	0,0385	0,339846	0,45624
PERMENTAN STANDARD 2019[2]					2-6

The results of the products can be seen in Figures 16 and 17, and the analysis of nutrient content and characteristics of liquid organic fertilizer from banana peel waste with coconut water has been tabulated in Tables 3.1, 3.2, and 3.3 below.

4.2 Discussion

In this study, the analysis results of spore density in liquid organic fertilizer made from banana peel waste, coconut water, and cassava leaves yielded a graph that can be seen in Figure 11.

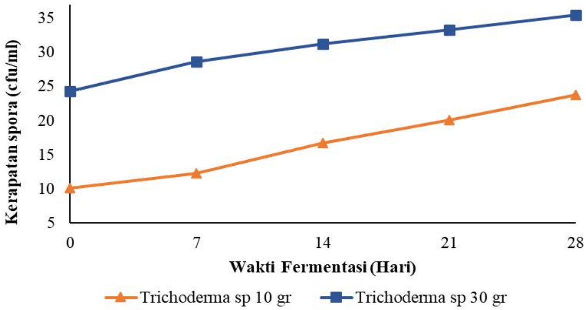

Fig 11: Graph of the Relationship between Trichoderma sp. Variation and Fermentation Time on Spore Density

Figure 11 shows that spore density increases from day 0 to day 28 because the initial inoculum amount (initial spore count) affects the rate of spore density growth during the fermentation process. The highest spore density was found in the treatment with the addition of Trichoderma sp 30 g on day 28, which was 35.475 x 10^7 cfu/ml, while the lowest spore density was observed in the treatment with the addition of Trichoderma sp 10 g on day 0, which was 10.175 x 10^7 cfu/ml. Based on all the spore density data obtained, it can be stated that it meets the quality standards for liquid organic fertilizers according to PERMENTAN No. 261/KPTS/SR.310/M/4/2019[3], which is ≥ 1 x 10^5 cfu/ml. The content of nitrogen, phosphorus, and potassium in liquid organic fertilizer

a. Nitrogen Content (N)

1.Based on the analysis results of nitrogen content in liquid organic fertilizer from banana peel waste, coconut water, and cassava leaves, it can be seen in Figure 12.

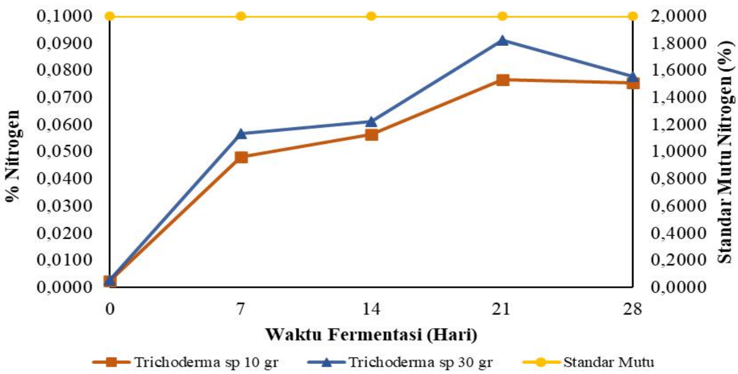

Fig 12. Graph of the Relationship between Trichoderma sp. Variation and Fermentation Time on Nitrogen Content

2.Based on the analysis results of spore density against the nitrogen content of liquid organic fertilizer from banana peel waste, coconut water, and cassava leaves, it can be seen in Figure 13.

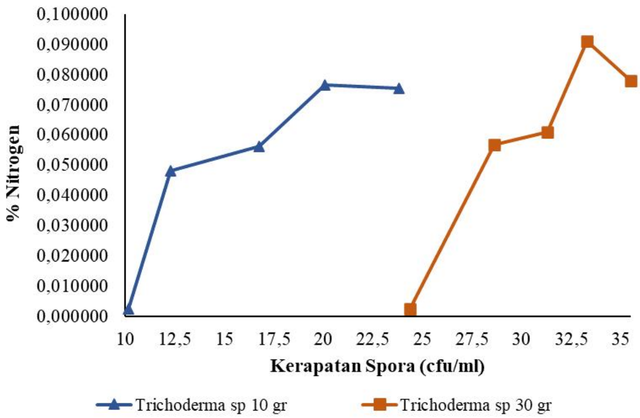

Fig. 13. Graph of the Relationship Between Trichoderma sp. Spore Density and Nitrogen Content

Figure 13 shows that with each variation in the addition of Trichoderma sp., the nitrogen content increases in line with the increase in the spore density of Trichoderma sp. The highest nitrogen content was obtained at a spore density with the addition of 30 grams of Trichoderma sp. in a petri dish, which was 0.091119%, with a spore density of 33.275 x 10^7 cfu/ml. The lowest nitrogen content was found at a spore density with the addition of 10 grams of Trichoderma sp. in a petri dish, which was 0.002447%, with a spore density of 10.175 x 10^7 cfu/ml.

Phosphorus Content (P)

Based on the analysis results of phosphorus content in liquid organic fertilizer from banana peel waste, coconut water, and cassava leaves, it can be seen in Figure 14.

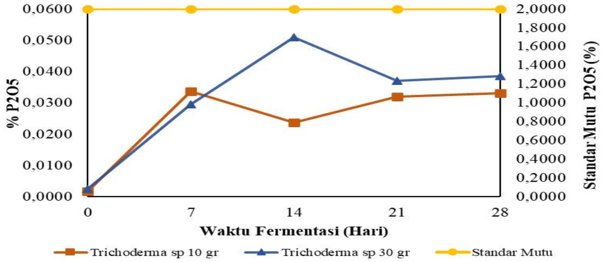

Fig. 14. Graph of the Relationship between Trichoderma sp. Variation and Fermentation Time on Phosphorus Content

Figure 14 shows a graph depicting the increase and decrease of phosphorus content, which occurs due to fermentation conditions such as temperature and pH that can affect microbial activity. The highest P2O5 content is found in the addition of 30 grams of Trichoderma sp with a fermentation time of 14 days, which is 0.050985%, while the lowest is in the addition of 10 grams of Trichoderma sp on day 0, which is 0.001736%.

Fig. 15. Results of Trichoderma sp. Activation

Fig. 16. Liquid Organic Fertilizer Products

Application of Liquid Organic Fertilizer from Banana Peel Waste and Old Coconut Water

In this study, the product of liquid organic fertilizer can be seen in Figure 16. This liquid organic fertilizer will be applied to plants with yellowing and wilting leaves, as shown in Figure 17. The results of applying this liquid organic fertilizer after the second week indicate a change in leaf color, which previously was yellow, now turning green and fresh again. Based on the results of applying liquid organic fertilizer made from banana peel waste and old coconut water, it has been proven effective in addressing yellowing leaves and restoring plant health. This is due to the nutrient content in the banana peel, particularly potassium (K), which helps enhance the plant's resistance to diseases, as well as other nutrients such as nitrogen (N) and phosphorus (P), which play important roles in the photosynthesis process and aid in chlorophyll formation.

Fig. 17. Comparison of Plants Before and After the Application of Liquid Organic Fertilizer from Banana Peel Waste and Old Coconut Water

4. Conclusion

The liquid organic fertilizer made from banana peel waste, old coconut water, and cassava leaves has not yet met the standards for liquid organic fertilizer according to PERMENTAN No. 261/KPTS/SR.310/M/4/2019[2], which stipulates that the NPK content of liquid organic fertilizer should be between 2-6%. However, the application of this liquid organic fertilizer to plants has yielded good results, as plants with yellowing leaves can turn green again after the second week of applying the liquid organic fertilizer made from banana peel waste, old coconut water, and cassava leaves.

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