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UTILIZATION OF MORINGA LEAVES (Moringa Oleifera) AND LAMTORO LEAVES (Leucaena Leucocephala) AS RAW MATERIALS FOR MAKING LIQUID ORGANIC FERTILIZER (LOF)

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ABSTRACT

This study aims to utilize Moringa leaves (Moringa oleifera) and Leucaena leucocephala leaves (Leucaena leucocephala) as raw materials for making environmentally friendly liquid organic fertilizer (POC). This study examines the effect of the composition of raw materials of Moringa leaves and Leucaena leucocephala leaves, as well as fermentation time on the quality of the resulting POC, which is tested based on parameters of pH, Total Dissolved Solids (TDS), macronutrient content (nitrogen, phosphorus, potassium), and C-organic content. This study was conducted with variations in the composition of Moringa leaves and Leucaena leaves at a ratio of 1:0, 3:1, 1:1, 1:3, and 0:1, as well as varying fermentation times for 7, 12, 17, 22, and 27 days. The results of the study showed that the combination of Moringa leaves and Leucaena leucaena leaves at a ratio of 1:1 and fermentation for 17 days produced POC with optimal nutritional content, namely Nitrogen (0.31%), Phosphorus (0.17%), Potassium (0.25%), and C-organic (0.42%). In addition, this study also showed that fermentation time had a significant effect on the quality of POC, with an increase in POC quality on the 17th day of fermentation. The results of this study can be used as an alternative in making liquid organic fertilizers with local, environmentally friendly raw materials, as well as contributing to sustainable agriculture through the use of more efficient and affordable fertilizers.

Keywords: Liquid Organic Fertilizer, Moringa Leaves, Leucaena Leaves, Fermentation, Plant Nutrition.

1. INTRODUCTION

1.1 Background

Agriculture is a crucial sector supporting food security and a country's economy. However, modern agricultural practices that rely on the excessive use of chemical fertilizers have caused various environmental problems, such as land degradation, water pollution, and soil degradation. Long-term use of chemical fertilizers can disrupt the natural balance of ecosystems and reduce soil fertility. To achieve sustainable agriculture, more environmentally friendly and efficient fertilizer alternatives are needed (Rahma, 2024).

Organic fertilizers are an alternative to reducing the use of inorganic (chemical) fertilizers. This is because inorganic fertilizers are increasingly expensive and can leave harmful chemical residues behind. Continuous use of chemical fertilizers also increases soil acidity, forms a layer of residue that impedes oxygen circulation, and kills beneficial organisms that play a role in restoring soil fertility, such as worms and gram-positive bacteria. This further increases the need for chemical fertilizers over time, resulting in increased production costs.

Most farmers are unaware that there are solutions to reduce dependence on chemical fertilizers, one of which is organic fertilizers. The use of organic fertilizers is one way to address these problems. Besides being abundantly available, it is also cheap and environmentally friendly (Malis et al., 2022).

Liquid organic fertilizer is a solution containing one or more readily soluble substances needed by plants. This liquid organic fertilizer is produced from the decomposition of plant or leaf debris, animal or human waste. The main components of liquid organic fertilizer include nutrients such as nitrogen, phosphorus, and potassium, which are essential for plant growth. Furthermore, this fertilizer plays a role in improving soil structure and supporting the presence of microorganisms in the soil (Hidayatullah et al., 2023).

One ingredient that can be used to make liquid organic fertilizer is moringa leaves. According to Adiaha (2017), moringa leaves contain 4.02% nitrogen (N), 1.17% phosphorus (P), 1.80% potassium (K), 0.10% magnesium (Mg), 12.3% calcium (Ca), and 1.16% sodium (Na). The nutrient content of Moringa leaves indicates their potential as a liquid organic fertilizer (Anzila & Asngad, 2022).

In addition to Moringa leaves, Leucaena (lamtoro) leaves can also be used to make liquid organic fertilizer. Leucaena leaves contain essential nutrients and elements essential for plants. Leucaena leaves contain 3.84% nitrogen (N), 0.2% phosphorus (P), 2.06% potassium (K), 1.31% calcium (Ca), and 0.33% magnesium (Mg) (Sugianti et al., 2024).

Several previous studies have examined the production of liquid organic fertilizer from various organic sources. Research conducted by Susilo (2021) analyzed nitrogen, phosphorus, and potassium based on varying fermentation times with and without the use of EM4 to produce liquid organic fertilizer from Moringa leaves. In total nitrogen analysis, the optimum concentration with EM4 variation occurred on day 21 at 216.75 ppm, while without EM4, the optimum concentration occurred on day 7 at 336 ppm. The optimum phosphorus concentration with and without EM4 occurred on day 14 at 80.095 ppm and 74.38 ppm, respectively. The optimum potassium concentration in liquid moringa leaf fertilizer occurred on day 28 at 0.829 ppm, and without EM4, the optimum concentration occurred on day 7 at 0.826 ppm (Susilo, 2021).

Previous research has shown that liquid organic fertilizer (POC) from moringa leaves, even after optimization with variations in fermentation time and EM4 use, still does not meet quality standards, particularly in terms of nutritional content. Therefore, this study aims to combine moringa leaves and lamtoro leaves as raw materials for POC production. This combination is expected to improve the quality of the fertilizer, particularly in terms of its more complete and balanced nutritional content, thus meeting the quality standards set by the Indonesian Ministry of Agriculture Decree No. 261 (2019). The combination of these two leaf types is predicted to produce a positive synergy that can improve the quality and quantity of essential nutrients in the fertilizer (Sugianti et al., 2024).

2. RESEARCH METHODS

Research methodology

2.1 Research Place

This research was conducted at the Water and Waste Treatment Laboratory, Chemical Engineering Department, Lhokseumawe State Polytechnic.

2.2 Tools and Materials

2.2.1 Tools used

The tools used in this study include: jerry cans, plastic hoses, aqua bottles, scales, scissors/knives, blenders, filters, sample bottles, volume pipettes, ball pipettes, beaker glasses, measuring flasks, pH meters, TDS meters, TOC Analyzers, Kjeldahl, UV-Vis Spectrophotometers, and ICP (Inductively Coupled Plasma).

2.2.2 Materials used

The materials used to make liquid organic fertilizer in this study include moringa leaves, lamtoro leaves, EM4 (Effective Microorganism-4), old coconut water, molasses (sugarcane drops), and water.

2.3 Experimental Treatment Design

2.3.1 Fixed Variables

- EM4 : 20 ml
- Old Coconut Water : 500 ml
- Molasses : 20 ml
- Water : 1 liter
- Total mass of ingredients moringa leaves: lamtoro leaves: 100 g

2.3.2 Independent Variables

- Ingredients (Moringa leaves : Leucaena leaves): 1:0, 3:1, 1:1, 1:3, 0:1
- Fermentation time: 7, 12, 17, 22, and 25 days

2.3.3 Dependent Variable

1. pH Test
2. TDS Test
3. Organic Carbon Test
4. Nitrogen Content Test
5. Phosphorus (P^2O^5) Content Test
6. Potassium (K^2O) Content Test

2.4 Experimental and Testing Procedures

2.4.1 Making the Fermentation Solution

1. Prepare 1 liter of water in a 2-liter jerry can.
2. Add 20 mL of EM4 and 20 mL of molasses, then stir until evenly distributed.
3. Then, let the solution stand for approximately 30 minutes before use.

2.4.2 Preparing the Fermentation Equipment and Raw Materials

Preparing the fermentation equipment

1. Prepare the jerry can, plastic tubing, and plastic bottles.
2. Punch holes in the lids of the jerry can and plastic bottles the same size as the tubing.
3. Attach tubing to both lids so that the CO_2 gas produced by fermentation can escape through the plastic bottles (indicated by the appearance of bubbles) to prevent excessive pressure in the jerry can.
4. Ensure that the plastic bottles contain water so that the fermentation gas can escape and outside air cannot enter the jerry can.

Preparing the Raw Materials

1. Prepare the moringa and lamtoro leaves.
2. Weigh the moringa and lamtoro leaves according to the following ratios: 1:0, 3:1, 1:1, 1:3, 0:1.
3. Cut the leaves into smaller pieces to make them easier to crush.
4. Place them in a blender and add a little water. Then, blend until they form a pulp or paste.

2.4.3 Making Liquid Organic Fertilizer

1. Place the ground moringa leaves and lamtoro leaves into a fermentation jerry can.
2. Add 500 ml of coconut water.
3. Add the prepared fermentation solution.
4. Close the jerry can tightly and store it in a closed, airtight container, away from direct sunlight.
5. Fermentation lasts for 7, 12, 17, 22, and 27 days, depending on the treatment.
6. Ensure the fermentation gas escapes safely (indicated by the appearance of bubbles in the water in the plastic bottle).
7. After the fermentation period has elapsed, filter the liquid organic fertilizer using a sieve to separate it from the leaf residue.
8. Analyze the pH and Total Dissolved Solids (TDS).
9. Analyze the Organic Carbon, Nitrogen, P^2O^5, and K^2O content.

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3. RESULTS AND DISCUSSION

3.1 Research Results

Table 3.1 Test Results of pH, TDS, N, P, K, and C-Organic Values and C/N Ratio of Liquid Organic Fertilizer (LOF) at Various Fermentation Times and Raw Material Compositions (Moringa Leaves: Leucaena Leaves)

Fermentation Time (days)	Ingredient composition	Testing						
		pH	TDS (ppm)	C-Organik (%)	N (%)	P_2O_5 (%)	K_2O (%)	Ratio C/N
	1:0	4,83	2874					
	3:1	4,84	2933					
7	1:1	4,89	2794	0,35	0,16	0,16	0,23	2,19
	1:3	4,75	2683					
	0:1	4,77	2971					
	1:0	4,78	3092					
	3:1	4,79	3021					
12	1:1	4,86	3041	0,29	0,20	0,15	0,23	1,45
	1:3	4,75	2916					
	0:1	4,76	3028					
	1:0	4,78	3371					
	3:1	4,76	3526					
17	1:1	4,85	3613	0,42	0,30	0,17	0,25	1,41
	1:3	4,67	3378					
	0:1	4,75	3536					
	1:0	4,36	3186					
	3:1	4,36	3393					
22	1:1	4,37	3563	0,47	0,14	0,14	0,19	3,34
	1:3	4,36	3022					
	0:1	4,37	3356					
	1:0	4,34	3123					
	3:1	4,35	3196					
27	1:1	4,36	3363	0,33	0,16	0,14	0,17	2,05
	1:3	4,35	3186					
	0:1	4,35	3331					

3.2 Discussion

Liquid organic fertilizer (POC) is an environmentally friendly alternative fertilizer derived from natural organic materials and can be used to enhance plant growth. In this study, POC was made from a combination of ingredients (moringa leaves and lamtoro leaves) through a fermentation process.

3.2.1 pH Value Testing

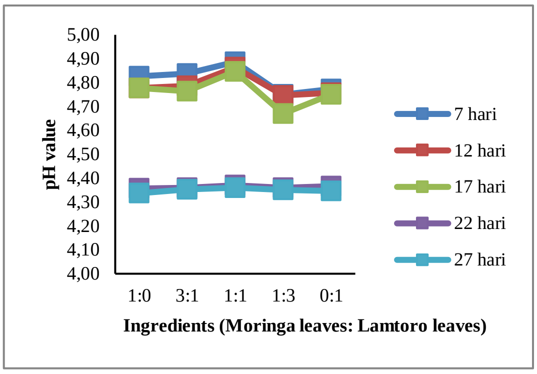

Figure 3.1 Graph of the Effect of Material Composition (Moringa Leaves: Leucaena Leaves) and Fermentation Time on pH Value

The graph above shows a pattern of decreasing pH values as fermentation time increases. The pH value decreased significantly from day 22 to day 27. This decrease in pH is closely related to the activity of microorganisms from the EM4 bioactivator, particularly lactic acid bacteria (Lactobacillus sp.), which decompose organic compounds into lactic acid and other organic acids. The accumulation of these acidic compounds becomes more dominant after fermentation passes the optimum phase, causing the solution to become more acidic.

According to (Kurniawan et al., 2017), fermentation of liquid organic fertilizer (POC) from goat urine showed a significant decrease in pH after day 12 due to the accumulation of lactic acid and other organic acids. Therefore, the decrease in pH after day 17 can be explained as a result of the increase in organic acids due to the continued activity of fermentative microbes. This indicates that day 17 is the optimal fermentation limit before excessive dehydration occurs, which could potentially reduce the quality of the POC.

3.2.2. Pengujian Nilai Total Dissolved Solid (TDS)

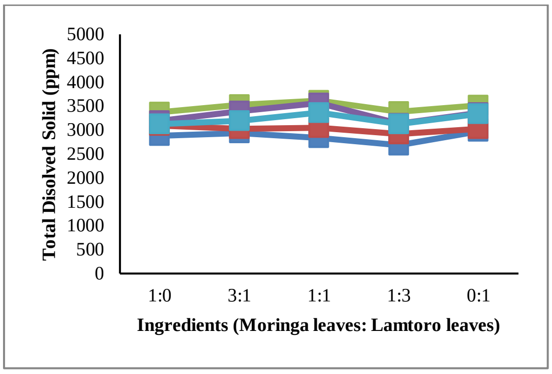

Figure 3.2 Graph of the Effect of Material Composition (Moringa Leaves: Leucaena Leaves) and Fermentation Time on TDS (Total Dissolved Solids) Values

Based on the graph above, it is known that the TDS value in the POC shows an increase along with the increase in fermentation time, especially until the 17th day. This indicates that the fermentation process actively breaks down organic matter into soluble compounds that can be utilized by plants, such as nitrogen, phosphorus, potassium, and other organic compounds. However, after the 17th day, several samples showed a decreasing trend. This decrease is thought to be caused by the activity of microorganisms that begins to decline due to limited substrate or nutrients. Over time, the organic matter in the solution begins to deplete. This causes microbial activity to decrease due to a lack of nutrients, resulting in a decrease in the production of soluble compounds. Furthermore, the composition of the ingredients also affects the TDS value. The composition of the mixture of moringa leaves and lamtoro leaves, especially at a ratio of 1:1, shows a higher TDS value than single compositions such as 1:0 (moringa leaves only) and 0:1 (lamtoro leaves only). This is due to the synergy of nutrients from the two types of leaves. The combination of these two ingredients enriches the nutritional content of the fermentation product (Sugianti et al., 2024).

3.2.3. Organic Carbon Content Testing

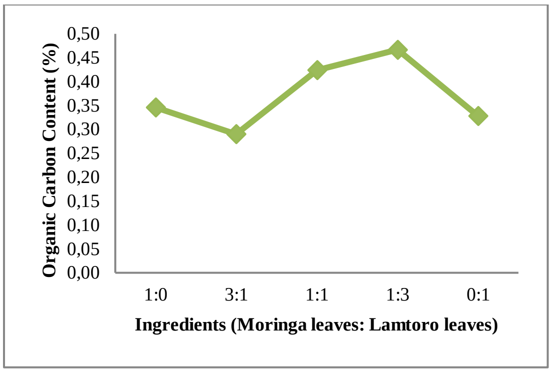

Figure. 3.3 Graph of the Effect of Material Composition on Organic Carbon Content

The graph above shows that the 1:3 composition (more lamtoro leaves) produced the highest organic carbon content, at 0.47%, followed by the 1:1 composition at 0.42%. Meanwhile, the 3:1 composition produced the lowest organic carbon content, at 0.29%.

The high organic carbon content in the 1:3 composition is thought to be due to the higher lignocellulose content in lamtoro leaves compared to moringa leaves, thus contributing more to the carbon compounds in the liquid organic fertilizer (POC). According to (Jeksen & Mutiara, 2017), lamtoro leaves contain relatively high levels of crude fiber and complex organic compounds, which can increase the carbon content of fermented products.

However, according to Minister of Agriculture Regulation No. 261/Kpts/SR.310/4/2019, the organic carbon content in liquid organic fertilizer should be at least 10%, equivalent to 100,000 ppm. This means that, although 0.47% appears relatively high across treatments, by national quality standards, all samples in this study did not meet the minimum organic carbon threshold required. This could be due to the suboptimal extraction rate of carbon compounds during the fermentation process.

3.2.4. Nitrogen Content Testing

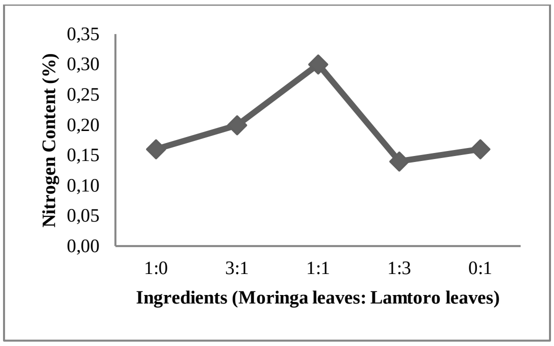

Figure. 3.4 Graph of the Effect of Material Composition on Nitrogen Content

Based on the graph above, the highest nitrogen content was found in a 1:1 composition of 0.30%, while the lowest content was found in a 1:3 composition of 0.14%. These results indicate that a balanced combination of moringa leaves and lamtoro leaves can produce a higher nitrogen content than either combination alone or in an unbalanced manner.

According to Susilo (2021), the correct composition of ingredients can influence fermentation effectiveness and the final nitrogen content, especially when dried for an optimal fermentation time and with the addition of a bioactivator such as EM4. In this case, a 17-day fermentation time has been shown to support maximum microbial activity, as indicated by the high TDS value.

Research by (Jeksen & Mutiara, 2017) also showed that lamtoro-based liquid organic fertilizer (POC) had the highest total N content among other ingredients, at 0.068%, compared to gamal (0.056%) and kirinyu (0.046%). This supports the assertion that lamtoro leaves are an organic material with a high nitrogen content.

However, all samples in this study still did not meet the standards set by Ministerial Regulation No. 261/Kpts/SR.310/4/2019, which requires a minimum total macronutrient content (N + P_2O_5 + K_2O) of 2%.

This low nitrogen content can be caused by several factors, including: initial organic matter concentration, decomposition rate during fermentation, bioactivator effectiveness, and fermentation environmental conditions such as pH and temperature. Furthermore, the length of time the samples were stored before testing can also affect total nitrogen levels. Nitrogen in the form of ammonia (NH_3) or nitrate (NO_3^-) is unstable and easily undergoes volatilization or chemical changes if not stored tightly closed and at a stable temperature. Nitrogen content can decrease during storage due to loss of nitrogen compounds through evaporation and residual microbial activity. Therefore, the longer a sample is stored before analysis, the greater the likelihood of a decrease in total nitrogen levels (Susilo, 2021).

3.2.5. Phosphorus (P^2O^5) Content Testing

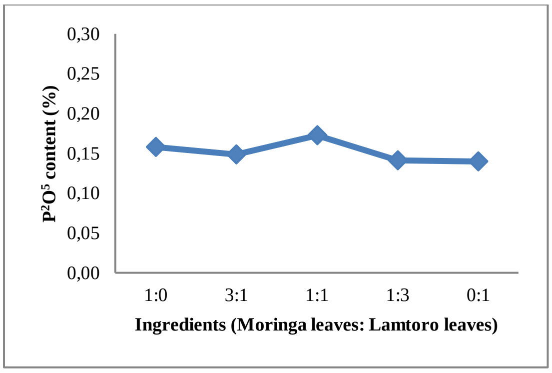

Figure. 3.5 Graph of the Effect of Material Composition on Phosphorus (P^2O^5) Content

The graph above shows that the test results show that the highest P_2O_5 content was obtained in a 1:1 composition of moringa leaves and lamtoro leaves, at 0.17%, followed by 1:0 (0.16%) and 3:1

(0.15%). The lowest content was found in the 1:3 and 0:1 compositions, at 0.14%, respectively.

A balanced combination (1:1) likely provides the best conditions for the fermentation process to dissolve the phosphate compounds from both ingredients. A balanced combination (1:1) likely provides the best conditions for the fermentation process to dissolve the phosphate compounds from both ingredients. According to research (Baray, 2022), the right combination of ingredients and optimal fermentation conditions can increase the solubility of organic phosphate into plant-available phosphorus.

However, when compared with Ministerial Regulation No. Based on Regulation No. 261/Kpts/SR.310/4/2019, which requires a minimum total macronutrient content ($N + P_2O_5 + K_2O$) of 2%, the P_2O_5 content of all these treatments is still relatively low. This indicates that, although phosphorus is available, its contribution to national quality standards is still inadequate.

Research by (Mualim et al., 2025) shows that although lamtoro contains phosphorus, increasing phosphorus levels in liquid fertilizer is highly dependent on fermentation effectiveness and microbial presence, as well as post-fermentation storage time, which can lead to reduced phosphorus content.

Therefore, although a 1:1 composition demonstrated the best phosphorus content in this study, increasing P_2O_5 levels to levels that meet national quality standards still requires further development. This could be achieved by adding phosphorus-rich additives (e.g., bone meal) or by more appropriately adjusting the fermentation pH.

3.2.6. Potassium (K2O) Content Testing

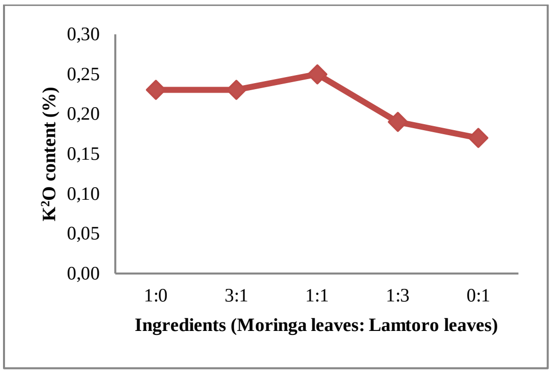

Figure. 3.6 Graph of the Effect of Material Composition on Potassium (K^2O) Content

The graph above shows that the highest potassium content was found in the 1:1 composition, at 0.25%. Meanwhile, the lowest potassium content was found in the 0:1 composition (leucaena leaves only), at 0.17%. In general, the graph shows a decreasing trend from the dominant composition of moringa leaves to the dominant composition of leucaena leaves.

This indicates that moringa leaves contribute significantly to increasing potassium levels in liquid organic fertilizer. According to Susilo (2021), moringa leaves contain significant amounts of macrominerals, such as potassium, so their use in fermentation can increase the dissolved K_2O levels in the fertilizer solution.

According to Minister of Agriculture Regulation No. 261/Kpts/SR.310/4/2019, the potassium (K_2O) content in liquid organic fertilizer must be at least 2%. However, research shows that the highest K_2O content is only 0.25%, thus falling short of the established standard. Despite this, this fertilizer can still be used because potassium plays a vital role in plant physiological processes such as flower and fruit formation and increases plant resilience to unfavorable environmental conditions. Furthermore, as an organic fertilizer, this product is still beneficial in improving soil structure and stimulating microbial activity, even though its nutrient content is not yet optimal.

3.2.7. C/N Ratio Analysis

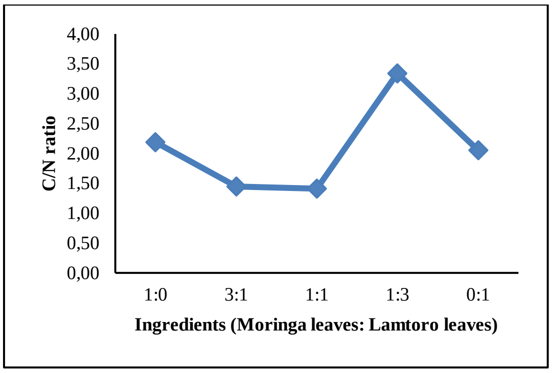

Figure. 3.7 Graph of the Relationship between C/N Ratio and Material Composition

Based on the results of this study, the C/N ratio of organic fertilizer (POC) ranged from 1.41 to 3.34, with the lowest value at a 1:1 composition and the highest at 1:3. The low C/N ratio in the 1:1 composition indicates relatively high nitrogen availability from moringa and lamtoro leaves, resulting in rapid decomposition. This finding aligns with the findings of Rahmawati et al. (2019), who stated that the decrease in the C/N ratio during fermentation is caused by a reduction in carbon content due to microbial use as an energy source, while the nitrogen content increases due to mineralization.

Although the C/N ratio in this study is far below the ideal range for solid composting (20–30), this low value is common in POCs made from fresh, high-protein ingredients. This is advantageous because nutrients become quickly available after application to plants (Pandi et al., 2023). Therefore, the lowest C/N ratio at a 1:1 composition indicates the most balanced composition to support optimal fermentation and produce high-quality POC.

4. CONCLUSION

4.1 Conclusion

Based on the research results, the following conclusions were drawn:

1. The composition of moringa leaves and lamtoro leaves significantly influences the quality of liquid organic fertilizer (POC). A 1:1 ratio of moringa and lamtoro leaves yields optimal nutrient content, with nitrogen content of 0.30%, phosphorus content of 0.17%, potassium content of 0.25%, and organic carbon content of 0.42%.
2. Fermentation time influences the quality of the POC, with the best results occurring after 17 days of fermentation, during which the pH value was stable and the TDS value was highest (3613.33 ppm). After 17 days, quality declined, indicating that the fermentation process must be carefully monitored to achieve optimal results.

4.2 Suggestions

1. To increase the nutritional content, it is recommended to add other organic materials, which can enrich the nutrients in the POC.
2. After the fermentation process is complete, the POC should be tested immediately and not stored for too long to maintain its quality.

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