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BIOAUGMENTATION OF MICROORGANISMS ON THE DECOMPOSITION OF A MIXTURE OF DAIRY CATTLE MANURE AND CHICKEN EXCRETA AS SOLID ORGANIC FERTILIZER

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Abstract

Solid organic fertilizer efficiently utilizes livestock waste, with laying hen excreta providing the highest nitrogen (N) content among livestock manure. Combining laying hen excreta with dairy cow manure and fiber sources as a fertilizer base is expected to meet KEPMENTAN No. 261 of 2019 standards. To maintain essential nutrients (N, P, K), the fertilizer is enriched with *Pseudomonas sp., Herbaspirillum sp.,* and *Streptomyces sp*. This study aims to analyze the effect of chicken excreta on macronutrient content (N, P, K), carbon (C) levels, C/N ratio, coliform presence, and microbial viability. The experiment followed a completely randomized design (CRD) with six treatments, namely P1: (95% Combination of Dairy Cow Feces (DCF) and Fiber Source (FS) + 5% Laying Hen Excreta), P2: (90% Combination of DCF and FS + 10% Laying Hen Excreta), P3: (85% Combination of DCF and FS +15% Laying Hen Excreta), MP1: (95% Combination of DCF and FS + 5% Laying Hen Excreta + 10% Microbial Consortium (MC)), MP2: (90% Combination of DCF and FS + 10% Laying Hen Excreta + 10% MC) and MP3: (85% Combination of DCF and FS + 15% Laying Hen Excreta + 10% MC). Dairy Cow Feces (DCF), Fiber Source (FS), Microbial Consortium (MC). Results showed that adding 15% laying hen excreta enriched with microbial consortium (*Pseudomonas sp., Herbaspirillum sp.,* and *Streptomyces sp.*) significantly increased ($P \leq 0.05$) macronutrient content, viability, C/N ratio, and coliform presence but did not significantly affect carbon (C) content.

Keywords: Laying hen excreta, Microbial Consortium, Solid Organic Fertilizer.

BIOAUGMENTASI MIKROORGANISME PADA PENGURAIAN CAMPURAN KOTORAN SAPI PERAH DAN FESES AYAM SEBAGAI PUPUK ORGANIK PADAT

Abstrak

Pupuk organik padat secara efisien memanfaatkan limbah ternak, dengan kotoran ayam petelur memberikan kandungan nitrogen (N) tertinggi di antara kotoran ternak. Menggabungkan kotoran ayam petelur dengan kotoran sapi perah dan sumber serat sebagai bahan dasar pupuk diharapkan dapat memenuhi standar KEPMENTAN No. 261 Tahun 2019. Untuk mempertahankan unsur hara esensial (N, P, K), pupuk diperkaya dengan Pseudomonas sp, Herbaspirillum sp, dan Streptomyces sp. Penelitian ini bertujuan untuk menganalisis pengaruh ekskreta ayam petelur terhadap kandungan unsur hara makro (N, P, K), kadar karbon (C), rasio C/N, keberadaan coliform, dan viabilitas mikroba. Percobaan mengikuti Rancangan Acak Lengkap (RAL) dengan enam perlakuan, yaitu P1: (Kombinasi 95% Feses Sapi Perah (DCF) dan Sumber Serat (FS) + 5% Feses Ayam Petelur), P2: (Kombinasi 90% Feses Sapi Perah dan FS + 10% Feses Ayam Petelur), P3: (85% Kombinasi DCF dan FS + 15% Ekskreta Ayam Petelur), MP1: (95% Kombinasi DCF dan FS + 5% Ekskreta Ayam Petelur + 10% Konsorsium Mikroba (MC)), MP2: (90% Kombinasi DCF dan FS + 10% Ekskreta Ayam Petelur + 10% MC), dan MP3: (85% Kombinasi DCF dan FS + 15% Ekskreta Ayam Petelur + 10% MC). Feses Sapi Perah (DCF), Sumber Serat (FS), Konsorsium Mikroba (MC). Hasil penelitian menunjukkan bahwa penambahan 15% feses ayam petelur yang diperkaya dengan konsorsium mikroba (Pseudomonas sp., Herbaspirillum sp., dan Streptomyces sp.) secara signifikan ($P \leq 0,05$) meningkatkan kandungan makronutrisi, viabilitas, rasio C/N, dan keberadaan coliform, namun tidak berpengaruh signifikan terhadap kandungan karbon (C).

Kata kunci: Kotoran ayam petelur, Konsorsium Mikroba, Pupuk Organik Padat.

INTRODUCTION

The dairy cattle industry in Indonesia is developed to fulfil food needs, especially animal protein. The annual growth of the dairy cattle population from 2013 to 2022 was 0.27%, which reached 542,969 heads per year (BPS, 2022). This growth is also accompanied by the production of livestock waste, such as manure, feed residues, and urine, which cause environmental hazards if not managed properly.

Utilizing livestock waste for organic fertilizer production is a strategic way to minimize environmental impacts while increasing sustainability. Organic fertilizer improves soil structure, increases microbial activity, improves water retention, and increases soil fertility. Dairy cow manure, which is rich in nutrients, is commonly used for solid organic fertilizer. To increase the macro nutrient content, this study incorporated laying hen manure, which contains three times more phosphorus (P) and nitrogen (N) than cow manure, creating a more balanced nutrient profile (Damanik et al., 2011; Setyorini et al., 2006). The mixture of dairy cow feces and fiber sources, added with laying hen excreta, is expected to meet the solid organic fertilizer requirements of KEPMENTAN No. 261 of 2019.

Decomposition is key to the utilization of organic waste, breaking down the material into simpler compounds with the help of microbial activity. Fiber-rich materials such as rice straw and cocopeat are often added, providing high carbon (C), potassium (K), and phosphorus (P) content (Alhanif et al., 2023). The decomposition rate depends on the C/N ratio of the material and biochemical properties, such as lignin content, which slow down the process. Bioaugmentation with functional microbes can accelerate decomposition. This study used nitrogen-fixing bacteria *Pseudomonas sp.* (K4N.J6), phosphorus-solubizing bacteria *Herbaspirillum sp.* (K4N.PSV1), and Actinomycetes *Streptomyces sp*., which increased N, P, and K content and acted as natural antibiotics against soil pathogens (Yoon & Nodwell, 2014; Vurukonda et al., 2018; Suryaminarsih, 2020)

The standard quality of solid organic fertilizer is regulated in KEPMENTAN No. 261/KPTS/SR.310/M/4/2019, which specifies minimum technical standards. Organic matter in fertilizer supports microbial growth, facilitates packaging, and extends shelf life. Storage conditions are very important for microbial survival, so it is necessary to test the shelf life to ensure optimal effectiveness in solid organic fertilizer.

MATERIALS AND METHODS

Solid Organic Fertilizer Preparation

The ingredients of solid organic fertilizer in this study are dairy cow manure and laying hen excreta, which are decomposed together with fiber sources (rice straw and cocopeat) for 14 days. The functional bacteria enriched in the solid organic fertilizer were a consortium of *Pseudomonas sp.* (K4N.J6) (BPN), *Herbaspirillum sp.* (K4N.PSV1) (BPF), and *Streptomyces sp.* (*Actinomycetes*), purified from leguminous roots by the National Research and Innovation Agency (BRIN). This research has 6 treatments, namely P1: (95% Combination of Dairy Cow Feces (DCF) and Fiber Source (FS) + 5% Laying Hen Excreta), P2: (90% Combination of DCF and FS + 10% Laying Hen Excreta), P3: (85% Combination of DCF and FS +15% Laying Hen Excreta), MP1: (95% Combination of DCF and FS + 5% Laying Hen Excreta + 10% Microbial Consortium (MC)), MP2: (90% Combination of DCF and FS + 10% Laying Hen Excreta + 10% MC) and MP3: (85% Combination of DCF and FS + 15% Laying Hen Excreta + 10% MC).

Bacterial Measurement

To multiply the functional bacterial consortium, Nutrient Broth (NB) was used. Specifically for multiplying *Actinomycetes*, the nutrient broth should be mixed with 4 grams/L of glucose. Once multiplied, the bacteria are consorted in a 1:1:1 ratio and added to the organic fertilizer at 10% at the time of mixing.

Temperature and Chemical Measurements

In this research, the temperature of solid organic fertilizer was recorded daily using a thermometer. pH and water content were measured upon completion of decomposition. C-Organic content was checked using the Walkley and Black method (Omposunggu et al., 2015). N-total content using the Kjeldahl method (Hermawati et al., 2021). Phosphorus content using the Olsen method (Nursyamsi & Setyorini, 2009; Dhasa & Mutiara, 2019). Potassium content was measured using flame photometry, which indicates the intensity of the emission rays (Horwitz, 2000; SNI 02-3776-2005). Coliforms were checked using the Most Probable Number (MPN) method (Fardiaz., 1989). While the viability test result can be seen from the Total Plate Count (TPC) every week for 4 weeks, the viability of functional bacteria was tested using Jensen's Agar, Pikovskaya Agar, and Starch Casein Agar (SCA) media.

Statistical Analysis

The research method used is experimental with a complete randomized design (CRD) and using further tests with Duncan's multiple range test (DMRT)

RESULTS AND DISCUSSION

Temperature of Solid Organic Fertilizer

Temperature in the decomposition process is an indicator of the sustainability of microorganism activity (Marlina et al. 2024). Based on Figure 1, it can be seen in all treatments that there is an increase in temperature from day 1 to day 2, where on day 1, there is a process of substrate degradation carried out by mesophilic microorganisms in the temperature range (25 - 40ºC), and this phase is called the mesophilic phase I. On day 2, the beginning of the temperature rise occurs with a range of > 40ºC on the substrate, where this phase is called the thermophilic phase. Barselia and Prasetyo (2016) stated that the increase in temperature in the thermophilic phase is due to active microorganisms carrying out the process of degradation of organic matter. On day 6 of the decomposition process, there is a decrease in temperature from thermophilic temperature to mesophilic temperature in the temperature range (25 - 40ºC), where this phase is the mesophilic phase II. Mesophilic phase II is a sign of the substrate entering the maturation phase. This opinion is in line with Pratama et al. (2019), which states that the substrate will lose heat due to decreased microbial activity, resulting in a decrease in temperature at the end of the composting process.

pH Level of Solid Organic Fertilizer

Based on Figure 2, it is known that the pH of solid organic fertilizer ranges from 7.30 to 7.60. These results meet the requirements of solid organic fertilizer according to PERMENTAN No.261 of 2019, where the pH requirements of solid organic fertilizer are in the range of 4-9. Riyanto et al (2023) stated that the optimal pH of the substrate decomposition results is 6.0-8.0. The pH level of compost in the range of 6.0-8.0 is the ideal pH to be applied to plants (Putra et al., 2023).

pH levels are related to nitrogen levels in the substrate; pH values that tend to be acidic are able to produce nitrogen elements due to the activity of microorganisms in degrading the substrate into organic acids (Ratna et al., 2017). The activity of bacterial groups that convert organic acids into methane and carbon dioxide also affects the high and low pH of the substrate (Putra et al., 2023). Suwahyono (2014) stated that the higher the pH level in the substrate, the faster the decomposition of organic matter by microorganisms.

Water Content of Solid Organic Fertilizer

Moisture content is an important factor in the decomposition process of solid organic fertilizer. Water content affects the growth of microorganisms contained in the substrate in decomposing organic matter. Based on Figure 3, the data shows that the range of moisture content is between 67.64% - 73.28%. The highest moisture content was obtained by MP1 treatment at 73.28%, and the lowest was obtained by P3 at 67.64%. Substrates with the addition of microbes have a higher moisture content than those that do not use microbes, as shown in Figure 3. This can be caused by the addition of a consortium of microorganisms that are liquid as much as 10% into the substrate at the beginning of decomposition. According to Hastuti et al (2017), large-scale moisture content, such as 60% or higher, has a relatively low pH level in solid organic fertilizer, which affects the maturation and quality of organic fertilizer.

Macro Nutrient Content of Solid Organic Fertilizer

Research data on the addition of laying hen excreta and consortium microorganisms into solid organic fertilizer and its effect on the content of macro nutrients, including the amount of nitrogen (N-Total), Phosphorus (P_2O_5), and Potassium (K_2O), are presented in Table 1

N-Total Content

The results of the calculation of N-total content as a macro nutrient element in the fertilizer content have been carried out with the Kjeldahl method SNI 7763: 2018. Based on Table 1, it is known that the addition of laying hen excreta produces a range of N-total values ranging from 2.94% - 8.03%. The treatment with the highest average was obtained by the MP3 treatment (85% Combination of Dairy Cow Feces and Fiber Source + 15% Laying Hen Excreta + 10% Microbial Consortium) with an N content value of 8.03% and the lowest was obtained by the P1 treatment (95%

Combination of Dairy Cow Feces and Fiber Source + 5% Laying Hen Excreta) at 2.94%. The results of the analysis of variance showed that the addition of chicken excreta up to 15% had a significant effect ($P \leq 0.05$) on the N-Total content of organic fertilizer, with optimal results in the treatment that added 10% microbial consortium.

Based on the results, it is known that the MP3 treatment produces significant differences when compared with the MP1 and MP2 treatments, as well as with all treatments without the addition of bacterial consortium (P1, P2, and P3). The high N-total content in MP3 is thought to be influenced by bacterial activity during the decomposition process. Nitrogen is obtained through 3 stages, namely the process of amination, ammonification, and nitrification reactions, with the final result obtained by changing ammonia compounds to nitrate by involving the role of microorganisms (Melsasail et al., 2019).

N content is used by microorganisms in the decomposition process for the formation of body cells, so that the higher the N content, the faster the substrate decomposition process takes place (Trivana et al., 2017). Suhesy and Adriani (2014) explained that after the composting process is complete, microorganisms will die and become a source of N in the substrate. This is in line with the research conducted that the addition of laying hen excreta aims to increase the relatively low N content of dairy cows and is maximized by the use of a bacterial consortium. Sanow et al. (2023) in their research stated that N-fixing bacteria (*Pseudomonas s*p.) are known to have the ability to fix nitrogen nutrients, thus providing nitrogen to the substrate. The activity of *Pseudomonas sp.* bacteria in N fixation is important to maintain nitrogen balance because nitrogen is easily lost by the denitrification process (Pamungkas and Prasetya, 2017). Therefore, MP3 has a higher N-total content than other treatments.

Phosphorus Content (P_2O_5)

Phosphorus (P) levels in solid organic fertilizer are presented in Table 1, where as many as 6 treatments each have average results that vary in the range of 2.24% - 4.20%. It is known that the treatment without the addition of microbes (P1 = 2.24%, P2 = 2.27% and P3 = 2.24%) all three have no significant effect on each other, as well as the MP1 treatment of 2.26% but the effect with MP2 of 4.13% and MP3 of 4.20%. MP2 and MP3 had no significant effect, indicating that the MP2 treatment was effective in increasing the P nutrient content of solid organic fertilizer.

In the treatment without the addition of microbes (P1, P2 and P3), there was no significant effect, presumably due to the lack of microorganisms capable of converting carbon sources into lactic acid in the substrate during the decomposition process as a process where phosphate dissolution occurs (Hutasoit et al., 2014; Rahmawati et al., 2020). The creation of an acidic environment in the substrate causes the creation of organic acids produced by microbial activity, which can make phosphate soluble (Rahmawati et al., 2020). This opinion is in line with Ventkatchalam et al. (2023), which explains that *Herbaspirillum sp*. bacteria can dissolve phosphate by releasing gluconic acid, which can dissolve phosphate minerals. Besides that, *Herbaspirillum sp*. can process the release of phosphate rock nutrients in the soil (Ventkatchalam et al., 2023).

Organic fertilizer made from laying hen manure has higher P than other types of animal manure (Komiyama & Ito, 2019). P is a macronutrient that is susceptible to loss due to leaching by water, especially in media containing high organic matter. The addition of BPF can reduce P loss due to leaching (Yu et al., 2022). The advantage of using BPF (phosphate-solubilizing bacteria) in solid organic fertilizer is that BPF is able to secrete low-weight organic acids such as citric, oxalic, malic, and fumarate (Rahmawati et al., 2020). This is why the P content in the treatment with >20% chicken manure dose added with microbes is greater.

Potassium Content (K_2O)

Potassium is a macronutrient that has an important role in the formation of proteins and carbohydrates, as well as strengthening plant immunity, making plants more resistant to disease. In this study, cocopeat was utilized as the main source of potassium for the production of organic fertilizer. The potassium content in the solid organic fertilizer was analyzed using an Atomic Absorption Spectrophotometer (AAS) and is presented in Table 1.

Based on Table 1, the average potassium content ranged from 0.90% to 1.83%. P2 had the lowest average potassium content, while MP3 had the highest. P1 (1.29%) showed no significant difference with P2 (0.90%), but had a significant effect compared to P3 (1.55%), MP1 (1.56%), and MP2 (1.56%). P3, MP1, and MP2 did not show significant differences from each other, but were significantly different from MP3. This indicates that the addition of microbes, together with 30% chicken manure, effectively increased the potassium content.

In soil, only 2%-10% of potassium is available, while 90%-98% is in an unavailable form in primary silicate minerals (Istiyova & Santosa, 2023). Potassium acts as a catalyst for microorganisms during the decomposition process, where potassium is stored in bacterial cells and then released during degradation, making it available to plants (Rahmawati et al., 2020). Potassium-solubilizing bacteria have the potential to break down silicate minerals, thereby increasing potassium availability. Musa et al. (2024) found that *Pseudomonas sp.* bacteria can synthesise potassium, thereby increasing its accessibility for plant uptake.

The Organic Carbon (C-Organic) Content and C/N Ratio of Solid Organic Fertilizer

The calculation results of C-Organic content and C/N Ratio of Solid Organic Fertilizer are presented in Table 2.

Carbon Content of Solid Organic Fertilizer

The analysis of C-organic content in solid organic fertilizer showed that the six treatments had no significant effect ($P>0.05$) on each other. The no significant effect on C-organic content may be due to the main composition of organic fertilizer in this study consisting of dairy cow feces with a fiber source of 60%: 40% with the same proportion, with the addition of chicken manure with varying levels (P1=10%, P2=20%, P3=30%, M=10% microbial consortium). Thus, it can be concluded that the addition of chicken manure does not affect the C-organic content of solid organic fertilizer.

The content of C-organic ranged from 27.22% to 30.40%. All six treatments met the standard of solid organic fertilizer according to KEPMENTAN No. 261 of 2019, which requires a minimum C-organic content of 15%. MP3 has the highest C-organic content of 30.40%, followed by MP1 at 29.57% and MP2 at 29.15%. The treatment with the addition of bacterial consortium has a slightly higher C-organic content compared to the treatment without the addition of microbes. C-organic content in solid organic fertilizer serves as a source of nutrients for microbial growth, where microbes act as decomposers of organic matter during the decomposition process.

C/N Ratio of Solid Organic Fertilizer

Based on Table 2, the mean C/N ratio of solid organic fertilizer ranges from 3.85-9.93. The six treatments met the standard set by PERMENTAN No. 261 of 2019, which requires a C/N ratio in solid organic fertilizer ≤ 25. The C/N ratio in solid organic fertilizer serves as an indicator of substrate maturity; a higher C/N ratio indicates that the substrate has not decomposed completely (Surtinah, 2013). Table 2 shows that the MP3 treatment is significantly different from the P1, P2, and P3 treatments but not significantly different from the MP1 and MP2 treatments. This shows that the addition of microbial consortium affects the content of the C/N ratio in compost.

The C/N ratio is directly inversely proportional to the nutrient content; the lower the C/N ratio, the higher the nutrient content. This can be seen in Table 1, where the MP3 treatment has the highest nutrient content, resulting in the lowest organic C/N ratio. The addition of microbial consortium containing actinomycetes, especially *Streptomyces sp.*, can affect the production of certain chemicals that accelerate the decomposition of organic matter in the substrate (Schneider et al., 2018).

Coliform of Solid Organic Fertilizer

Based on Table 3, the average total coliform bacteria count ranged from 0.31 to 0.81 MPN/g. This range is in accordance with the KEPMENTAN No. 261 of 2019 standard, which sets the maximum allowable coliform limit at 1×10^2 MPN/g. The MP3 treatment showed no significant difference with MP1 and MP2 but was significantly different from P1, P2, and P3. This shows that the treatment with the addition of bacteria is significantly different from the treatment without the addition of bacteria. The addition of Streptomyces (an actinomycete genus) can reduce the number of coliforms in the substrate (Naggar et al., 2017). The low number of coliforms in organic fertilizer is caused by decomposition activity, in which microorganisms produce organic acids that reduce the pH level, inhibiting the growth of coliform bacteria.

After determining the total coliform count, a coliform amplification test is performed to confirm their presence and type (non-fecal or fecal). Non-fecal colonies appear reddish, while fecal colonies show a metallic green color. Samples are streaked on EMBA (Eosin Methylene Blue Agar) medium, which inhibits Gram-positive bacteria and selectively allows Gram-negative bacteria, such as *Escherichia coli*, to grow (Alamsyah et al., 2024).

Based on Table 4, all of the isolates showed a pinkish color, indicating non-fecal coliform bacteria, which are Gram-negative bacteria that cannot ferment lactose (Hadiansyah et al., 2021). These bacteria are generally found in decaying organic matter; one example is Enterobacter aerogenes (Rophi, 2022). Thus, the organic solid fertilizer in this study did not contain Escherichia coli, as no green isolates were observed. The lack of fecal coliforms is likely due to fermentation, which lowers the pH level and reduces the E. coli population by about 40% (Rahmadita et al., 2024). The coliform amplification test is further complemented by the coliform confirmation test, which involves Gram staining to determine the Gram characteristics of the bacteria.

Based on Figure 4, the bacteria observed showed Gram-negative characteristics with rod-shaped cells (bacilli). This result is consistent with Alamsyah's research (2024), which identified coliform bacteria as Gram-negative and rod-shaped bacteria. Gram-negative bacteria contain high levels of protein and lipids in their cell membranes, so they cannot maintain crystal violet staining when given alcohol in the Gram staining process (Riyanto et al., 2024).

Viability of Solid Organic Fertilizer

Viability refers to an isolate's ability to grow and maintain its population with an appropriate carrier. The bacterial population in solid organic fertilizer influences plant yield, as a stable population with a suitable carrier ensures optimal results (Syarifain et al., 2022). The shelf life (viability) of solid organic fertilizer is assessed based on its response to room temperature. Viability data across these conditions are presented in Figure 5,

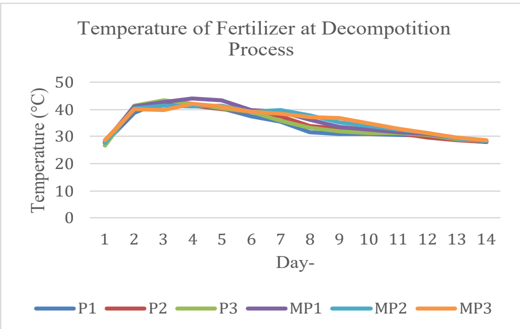

Figure 1. Temperature of Fertilizer during the Decomposition Process

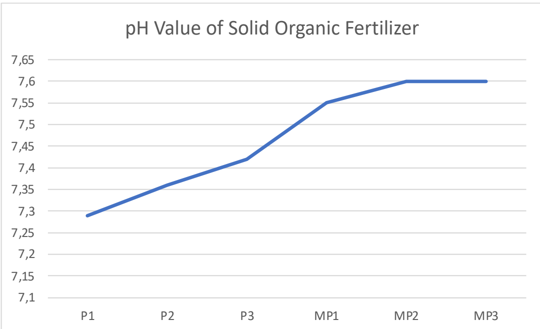

Figure 2. pH of Solid Organic Fertilizer

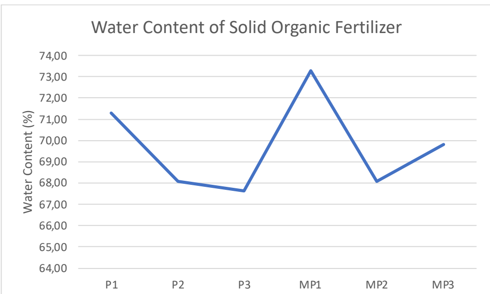

Figure 3. Water Content of Solid Organic Fertilizer

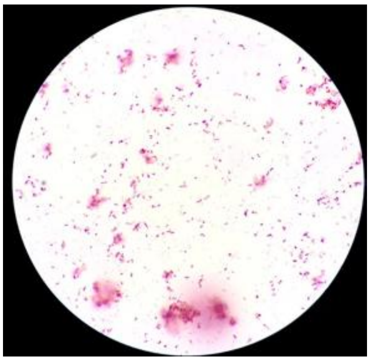

Figure 4. Gram Staining Result

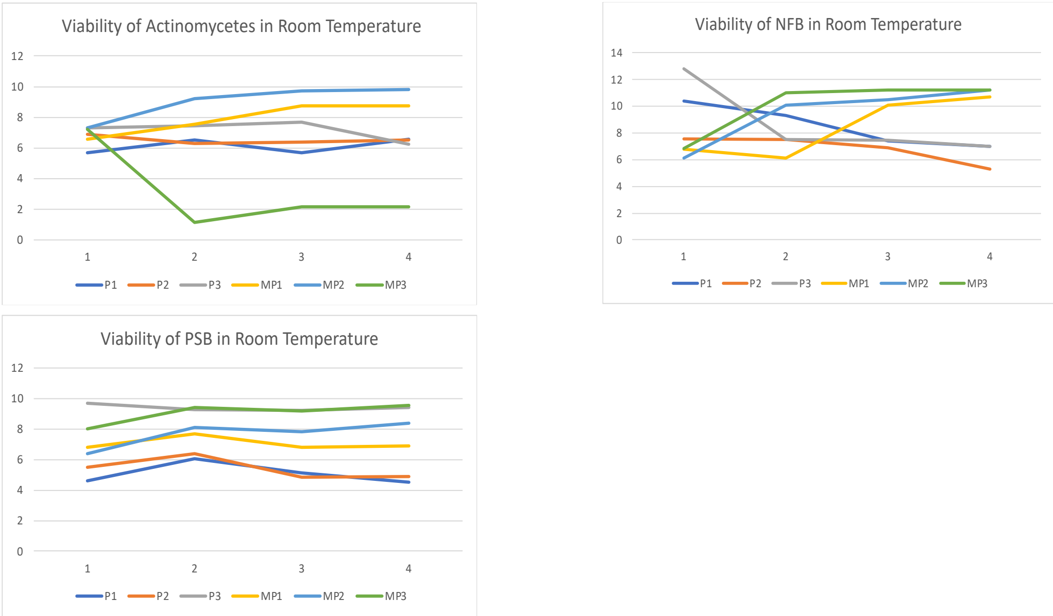

Figure 5. Viability of Solid Organic Fertilizer at Room Temperature

Table 1. Macro Nutrient Content of Solid Organic Fertilizer

Parameter	P1	P2	P3	MP1	MP2	MP3
N-total (%)	2.94^{a}	3.27^{a}	3.83^{a}	$4,68^{b}$	$6,06^{b}$	$8,03^{c}$
P_2O_5 (%)	2.24^{a}	2.27^{a}	2.24^{a}	$2,26^{a}$	$4,13^{b}$	$4,20^{b}$
K_2O (%)	1.29^{ab}	0.90^{a}	1.55^{bc}	$1,56^{bc}$	$1,56^{bc}$	$1,83^{c}$
Macro Nutrients	6.47	6.44	7.62	8,5	11,75	14,06

Table 2. Carbon (C-Organic) Content and C/N Ratio of Solid Organic Fertilizer

Parameter	P1	P2	P3	MP1	MP2	MP3
Carbon (%)	$28,55^{a}$	$27,93^{a}$	$27,22^{a}$	$29,57^{a}$	$29,15^{a}$	$30,40^{a}$
C/N Ratio	$9,93^{d}$	$8,89^{cd}$	$7,34^{bc}$	$6,58^{ab}$	$4,94^{ab}$	$3,85^{a}$

Table 3. Total Coliform of Solid Organic Fertilizer

Parameter	P1	P2	P3	MP1	MP2	MP3
Total Coliform (MPN/g)	$0,68^{bc}$	$0,81^{c}$	$0,81^{c}$	$0,50^{ab}$	$0,40^{a}$	$0,31^{a}$

Table 4. Coliform Amplification Test

Replicant	Treatments					
	P1	P2	P3	MP1	MP2	MP3
1	NF	NF	NF	NF	NF	NF
2	NF	NF	NF	NF	NF	NF
3	NF	NF	NF	NF	NF	NF

Based on these graphics, the treatments effectively maintained bacterial populations in the substrate, as indicated by the high counts of indigenous microbes (NFB, PSB, *and Actinomycetes*) in both microbial-enriched (MP1, MP2, MP3) and non-enriched (P1, P2, P3) fertilizers. Organic fertilizers enriched with microbes (MP1, MP2, MP3) stored at room temperature (26–28°C), refrigeration (4°C), and incubation (37°C) met the requirements of KEPMENTAN No. 261 of 2019, which stipulates a minimum bacterial content of ≥ 1 × 10^5 CFU/g. As shown in Figure 4, fertilizers stored at room temperature maintained the highest bacterial populations over four weeks. Fertilizers enriched with microbial consortia during decomposition exhibited a higher bacterial population at room temperature compared to those without microbial additives. The microbial consortium in this study included *Pseudomonas sp.*, *Herbaspirillum sp.*, and *Streptomyces sp.*—all of which thrive optimally at room temperature. According to De Moura et al. (2021), *Streptomyces sp.* grows best at 25–35°C. Bajerski et al. (2024) reported that *Herbaspirillum sp.* has an optimal growth temperature of 28°C but can survive in a range of 4–37°C, allowing it to persist in both refrigeration and incubation conditions, albeit with slower growth. Similarly, *Pseudomonas sp.* grows optimally between 25–37°C but can also survive at 4°C and up to 42°C, though its growth rate decreases at extreme temperatures (Xing et al., 2023).

CONCLUSIONS

The addition of 15% laying hen excreta to a mixture of dairy cow faeces and fiber sources added by a 10% microbial consortium (MP3) produced the best N 8.03%, P 4.20% and K 1.83% content among other treatments with a total macro nutrient value of 14.06% which met the macro nutrient standards of KEPMENTAN No.261 of 2019. Storage of solid organic fertilizer at room temperature (25°C - 28°C) for 4 weeks of measurement of PSB, NFB, and Actinomyces was able to maintain their population in solid organic fertilizer in accordance with the provisions of the microbial content of KEPMENTAN No.261 of 2019, which is ≥ 1 × 10^5 cfu/g.

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