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RESEARCH ARTICLE

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Optimization of Fertilizer Cow Waste-Based Bokashi Composting Process Using 3 Types Effective Microorganism in Smart Pot Sak

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Abstract
Bokashi fertilizer is the result of recycling organic waste through a composting process that functions to improve soil health and plant production. However, the quality of organic waste and the composting process time are affected by the type of Effective Microorganisms used. This study was designed to evaluate the process and quality of organic waste produced from three types of Effective Microorganisms (EM4, Eco Farming, and MA11). Organic waste consisting of cow dung, rice husk, and bran mixed with each type of microorganism solution according to the treatment of 10, 15, and 20 mL/10 kg weight of organic waste with a composting time of 30 days. pH, Temperature, Color, water content, N-organic, C-organic, C/N Ratio, Potassium, and Phosphate were recorded in this study. The results showed that 20 mL MA11 provided a faster composting process with an optimal pH level and C/N ratio. In addition, the water content produced was lower and there was an increase in nutrients compared to other treatments. The use of MA11 in optimum quantities will produce good quality organic waste and quickly without causing environmental problems in its application to soil.

KEYWORDS
Bokashi maturation, Composting Process, Cow waste, Effective microorganism

1. INTRODUCTION

Organic waste contains elements of hydrogen and carbon (Alibardi & Cossu, 2016). Organic waste can and is easily broken down by the help of microorganisms (Palaniveloo et al., 2020). Organic waste usually in liquid or solid form (Li et al., 2011). Solid organic waste waste and dirt such as organic waste (food scraps, kitchen scraps and vegetable waste) and animal waste (cows, chickens, goats, elephants, buffaloes) (Khalid et al., 2011), while liquid waste is waste or impurities such as feces and residual organic matter washing water (Koul et al., 2022). This waste can be processed and used as the main raw material for bokashi. Animal manure that is widely used as bokashi cow dung (Gupta et al., 2016).

Composting stands as a pivotal practice for repurposing organic matter into nutrient-rich fertilizers. Nevertheless, Efficacy hinges greatly on microbial involvement. Microorganisms serve as primary catalysts in breaking down organic substances, with microbial diversity playing a crucial role in shaping composting dynamics (Karwal & Kaushik, 2020). As human populations burgeon and organic waste generation escalates, waste management systems face escalating strains. Thus, there's a pressing need to refine composting methodologies to mitigate the adverse environmental repercussions of mounting organic waste (Sun et al., 2022). Moreover, delving deeper into microbe-organic material interactions holds promise for innovating greener composting technologies (Xiong et al., 2023). Studying microbial optimization for expediting decomposition not only bolsters composting efficiency but also underpins broader environmental sustainability endeavors, fostering ecological equilibrium and mitigating ecological imbalances.

Composting stands as a pivotal practice for repurposing organic matter into nutrient-rich fertilizers. Nevertheless, Efficacy hinges greatly on microbial involvement.

Cow dung contains cellulose (Fasake & Dashora, 2020). In one day, an average cow excretes around 10-15 kg of feces (Novia et al., 2019). Currently cow dung has not been used optimally by breeders, especially in Pamekasan, Madura. Composting is an alternative to turning cow dung more useful (Pan et al., 2012). Compost is an organic fertilizer that has gone through the decomposition process of microorganisms, both naturally and with the addition of bioactivators (Pan et al., 2012).

Previous research on optimizing cow manure composting with microbial interventions has yielded promising outcomes. Duan et al. (2021) explored diverse microbial blends alongside supplementary organic matter to enhance decomposition efficacy and compost quality. Findings indicate that specific microbial combinations accelerate decomposition, enrich compost with nutrients, and bolster nutrient accessibility for plants. Moreover, the research underscores the significance of regulating environmental factors like temperature, humidity, and pH to optimize the organic matter conversion process into high-quality compost (Song et al., 2018). These insights lay the groundwork for future studies aimed at refining composting strategies through the integration of diverse microbial strains and management practices, thus advancing eco-friendly compost production methods.

Many bioactivators have been added to speed up the composting process for some organic materials. EM-4 bioactivator is used in composting cow manure (Sutrisno et al., 2020), elephants (Nair et al., 2019), goats (Sunaryo et al., 2018), chickens (Pujiastuti et al., 2018). Apart from EM-4, there is also the Microbacter Alfaafa-11 (MA-11) bioactivator which has been used in composting cassava peels (Suryanti & Santiasa, 2020) and the Eco Farming bioactivator was used in composting cow dung. The bioactivators used in this study were EM-4, MA-11 and Eco Farming. The purpose of this study was to determine the effect of the addition of EM-4, MA-11 and Eco Farming bioactivators on pH, temperature, aroma, color, water content, C/N ratio, organic matter produced and to determine the concentration of the three bioactivator solutions that produce quality the best compost from cow manure.

2. MATERIALS AND METHODS

2.1 Material used, their sources, and bokashi fertilizer preparation

The organic materials used were cow dung, husk charcoal, bran, and molasses collected from the Rahayu cattle farm, Samatan Village, Pamekasan, Madura, Indonesia (7°07'59.5"S 113°26'45.4"E). Three types of effective microorganism (EM) were obtained from a commercial company consisting of (EM4, MA11, and Eco Farming). 3 effective microorganisms are presented in Figure 1. Other items used were airtight plastic drums and smart pot sacks (L 25 X W 25 X H 25 cm) made by polypropylene (PP) was purchased from an online platform.

Figure 1. Three kinds of EM were used in the experiment. (A) EM4. (B) MA-11. (C) Eco Farming

2.2 Bokashi preparation

The research was conducted at Rahayu Animal Husbandry, Samatan Pamekasan Village, Madura, from March 4 to May 4, 2022. The effective microorganism solution was prepared as reported by Lasmini et al. (Lasmini et al., 2018) but with slight modifications. First, fermented EM4 solution is made from a mixture of 200 mL of water and 10 g of sugar as a substitute for molasses (Sánchez et al., 2017). Molasses is mixed with 20 mL EM (Gustian et al., 2023) and labeled according to the type of EM used and then left for 2 x 24 hours so that the bacteria can be active again. All organic ingredients are mixed which includes 10 kg of dry cow manure, 4 kg of rice husk, and 1 kg of bran. The organic material sprayed with the EM solution that has been made evenly while stirring. After blending, the organic material placed into the smart pot sack. This was kept tightly sealed and in the shade (Li et al., 2021). The length of time for posting is 30 days. Every week, the organic material is opened to check the temperature and the organic material was stirred so that it can be decomposed evenly by decomposing bacteria.

2.3 Physical and chemical analysis

Micro observations in the field include temperature and pH. The temperature was measured using a 110 ^{o}C thermometer with a length of 30 cm while the pH used a Takemura DM-15 pH & Moisture Tester. Physical observations include aroma and color using panelists with observations giving points (1-5). Bokashi reversal is carried out every temperature and humidity observation, which is once every 7 days. Laboratory test observations (moisture content, N-Total, C-Organic, K elements, and P elements) were carried out at BALITKABI Malang after physical and field observations.

Moisture content was measured using the Gravimetric method (Voroney, 2019). The water in the organic fertilizer samples was evaporated by means of oven drying at 105 ^{o}C overnight (16 hours). Accurately weigh 10 g each of the fertilizer sample and 5 g of fine fertilizer (<2 mm) into a porcelain cup with a lid of known weight, then place in the oven and dry overnight at 105 ^{o}C. Cool in desiccator and weigh. Measurement of water content using the formula (Ren et al., 2023):

$$\text{Water content (\%)} = (W - W1) \times \frac{100}{W}$$

W is the weight of the original sample (g) and W1 is the weight of the sample after being dried using an oven. Calculation of N Total using the Walkley and Black method (Long et al., 2015) while for the measurement of potassium content using the UV-Vis instrument and the determination of potassium using the ICP instrument (Indrawan et al., 2015).

2.4 Statistical analysis

The method used in this study was an experimental method using a completely randomized design (CRD) consisting of 3 EM types (Eco Farming, EM4, and MA11) with 6 repetitions. so that 18 kinds of experimental samples were obtained. The composting process is carried out for 30 days. The data were analyzed using analysis of variance (ANOVA) of SAS software, 9.4 version (SAS Institute, Cary, NC, USA). Significant differences between the treatment means were compared using LSD at 5%

3. RESULTS AND DISCUSSION

3.1 Smell of bokashi

Observation of physical quality to determine the maturity level of bokashi which consists of (color, aroma and texture). Observations were made by giving a score from 1-5. The aroma of bokashi is one of the parameters that characterizes the successful and well-running fermentation process. At the stage of the fermentation process there are stages of decomposition of organic matter with the help of microorganisms. The results of the compost aroma assessment can be seen in Figure 2.

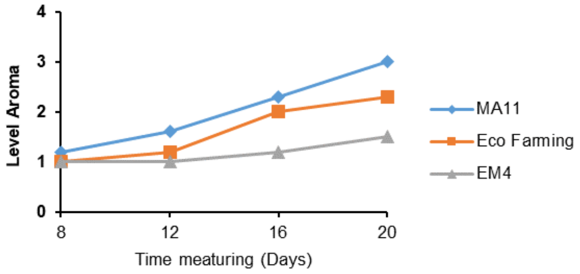

Figure 2. Changes in the Smell of Cow Manure Compost

In Figure 2, graphically shows an increase in the aroma score at each observation. The peak of aroma observation occurred on day 20, in which of the three bioactivators used, it was seen that the MA-11 activator had the highest aroma score (3). The aroma score indicates that it smells slightly earthy towards the smell of earth, while the other activators have a score (1-2) this indicates that it does not smell earthy. According to Ranadheera (Ranadheera et al., 2017) and Saswat (Mahapatra et al., 2022) stated that fertilizer that has been perfectly cooked will emit an earthy odor, if it smells an unpleasant odor indicates anaerobic fermentation in the compost is taking place. Complete anaerobic fermentation helps break down the cellulose content in cow dung to produce organic acids and esters (Olatunji et al., 2021).

3.3 Colour of bokashi

Color is one of the parameters that characterizes the fermentation process going well or not in botoxing. The fermentation process was the decomposition of organic matter with the help of microorganisms, which if the compost was fermented for a long time tends to produce a very dark color. The results of the compost color assessment can be seen in Figure 3.

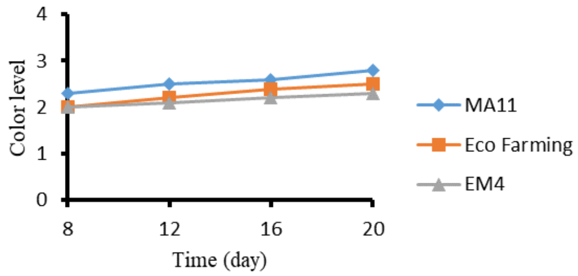

Figure 3. Color Change of Cow Manure Compost

In Figure 3, graphically shows an increase in the color score at each observation. The peak of color observation occurred on day 20, which of the three bioactivators used showed that the MA-11 activator had the highest color score (2.87). The color score shows that it was blackish brown, while the other activators have a score (2) this shows that it was brown.

The darker color of the compost illustrates that the fermentation process of solid cow dung with the help of bioactivators was running normally and shows the best compost characteristics (Aziz et al., 2022). This is also in line with Nurweni et al. (Nurweni et al., 2019) that decomposition by microbes during fermentation helps the compost color change to darker and perfectly mature compost was blackish brown. During the fermentation process decomposition occurs in the material, the color of the compost material undergoes stages of change starting from light brown, brown, until at the end of the composting process it becomes blackish brown and the final color was black (Nurweni et al., 2019).

3.4 pH and temperature

Table 1. Average value of pH and Compost temperature due to treatment

EM type	Observation parameters	
	Temperature (°C)	pH
MA11	28.00^{c}	7.02^{b}
Eco Farming	24.00^{b}	6.63^{b}
EM4	20.33^{a}	5.92^{a}

The composting process can cause fluctuations in the pH and temperature values of the organic matter itself. The occurrence of periodic release of acid solutions will cause a decrease in pH (acidification) while in the initial phase of the composting process there was generally an increase in pH as a result of the production of ammonia from nitrogen-containing compounds. Table 1 shows that MA11 and Eco Farming starter types produce compost with pH values that are not significantly different. The pH at the beginning of the composting process shows an acid value (below 6). The increase in pH was thought to be due to the production of ammonia. Lopez et al. (López et al., 2021) explain that the increase in pH was also due to the decomposition of the material as a form of influence from microorganisms originating from starter microorganisms and cow dung. MA 11 and Eco Farming are types of starters that have a higher number of microorganisms compared to EM4. In the next process, microorganisms will convert the organic acids that have been formed so that the blotong which has a degree of acidity will slowly rise to near neutral pH because of the characteristics of the material that is easily broken down by microorganisms (Sauer et al., 2008). This is in accordance with the results in Table 1 which shows that EM4 has a relatively acidic pH compared to other starters. The number of microorganisms in the compost will affect the decomposition activity of organic matter so that the increase in pH during the composting process goes hand in hand with the increase in pH caused by the activity of these microorganisms. The starter MA11 and Eco Farming produced a pH of 7.02 and 6.63 which was the optimal pH for the growth and development of microorganisms. This is in accordance with the statement of Yuanita and Amir et al. (Amir et al., 2005) which explains that the pH range that allows microorganism activity to run optimally in the composting process was between 6-7.5.

Besides pH, temperature was also an indicator of the decomposition process related to the activity of microorganisms. The type of starter has a significant effect on temperature in the composting process (Table 1). During the composting process the average temperature was 19 ^oC. From the table it can be seen that there was an increase in the composting process. The increase in temperature was due to the presence of bacteria from the starter which proliferates causing an increase in heat and an increase in temperature (Suryanti & Santiasa, 2020). MA11 type starter showed compost yield with the highest temperature compared to other types of starter, namely 28 ^oC. when viewed from the bacterial content of the three types of starter, starter MA11 was the starter with the most bacteria content, followed by Ecofarming and followed by EM4. The activity of bacteria will trigger an increase in temperature in the composting process. When the temperature reaches 30 ^oC, mesophic fungi will reduce their activity and the activity of decomposing organic matter will be replaced by thermophilic fungi. When the temperature increases in the mesophilic phase, it will also be followed by an increase in C/N (Huang et al., 2004). This statement was supported by table 3 which shows the MA11 starter produced the highest organic C/N. This was as a result of the use of N-organic as a nutrient that was used by microorganisms in their development. The smell of compost shows the highest average level in starter MA11 (figure 2) which indicates a reduction in the unpleasant odor in the compost. When the process of decomposition of organic matter has passed the optimal temperature, it will be marked by a reduction in the rotten smell produced in the compost (Huang et al., 2004).

3.4 Chemical properties of bokashi fertilizer

From the results of laboratory tests in Table 2, it shows that the type of starter MA11, Eco Farming and EM4 used in the decomposition of cow manure has a significantly different effect on the moisture content and potassium content of the compost. The lowest water content value was the use of the EM4 starter type. Guo et al. (Guo et al., 2012) revealed that raw material size and moisture content are one of the factors for the success of the composting process. According to Zafari & Kiamehr (Zafari & Kianmehr, 2014) the value of water content that meets the standard was 40-60% vulnerable.

Potassium analysis is carried out on the compost after the composting process was complete. Microbes in the starter use potassium for their activities and the process of decomposing complex organic matter into simpler organic matter during composting will produce potassium elements available to plants . The requirements for potassium content for compost according to SNI 19-7030-2004 are at least > 0.2%. From the test results it was found that all types of starter used had a potassium value of > 0.2% and the highest was the MA11 starter type. Potassium in plants functions in the process of forming sugar and starch, sugar translocation, enzyme activity and stomata movement. The results of the Potassium content of each type of starter use are in accordance with the SNI 19-7030-2004 standard, namely a minimum of> 0.1%. In the composting process, part of the phosphorus was sucked up by microorganisms for the formation of egg whites. The more microorganisms, the faster the compost will mature so that the microorganisms have the opportunity to suck up the phosphorus in the compost. For the use of the EM4 starter the Potassium content in the compost was different but not significant with the use of MA11 and Eco Farming starters.

Tabel 2. The average content of water content, potassium, and potassium bokashi due to treatment

EM type	Observation parameters		
	Water content (%)	Potassium (%)	Phospate (%)
MA11	44.93^{c}	1.31^{c}	0.94^{b}
Eco Farming	29.78^{b}	1.11^{b}	0.69^{a}
EM4	16.95^{a}	0.82^{a}	0.75^{ab}

The test results for C-organic content, total N, and C/N ratio for each type of starter are presented in Table 3. The use of this type of starter showed a significantly different effect on the organic C content of the compost. The highest C-organic content was in the starter type MA11 which was 19.33% which indicated that the compost had low an-organic content. C-Organic content is the formation of tissues in the plant body. Organic Matter is the percentage of soil fertility which has many benefits for plants, one of which is as a source of nutrients which has an impact on increasing plant productivity. The C-organic content for MA11 and Eco Farming starter types has met the minimum standards of SNI for compost, namely 9.8% - 32%. However, when using EM4 starter, the C-organic content is low. Low organic C content reflects the poor quality of the compost, which reflects the high level of contaminants (foreign materials) in the product.

The total N content for the use of the MA11 and Eco Farming starter types was not significantly different, namely 1.72% and 1.51% respectively, however, it was significantly different for the use of the EM4 type. The greater the total N content, the greater the number of microbes, thus, the phosphorus that is broken down also increases, and this is one of the reasons for the high levels of phosphorus in compost.

Tabel 3. The average C-organic content, total N, and C/N ratio due to treatment

EM type	Observation parameters		
	C-organic (%)	N-total (%)	C/N ratio (%)
MA11	19.33^{c}	1.72^{b}	10.55^{b}
Eco Farming	9.80^{b}	1.51^{b}	6.59^{a}
EM4	5.68^{a}	0.60^{a}	10.62^{b}

The N-Total content for the use of EM4 starter types is low (0.6%) but if this value is used as a ratio value for comparison with C it will produce a C/N ratio of 10.62. The value of the C/N ratio of organic matter is an important factor in composting. According to Gurmessa et al. (Gurmessa et al., 2021), the C/N value is an indicator of the quality and maturity level of the compost material. So that the cow manure compost product can be said to be mature and ready for use. This is in accordance with the range of C/N values of mature compost in SNI 19-7030-2004, namely 10-20. However, for the use of the Eco farming starter type, the final value of C/N still does not meet the SNI even though the C-organic content is in accordance with the minimum standards.

During the composting process, microorganisms utilize a small portion of the elements phosphate and potassium for their metabolic activities. Phosphate solubilizing bacteria can generally dissolve potassium in organic matter. The longer the composting process is carried out, the lower the C/N ratio will be (Huang et al., 2004). Low C/N value is caused by the C content in the compost material which has been reduced a lot because it used by microorganisms as a food or energy source, while the nitrogen content has increased due to the decomposition process of the compost material by microorganisms produce ammonia and nitrogen so that the C/N ratio decreases (Gurmessa et al., 2021).

4. CONCLUSION

The results showed that 20 mL MA11 provided a faster composting process with an optimal pH level and C/N ratio. MA-11 activator had the highest color score and temperature (28 ^{o}C), however not significant diffeence in pH compare Eco Farming. MA-11 produces compost with chemical content in accordance with SNI. In addition, the water content produced was lower and there was an increase in nutrients compared to other treatments. The use of MA11 in optimum quantities will produce good quality organic waste and quickly without causing environmental problems in its application to soil. Further research to evaluate the impact of different microbial combinations on compost quality and their subsequent effects on the growth performance of various plant species was recomended.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Mohd Sabri Mohd Ghazali: Conducted the research trial. Marchel Putra Garfansa: Supervised the trial. Iswahyudi Iswayudi: Cosupervised the trial. Mohammad Shoimus Sholeh: Technical assistance for lab analysis, proof reading and final editing

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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