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EFFECT OF ADDING "RAJA" BANANA PEEL BIOACTIVATOR (MUSA TEXTILIA) ON TEMPEH LIQUID WASTE IN MAKING ORGANIC LIQUID FERTILIZER

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Abstract

Introduction: *The organic content of tempeh liquid waste and "Raja" banana peel can be utilized to make organic liquid fertilizer as an alternative for waste control. This study aims to analyze the effect of "Raja" banana peel bio-activator on tempeh liquid waste during the production of organic liquid fertilizer.* ***Methods:*** *The research design is a pure experiment with a posttest only and a control group design. The object of the study was tempeh liquid waste treated with Raja banana peel bio-activator in three replicates of 30 mL 40 mL and 50 mL. Data analysis used the Kruskal Wallis test.* ***Results and Discussion:*** *The highest average in C content was found in liquid fertilizer with bio-activator 30 mL (1.84%), N content in liquid fertilizer with bio-activator 50 mL (0.17%), P content in liquid fertilizer with bio-activator 50 mL (0.11%), K content in liquid fertilizer with bio-activator 30 mL (0.13%) and total macro nutrients (N, P, K) in liquid fertilizer with bio-activator 50 mL (0.36%). The average volume of "Raja" banana peel bio-activator did differ significantly between 30 mL, 40 mL and 50 mL, indicating that it did not significantly affect the content of C, N, P and K in organic liquid fertilizer.* ***Conclusion:*** *The contents of macro nutrient in this organic liquid fertilizer do not meet the government standard on Minister of Agriculture Regulation; therefore' further research is needed to determine the appropriate levels of bio-activators in producing organic liquid fertilizer.*

INTRODUCTION

Wastewater is the residual water from 70% of household activities, 16% of industrial processes and 14% of activities in public places. Wastewater contains materials or substances that are detrimental to human health and can harm the environment due to content of inorganic substances that are difficult to decompose (1-2). Inorganic substances are not processed; as a result, they can cause health problems such as diarrhea and other infections, as well as clog the drainage canals and cause flooding (2). Industrial wastewater must be treated before disposal to protect the environment. One of the household industries around us is the tempeh industry.

The tempeh industry generates liquid waste that is considered to have no economic value, so it is directly discharged into the ditches (3). The act of disposing of liquid waste directly into ditches can pollute water bodies. Poor quality of water bodies can be a source of pollutants that can directly or indirectly affect human health. Tempeh liquid waste, which is produced during the soaking and boiling of soybeans, can be processed into organic liquid fertilizer because of its organic and nutrition content. Liquid waste from the washing process can be returned into the soaking and boiling process if it has been previously processed. This process can reduce tempeh waste pollution, especially *Dissolved Oxygen* (DO), organic matter and NH_3 (4). The characteristics of liquid waste from soaking and boiling tempeh include the presence of organic compounds such as the protein (0.42%), fat (0.13%), carbohydrates (0.11%), nitrogen (0.045%), phosphorus (0.087%), potassium (0.086%), calcium (13.60 ppm) and iron (4.55 ppm) (5).

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In general, the waste water generated by the food industry has the characteristics of containing large amounts of organic matter such as proteins, carbohydrates, fats, suspended solids and high levels of Biochemical Oxygen Demand and Chemical Oxygen Demand. Industrial waste management techniques can be classified into three ways, specifically reducing waste sources through modification of treatment factory, detoxification or neutralization of unwanted waste components and waste recovery processes (recycling or processing of waste for added value products). Good waste management makes the production process more efficient and reduces pollution (4).

The technique of reducing waste sources through modification of treatment factory are usually carried out by large factories because it is costly and time-consuming, causing delays in the production process (4). Detoxification techniques or neutralization of unwanted waste components are carried out to reduce the level of toxicity of substances in waste because the disposal of this waste will have direct contact with the community. One example is the application of the phytoremediation method, which is the use of plants with the ability to absorb contaminants in waste to reduce pollutant content (6). Waste recovery technique is a process of recycling waste or additional processing so that the waste does not damage the environment and has added value (4). Waste recovery technique is usually used by home industries because it does not require high costs and the processing is simple. One of the alternatives in waste recovery technique is by making organic liquid fertilizer.

Organic liquid fertilizer is fertilizer derived from fermented animals or plants and is liquid. The physical characteristics of good organic liquid fertilizer are brownish yellow in color, neutral pH, no foul smell, and high nutrients (7). The advantage of using organic liquid fertilizer is that it can provide nutrients according to plant needs (8). The liquid form and the concentration of the application that can be adjusted according to the needs of the plant will allow for uniform distribution of nutrients. In making organic liquid fertilizer, liquid waste is mixed with bio-activators to accelerate decomposition. Bio-activators are organic compounds that have beneficial microorganisms (9). In this study, the bio-activators used was “Raja” banana peel.

According to the Central Bureau of Statistics of Indonesia, in 2020, East Java province had a high productivity of bananas as much as 2,618,795 tons. Processing bananas into various foods will produce waste in the form of banana peels. Raja banana contains a high content of Vitamin C and Vitamin A. Raja banana peel is known to be quite thick, comprising 20-25% of the fruit’s whole body. The Raja banana peel is yellow in color with black spots and fragrant. Raja banana peel can be used as a bio-activator because it has high organic matter and chemicals, such as *Magnesium*, *Sodium*, *Phosphorus* and *Sulphur* (10). In the process of making organic liquid fertilizer, the use of Raja banana peel as a bio-activator must be added to 4 microbial consortiums. This is due to the fact that Raja banana peel is known to contain relatively low levels of nutrients. The result of the fermentation process of Raja banana peel mixed with water and 4 microbial consortiums will become a bio-activator in the manufacture of organic liquid fertilizer. The advantage of a bio-activator is that it contains selected strains that are highly adaptable. This strain is processed into a natural carrier material to maintain the lifespan of microorganisms. The addition of the 4 microbial consortiums will increase the nutrients and can shorten the fermentation time.

Bio-activators made from Kepok banana peel and 4 microbial consortiums with fermentation for 7 days produced C-Organic content of 13.40%, N-total as much as 5.85%, P_2O_5 of 0.10%, K_2O of 5.80% and pH of 4 (11). Bio-activators made from 1 kg of plantain peel and 1 liter of water by adding 25 mL of 4 microbial consortium produced 0.10% of nitrogen, 0.12% of P_2O_5, 0.73% of C-Organic, 7.30 of C/N ratio and a pH of 4.8 (12). The optimum fermentation time for organic liquid fertilizer is 10 days, the ratio of 4 microbial consortium: starter 40mL:100mL will produce 1.24% of Nitrogen, 1.01% of P_2O_5, 3.36% of K_2O and the pH is 4.2 (13). In organic liquid fertilizer derived from 500 mL of soybean processing cooking water and 15 mL of 4 microbial consortium fermented for 10 days contained 0.30% of Nitrogen, 0.0068% of phosphorus and a pH of 4.8 (5). In this study, Raja banana peel (*Musa textilia*) was used as a bio-activator in the production of organic liquid fertilizer. Raja banana peel (*Musa textilia*) contains 27.64% carbohydrate (12).

The manufacture of organic liquid fertilizer using tempeh liquid waste with Raja banana peel (*Musa textilia*) fermentation and 4 microbial consortia as bio-activators can be an alternative to increase economic value for producers and people who want to use it.

The purpose of this study was to analyze the process of making organic liquid fertilizer from tempeh liquid waste with Raja banana peel (*Musa textilia*).

METHODS

The research design is experimental research with a posttest only and control group design. The research was conducted in the workshop of the Department of Environmental Health Polytechnic of Health Surabaya.

The equipment used was a 5 liters plastic container/ reactor with hose, plastic faucet and used 600 mL water bottle, filter, dipper, measuring cup, scale, thermometer, pH meter and stationery.

The object of the research was tempeh liquid waste from Wonocolo Subdistrict of Surabaya and obtained from soaking and boiling soybeans. Bio-activator derived from Raja banana peel (*Musa textilia*) was used to produce fertilizer in this study. The whole research was conducted anaerobically.

The research procedure began with the preparation of bio-activator made from 3 kg of Raja banana peel (*Musa textilia*) that had been cut into pieces with 75 mL of a consortium of 4 microbes and 3 liters of water. The bio-activator was fermented for 7 days and filtered to produce a filtrate.

The 4 microbial consortiums used in this study was produced and marketed by PT Songgolangit Persada Jakarta under the brand name EM-4 and expires on 10/2023. The composition of EM-4 is *Lactobacillus sp*. (fermentation bacteria), *Saccharomyces sp*. (active cell enhancer), *Phytohormones* (organic compound producer) and organic matter decomposers (*cellulolytic and lognolytic*).

Fertilizer production was followed by the addition of Raja banana peel (*Musa textilia*) bio-activator into 500 mL of tempeh liquid waste with different volume variations of 30 mL, 40 mL and 50 mL and fermented for 10 days with 3 days of replication. The test parameters of organic liquid fertilizer were C, N, P, K, C/N ratio, pH and temperature. The C, N, P, K content and C/N ratio measurements were carried out by sending samples to a laboratory, whereas pH and temperature were measured using a pH meter and a thermometer, respectively. Data on C, N, P and K content were analyzed using the Kruskal Wallis test.

RESULTS

The result of fermentation / filtrate of Raja banana peel (*Musa textilia*) bio-activator was dark brown in color, thick and no bad odor (smelled similar to Tapai). The test results of the Carbon (C) content and macro nutrients content, specifically Nitrogen (N), Phosphorus (P) and Potassium (K) can be seen in Table 1.

Based on Table 1, the average Carbon (C) content of organic liquid fertilizer with 30 ml bio-activator is 1.84%, 40 mL bio-activator is 1.34% and 50 mL bio-activator is 1.72%. The average Nitrogen (N) content of organic liquid fertilizer with 30 mL bio-activator is 0.10%, with 40 mL bio-activator is 0.13%, and with 50 mL bio-activator is 0.17%. The average Phosphor (P) content of organic liquid fertilizer with 30 mL bio-activator is 0.08%, 40 mL bio-activator is 0.09% and 50 mL bio-activator is 0.11%. The average content of Potassium (K) of organic liquid fertilizer with 30 mL bio-activator is 0.13%, 40 mL bio-activator is 0.10% and 50 mL bio-activator is 0.10%. The results showed that the lowest total micro nutrients were found in the 30 mL bio-activator treatment (0.31%) and the highest content was found in the 50 mL bio-activator treatment (0.36%). Based on the results of the research, the addition of Raja banana peel (*Musa textilia*) bioactivator in varying amounts, specifically 30 mL, 40 mL and 50 mL, into tempeh liquid waste to produce organic liquid fertilizer did not significantly increase the content of C, N, P and K.

Table 1. Contents of C and Macronutrients (N, P and K) in Organic Liquid Fertilizer

Parameter	Bio-activator Concentration (%)		
	30 mL	4 mL	5 mL
C	1.84	1.34	1.72
N	0.10	0.08	0.13
P	0.13	0.09	0.10
K	0.17	0.11	0.08
Total Macronutrients (N+P+K)	0.31	0.32	0.36

Based on the results in Table 2, the C/N ratio of organic liquid fertilizer increased after being given the treatment. The average C/N ratio of organic liquid fertilizer with 30 mL bio-activator is 18, 40 mL bio-activator is 19.24 and 50 mL bio-activator is 24.23. The C/N ratio of tempeh liquid waste is 29.3 and the C/N ratio of Raja banana peel (*Musa textilia*) is 16.39.

Table 2. C/N Ratio in Organic Liquid Fertilizer

Replication	Bio-activator Concentration (%)				
	30 mL	40 mL	50 mL	Tempeh Liquid Waste	Raja Banana (*Musa textilia*) Bi-oactivator
1	16.22	16.38	21.38		
2	18.36	18.31	21.06		
3	21.75	21.77	29.17		
Average	18	19.24	24.23	29.3	16.39

Temperature and pH levels were also measured by the researchers. The average pH of 30 mL, 40 mL and 50 mL of organic liquid fertilizer derived from Raja banana peel (*Musa textilia*) bio-activator were 7.6, 7.8 and 7.4, respectively. The pH scale meets the quality standards. The average temperature of organic liquid fertilizer derived from Raja banana peel (*Musa textilia*) bio-activator in varying amounts, specifically 30 mL, 40 mL and 50 mL, is 30.1°C, 29.8°C and 30.1°C, respectively.

Table 3. The Result of Kruskal Wallis' Test of Organic Liquid Fertilizer Content

Liquid Fertilizer Content	p-value
C	0.561
N	0.199
P	0.561
K	0.051

Table 3 shows the analysis of mean differences between bio-activator treatment and organic liquid fertilizer for C, N, P and K using the Kruskal Wallis test. The significance value was ($P > \alpha$) or $P > 0.05$. This shows that there was no difference between the average of 30 mL, 40 mL, and 50 mL of Raja banana peel (*Musa textilia*) bio-activator treatment against tempeh liquid waste for producing organic liquid fertilizer.

In this study, it was found that the addition of Raja banana peel bio-activator to tempeh liquid waste in the manufacture of organic liquid fertilizer had no significant effect. The application of Raja banana peel filtrate did not increase the levels of C content and macro nutrients (N, P and K) as elements required for an organic liquid fertilizer.

DISCUSSION

Based on the test results, the Carbon (C) content decreased. In the organic liquid fertilizer of this study, 30 mL of bio-activator had the greatest C content, at 1.84%. The C content is likely to decrease because carbon is a source of energy for microorganisms to metabolize and break down into CO_2 (11). The C content is also influenced by the amount and composition of organic matter. In this study, the C content of the Raja banana peel was only 1.45% (14). The content of this Raja banana peel is still low of value, thus the right ratio of ingredients are needed when making organic liquid fertilizer. The results of the analysis showed that the average C content of the 30 mL, 40 mL and 50 mL Raja banana peel (*Musa textilia*) bio-activator treatments did not significantly differ. This result could be caused by the Raja banana peel (*Musa textilia*) bio-activator not being sufficient enough as a source of energy and food for microorganisms to carry out activities (8). The C content can be increased by adding 20 - 30 mL of molasses as a source of energy and food for microorganisms (15).

The highest average of the Nitrogen (N) content in the organic liquid fertilizer was found in the 50 mL bio-activator treatment, which was 0.17%. The Nitrogen (N) content in the organic liquid fertilizer increased because decomposer microorganisms can grow and divide at maximum speed; as a result, microorganisms can decompose organic compounds optimally (16). This N content requirement was also obtained from the main ingredients of liquid fertilizer, namely tempeh liquid waste at 0.04% and Raja banana peel (*Musa textilia*) bio-activator at 0.07% (14). Although these content values were insufficient, they had an influence on increasing the N content in organic liquid fertilizer. The analysis showed that the average of the N content in the Raja banana peel (*Musa textilia*) bio-activator treatments of 30 mL, 40 mL and 50 mL was not significantly different. This significantly different average can be caused by the low N content of the main ingredients, which are tempeh liquid waste and Raja banana peel (*Musa textilia*) (17). The N content can be increased by adding other fruit peels that have high N contents. One of the fruit peels that has a high N content is mango peel, which is 1.05% (11).

The highest average of the Phosphor (P) content in organic liquid fertilizer was found in the 50 mL bio-activator treatment, which was 0.11%. The average P content in organic liquid fertilizer increased. The increase in average of the P content indicates that the increase in Raja banana peel (*Musa textilia*) bio-activator has an effect. The increase in P content is due to the microbial consortium (EM-4) dissolving phosphate in organic matter because it has phosphate solubilizing bacteria (10,17). In the form of substrate, the higher the N content, the more microorganisms dissolve phosphate, thus increasing the P content in liquid fertilizer (18). The results of the analysis showed that the average P content in Raja banana peel (*Musa textilia*) bio-activator treatment of 30 mL, 40 mL and 50 mL was not significantly different. There is no difference due to the low nitrogen content; therefore, the phosphate solubilizing bacteria did not work optimally to decompose organic matter containing a substantial amount of phosphorus (17). The P content can be increased by increasing the volume of bio-activator because it contains solvent microorganisms, such as *Streptomyces sp*., *Lactobacillus sp*. and cellulose-decomposing fungi and yeasts that are able to change P and affect the increase in P content in liquid fertilizers (5).

The highest average of the Potassium content in organic liquid fertilizer was found in the 30 mL bio-activator treatment, which was 0.13%. The average K content decreased after the treatment. The majority of the K content in organic liquid fertilizer comes from Raja banana peel (*Musa textilia*), which has a K content of 1.03% (14), compared to tempeh liquid waste, which has a K content of 0.09%. In this test, it was discovered that the length of fermentation did not increase the total K content in the liquid fertilizer. The K content may decrease due to the presence of sediment in the container, resulting to the K content being undetected (19).

The activity of microorganisms in the degradation process is ineffective, so the carbon bonds in the organic matter are not separated to simplify it. Fertilizers contain K+ ions to form K compounds for metabolism; therefore, the K content does not increase as the number of bacteria increases (19). The results of the analysis indicate that the average K content in Raja banana peel (*Musa textilia*) bio-activator treatment with 30 mL, 40 mL and 50 mL is not significantly different. There is no difference in the average K content due to the reduced potential of K+ ions caused by organic compounds (20). The K content can be increased with high fiber organic matter. Fiber is cellulose and lignin that can bind the K content (21).

Based on the analysis results, the 30 mL bio-activator treatment contained the least total macronutrients (0.31%), followed by the 40 mL bio-activator treatment (0.32%), and the 50 mL bio-activator treatment contained the most total macronutrients (0.36%). The content of macro nutrients in this organic liquid fertilizer does not meet the standards of the Minister of Agriculture Regulation Number 70 of 2011 (22).

Based on the test results, the C/N ratio of organic liquid fertilizer increased after treatment. The highest level of C/N ratio of organic liquid fertilizer in the provision of 50 mL bio-activator was 24.23. The C/N ratio of organic liquid fertilizer depends on the original C/N ratio. The C/N ratio is influenced by the needs of the material and the maximum ratio that can be used in order to not damage the environment. In this study, the C/N ratio of tempeh liquid waste was 29.3 and the C/N ratio of Raja banana peel (*Musa textilia*) bioactivator was 16.39. Based on the C/N ratio test results, the organic liquid fertilizer produced from Raja banana peel (*Musa textilia*) bio-activator had a lower C/N ratio than the organic liquid fertilizer without Raja banana peel (*Musa textilia*) bioactivator. Based on the calculation of the C/N ratio requirement, 1 liter of tempeh liquid waste required 260 mL of Raja banana peel (*Musa textilia*) bio-activator. Therefore, the C/N ratio requirement for producing organic liquid fertilizer does not meet the standards because 500 mL of tempeh liquid waste uses 30 mL, 40 mL and 50 mL of bio-activator. If there excessive carbon is present, metabolism will not be complete and the carbon in the substrate does not change completely, so maximum methane is not achieved. Conversely, excessive nitrogen will increase ammonia (NH_3) and inhibit bacterial growth even at low concentrations (23). A high C/N ratio can slow down fermentation and a low C/N ratio can produce ammonia as well as nitrogen (24). The fermentation process is the process of breaking down the carbohydrate content of organic matter so that it decreases and the soluble N compound (ammonia) increases. As a result of this process, the C/N content decreases and remains relatively stable, indicating that the C/N ratio of the material will approach that of the soil (21).

The average pH of organic liquid waste has met the standard. The average pH of this liquid organic fertilizer was 7.6. PH in fertilizer fermentation is influenced by the enzyme activity of microorganisms to form substrate-enzyme complexes. Anaerobic digestion of carbohydrates and amino acids of liquid waste and Raja banana peel (*Musa textilia*) produces methane, carbon dioxide, and organic acids as a fermentation process (25). The process increases the pH to neutral - alkaline. Fermentation (increased bacterial activity) can also lead to an increase in pH by degrading ammonia and nitrogen, resulting in an alkaline condition (16).

Based on the measurement results, the groundwater temperature of the liquid fertilizer was ≤ 30°C, indicating that fermentation is in a proper temperature range (26). The temperature of organic liquid fertilizer is measured to determine any changes in microorganism activity in the fermentation process (27). During the production of organic liquid fertilizer, a homogeneous or stirring process is carried out to keep the temperature optimal.

Data analysis of mean differences was done with the Kruskal Wallis test. The results of the analysis showed no significant difference between the average content of C, N, P and K in 30 mL, 40 mL and 50 mL of Raja banana peel (*Musa textilia*) bio-activator added to tempeh liquid waste during the production of organic liquid fertilizer ($P > 0.05$).

The content of C and macro nutrients (the N, P and K content) in the organic liquid fertilizer do not meet the standards of the Minister of Agriculture Regulation number 70 of 2011 (22). However, the liquid fertilizer can be used by sprinkling it on the soil and/or spraying it directly on the plants regularly. Recommended crops for organic liquid fertilizer application are rice, secondary crops (soybean / peanut), vegetables >3 months, plantation crops and crops >3 months (22).

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CONCLUSION

The content of C and macro nutrients (the N, P and K content) in organic liquid fertilizer still do not meet

the standards of the Minister of Agriculture Regulation number 70 of 2011. Raja banana peel (*Musa textilia*) bio-activator does not have a significant effect in increasing the content of C and macro nutrients (the N, P and K content) in organic liquid fertilizer. Further research is needed to determine the appropriate levels of bio-activators in making organic liquid fertilizer.

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