Indonesian Journal of Bioscience (IJOBI)
Vol.1, No.1, Page 37-44, Maret 2023, E-ISSN: xxxx-xxxx | P-ISSN: xxxx-xxxx
DOI: ijobi/v3

The Effect of Different Bio-Activators on Compost Quality of Agricultural Waste

Ellyza Yohana Putri Pratiwi[a], Suhartini[a], Ahmad Kamal Sudrajat[a]
[a]Departement of Biology Education, Universitas Negeri Yogyakarta
ellyzayohana.2017@student.uny.ac.id[1], suhartini@uny.ac.id[2]

Article Info

Article history:

Received 25 October 2023
Revised 23 December 2023
Accepted 23 December 2023

Keyword:

Agricultural waste
Bio activator
Compost quality

ABSTRACT

This study aims to assess the impact of various bio-activators on enhancing the quality of compost derived from agricultural waste, identifying the most effective bio-activators in producing high-quality compost. This research adopts an experimental approach employing a Completely Randomized Design (CRD). The focus lies on compost generated from agricultural waste supplemented with distinct bio-activators: Tape Yeast, Tempe Yeast, Stardec, EM-4, and M-21 Decomposer, each treatment replicated thrice. The study spanned 75 days. Compost quality assessment involves examining physical parameters (temperature, humidity, pH, volume, weight, color, texture, odor), chemical constituents (carbon (C), nitrogen (N), C: N ratio, phosphorus (P), potassium (K)), and the overall composting duration. Data analysis encompassed One Way ANOVA and the Kruskall Wallis Test. Results of physical parameters revealed similar appearances across all treatments, characterized by a dark brown color, a granular texture of 2-4mm, and an earthy aroma. Conversely, chemical analysis highlighted a significant influence of diverse bio-activators on compost quality. Additionally, the composting duration demonstrated that the utilization of bio-activators impacts both quality and accelerates composting time. Notably, EM-4 emerged as the most effective bio-activator, contributing to superior compost quality.

Corresponding Author:

Ellyza Yohana Putri Pratiwi
Departement of Biology Education
Universitas Negeri Yogyakarta
Indonesia
Email: ellyzayohana.2017@student.uny.ac.id

1. INTRODUCTION

Ngawi Regency is one of the leading districts in the field of agriculture. Based on data from the Central Statistics Agency, around 39 percent of its area, or around 50,480 Ha, is agricultural land, with contributions in the agricultural sector until the end of 2017 amounting to 35.90 percent in East Java. Agricultural commodities in Ngawi Regency include rice, soybeans, corn, sugar cane, cassava, and tobacco (BPS, 2018). The extent of agricultural land is directly proportional to the amount of agricultural waste produced. Agricultural waste can be in the form of unused waste materials and residual materials from processing results. The handling of agricultural waste is still not getting the attention it deserves because people generally think it is just a side product of the main business that does not need to increase its production. If this is allowed to continue, there will be an accumulation of waste, which can cause new problems for the surrounding environment, such as environmental pollution. Therefore, proper handling is needed, namely by utilizing agricultural waste as fertilizer.

Fertilizer is one of the important elements and strategies in increasing production, crop productivity, and farmers' income to build national food security. There are two types of fertilizers:

organic and inorganic (Supartha, 2012). The use of inorganic fertilizers in Ngawi Regency is still high and still depends on fertilizers subsidized by the government. With the subsidy, the price of inorganic fertilizers will be lower. However, the problem that farmers often face in each growing season is the scarcity of subsidized fertilizers. In addition, using inorganic fertilizers will lead to the degradation of agricultural land resources faced primarily by a decrease in the soil's physical, chemical, and biological fertility due to intensive soil use and reduced use of organic fertilizers so that the organic matter content in the soil remains high. Thus, the application of organic fertilizers in the form of compost needs to be further encouraged because apart from being able to overcome the problem of agricultural waste production and the scarcity of subsidized fertilizers, compost contains organic matter, which is very important for soil fertility, which can improve soil physical properties such as the formation of aggregates or soil granulation and increase soil permeability, soil porosity, and soil microbial content (Rosmarkam, 2009).

Some agricultural wastes that can be used as compost and have good organic matter content are 1) straw which has N, P, and K nutrients of 0.4%, 0.2% and 0.7%, respectively, while the Si content and C are quite high, namely 7.9% and 40% (Man, Luu Hong, et al., 2010); 2) bagasse (bagasse) which has an organic matter content of about 90%. Contains nutrients N (0.30%), P(0.2%), K (0.14%), Ca (0.06%), Mg (0.04%), and has a very high carbon content, namely hemicellulose (25%), cellulose (50%) (BPP, 2002); 3) cow dung containing 2.33% N, 1.61% P, 1.58% K, 1.04% Ca, 0.33% Mg, 179 ppm Mn and 70.5 ppm Zn (Widowati, 2004).

Bio activators have roles, including speeding up the composting process, removing odors from garbage, fertilizing the soil, and inhibiting the growth of pests and diseases. The process of this physical-chemical change into small molecules and even into their components and elements is called decomposition. Bio activators are widely used in the manufacture of organic compost. Bio activators can be obtained from natural ingredients, for example, tempeh yeast and tape yeast, and there are several bio activators on the market, including Stardec, EM4, M-21, and others (Sulistyorini, 2005).

Compost is a type of organic fertilizer. Organic fertilizers consist of manure, green manure, compost, bone meal, and blood meal. Compost with adding a bio-activator has advantages over other organic fertilizers because it has a higher nutrient content than other organic fertilizers and contains complete micro and macro elements due to the help of microorganisms in the bio-activator (Hasibuan, 2006). Based on the information above, an understanding of the role of bio activators in the process of making compost from agricultural waste can reduce the accumulation of agricultural waste, speed up the composting process, improve the quality of compost, and help farmers obtain alternative fertilizers that are environmentally friendly and easy and inexpensive to produce. Therefore, this study aimed to determine the differences in the effect of using various bio activators on the quality of compost from agricultural waste and to determine which bio activator can produce the best quality compost from agricultural waste.

2. METHOD

This research was conducted on February 19 – May 5, 2021, at the Biology Garden, Department of Biology Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University. It was an experiment with a completely randomized design (CRD) with 5 (five) treatments, and each treatment consisted of 3 (three) replications. The treatment was carried out by adding various bio activators to agricultural waste, where the bio activators used included: Yeast Tape, Yeast Tempe, StarDec, EM-4, and M-21 Decomposer, with the dosage according to the recommendations for use in the instructions for use.

2.1. Bio Activator Manufacturing

There are 5 types of bio-activators used in this study: solid and liquid. The bio-activator has a different dosage, dissolved in 1000 ml of water and allowed to stand for 24 hours. the dosage used follows the instructions for the use of each bio activator , which are as follows:

1. Yeast Tape: 2.5 grams/kg. So for 1.5 kg of waste: 2.5 x 1.5 = 3.75 grams.
2. Tempe yeast: 3.4 grams/kg. So for 1.5 kg of waste: 3.4 x 1.5 = 5.1 grams.
3. Stardec : 2 grams / kg. So for 1.5 kg of waste: 2 x 1.5 = 3 grams.
4. EM – 4 : 1 milliliter / 1 kg. So for 1.5 kg of waste: 1 x 1.5 = 1.5 ml.
5. M-21 Decomposer 1 milliliter/ 1 kg. So for 1.5 kg of waste: 1 x 1.5 = 1.5 ml.

2.2. Producing of Compost

Organic material derived from agricultural waste, such as rice straw, is prepared and enumerated. The organic matter is mixed with 0.5 kg of rice straw, 0.5 kg of bagasse (bagasse), and 0.5 kg of cow dung each. The prepared bio-activator solution is mixed with organic matter (agricultural waste), with 3 repetitions for each treatment. The compost is stirred thrice a week to maintain moisture and facilitate aeration and 500 ml of water once a week if needed.

2.3. Compost Physical and Chemical Quality

Temperature measurements were carried out using a soil thermometer every 2 days. Moisture and pH measurements were carried out using a soil tester every 2 days. Weight measurements were carried out using a scale every 15 days. Volume measurement is done by calculating the remaining volume of compost every 15 days. The texture, color and smell of compost were observed by organoleptic tests every 15 days. The chemical parameters measured in this study referred to SNI 7763-2018 concerning Quality Requirements for Solid Organic Fertilizers. Carbon, Nitrogen, Phosphorus and Potassium quality measurements were carried out at the beginning and end of the study using laboratory analysis. Carbon measurements were carried out using the Walkley & Black method. Nitrogen measurements were carried out using the Kjeldahl method. Phosphorus measurements were carried out using the spectrophotometric method. While the measurement of Potassium was carried out using a flame photometer.

3. RESULTS AND DISCUSSION

3.1. Compost Physical Quality

3.1.1 Temperature

Based on the observations, it can be seen that the time the compost temperature increased was not the same between one compost treatment and another. The fastest and highest temperature rise was P4 (EM-4) with a peak temperature of 51°C, followed by P5 (M – 21 Decomposer) with a peak temperature of 45°C, P3 (Stardec) with a peak temperature of 42°C, P1 (Yeast Tape) with peak temperature of 42°C, P2 (Yeast Tempe) with a peak temperature of 39°C, while the lowest and late rise in temperature is at P0 (Control) with a peak temperature of 35°C (Figure 1).

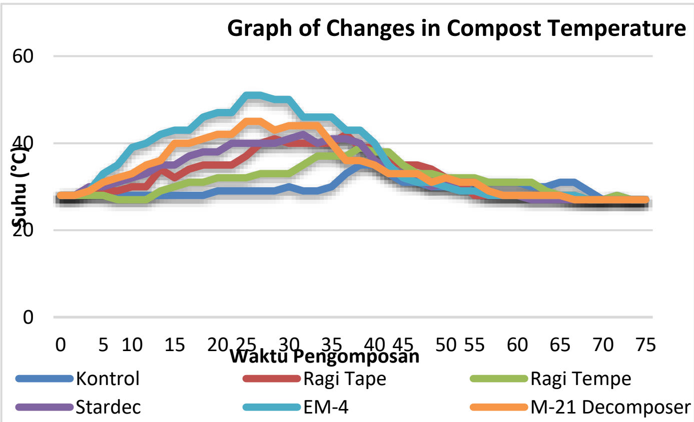

Figure 1. Graph of Changes in Compost Temperature

The data obtained was analyzed to find out whether there was an effect from the addition of various bio activators on compost temperature with the Kruskal Wallis Test using the SPSS program. The test results (Table 2) show a significance value of 0.024. The significance value obtained was sig <0.05, meaning that adding various bio activators significantly affected changes in compost temperature.

Table 1. Results of the Kruskal-Wallis Test Effect of Different Bio activators on Compost Temperature

Variable	Amount
Kruskal-Wallis H	12.960
Df	5
Asymp. Sig.	.024

The composting process is divided into several phases. The first phase is the mesophilic phase. The temperature ranges from 10 – 40°C. Mesophilic microorganisms are responsible for reducing the particle size of organic matter to speed up the composting process. According to Hartuti et al. (2009), the increase in temperature at the beginning of composting occurs due to microbial activity in decomposing organic matter with oxygen to produce energy in the form of CO2 heat and water vapor. The heat generated will be stored in the pile, while the surface is used for evaporation.

3.1.2 Humidity

Based on the results of the study, it was seen that P4 (EM-4) experienced the fastest average moisture reduction of all treatments, followed by P5 (M-21 Decomposer), P3 (Stardec), P1 (Yeast Tape), P2 (Yeast Tempe), and P0 (Control). The data obtained was analyzed to find out whether there was an effect from the addition of various bio activators on compost moisture using the Kruskal Wallis Test using the SPSS program. The test results (Table 3) show a significance value of 0.000. The significance value obtained was sig <0.05, meaning that adding various bio activators significantly affected changes in compost moisture.

The decrease in humidity in the compost is a sign that the decomposition of organic matter by microorganisms occurs and causes an increase in temperature in the compost and encourages the evaporation process. In addition, the availability of moist organic matter can provide optimal conditions for microorganisms. This is supported by the theory, which states that the activity of microorganisms in compost can reduce the value of the water content during the composting process as a result of metabolic processes which produce heat. In addition, temperature fluctuations in the compost can also affect the water content in the compost. So, in this case, it can be said that humidity is very closely related to the development of microorganisms and composting temperature fluctuations (Sunjoto, et al. 2014).

Based on the Quality Requirements for Solid Organic Fertilizer in SNI 7763-2018 (Table 1), the permissible moisture content of mature compost is 8 - 25%. In this study, P4 (EM-4), (M – 21 Decomposer), P3 (Stardec), and P1 (Yeast Tape) met the standard on day 60, while P0 (Control) and P2 (Yeast Tempe) met standards at day 75.

3.1.3 pH

At the beginning of the composting process, all treatment groups with the addition of bio activators and controls had an acidic pH value. This acidic pH is formed due to microorganisms' overhaul of organic matter into organic acids. Then gradually, the pH value increases to near neutral and reaches a neutral pH value. This is consistent with the theory according to Supadma and Arthagama (2008), which states that the pattern of changes in compost pH starts from slightly acidic pH due to the formation of simple organic acids, then the pH increases in further incubation due to the decomposition of proteins which produce ammonium accompanied by the release of OH- ions which can raise the pH value. Changes in pH indicate the activity of microorganisms in degrading organic matter (Ismayana et al., 2012).

The final result of the pH value for all treatments was the pH value P0 (Control) was 6.8, P1 (Yeast Tape) was 7, P2 (Yeast Tempe) was 6.8, P3 (Stardec) was 7, P4 (EM-4) is 7, and (M – 21 Decomposer) is 7. In this study, all treatments met the standards.

3.2. Chemical Quality of Compost

3.2.1 Nitrogen

Based on the results of the study (Figure 14), it can be seen that the Nitrogen (N) content in the initial measurement ranges from 0.8 – 0.9%. While in the final measurement, nitrogen levels increased with different levels in the treatment and control groups, the highest increase in nitrogen levels was found in P4 (EM-4) with a final content of 3.35%, followed by P5 (M - 21 Decomposer) by 2.67%, P3

(Stardec) by 2.63%, P1 (Yeast Tape) by 2.18%, P2 (Tempeh Yeast) by 1.99% and the lowest decrease in nitrogen levels was found in P0 (Control) with a final content of 1.69%.

The availability of nitrogen in the composting process is very necessary, when nitrogen is small, the compost will smell bad because of ammonia. Increased nitrogen levels can be caused by the decomposition of organic matter by microorganisms that convert ammonia into nitrites, resulting in an increased total N- content. This is by the theory that states that the increase in fertilizer nitrogen levels occurs due to the decomposition process carried out by microorganisms that produce ammonia and nitrates (Cesaria, et al. (2010). The increase in nitrates in compost is due to the process of nitrogen mineralization, which is the change of inorganic nitrogen into organic nitrogen with the help of enzymes produced by microorganisms. The mineralization reaction has two stages, namely ammonification and nitrification. The reaction explains that ammonia will bind to oxygen to produce nitrites and then nitriles will turn into nitrates. From this reaction, it is known that nitrates are more abundant in compost. This is related to the increase in total N in compost (Diyan, 2010).

3.2.2 Phosphorus

The average level of Phosphorus (P) in the initial measurement ranged from approximately 0.7-0.8%. While in the final measurement, the average Phosphorus (P) levels were different, the highest increase in phosphorus levels was found in P4 (EM-4) with a final content of 3.98%, followed by P5 (M - 21 Decomposer) by 3.51%, P3 (Stardec) by 3.29%, P1 (Yeast Tape) by 2.53%, P2 (Tempeh Yeast) by 2.18% and the lowest decrease in nitrogen levels was found in P0 (Control) with a final content of 1.93%.

Increased phosphorus occurs because the aerobic decomposition process will produce products, one of which is phosphorus. Thus, phosphorus levels will continue to increase during the decomposition process. This is by Widarti, et al., (2015), which states that the subdument of element P is higher with the weathering of composted organic matter. The phosphorus content increases due to the presence of P mineralization of organic matter with the help of extracellular enzymes.
Another source of phosphorus is at the compost maturation stage, microorganisms will gradually die and the P content in microorganisms will mix in the compost material which will directly increase the phosphorus content in the compost (Widarti, et al., 2015).

3.2.3 Kalium (K)

The average potassium levels in the initial measurement ranged from approximately 0.7-0.8%. While in the final measurement, all treatment and control groups increased, the average potassium levels were different, the highest increase in phosphorus levels was found in P4 (EM-4) with a final content of 2.99%, followed by P5 (M - 21 Decomposer) by 2.8%, P3 (Stardec) by 2.75%, P1 (Yeast Tape) by 2.47%, P2 (Tempeh Yeast) by 2.26% and the lowest increase in potassium levels was found in P0 (Control) with a final content of 1.99%.

Increasing potassium levels in compost can be caused by the activity of microorganisms and the mineralization process. This is in accordance with the theory according to Hidayati et al., (2011), which states that Potassium (K) is used by microorganisms in substrate materials as catalysts, with the presence of bacteria and their activity will greatly affect the increase in potassium content. Potassium can be bound to and stored in cells by bacteria and fungi. The binding of potassium elements comes from the decomposition of organic matter by microorganisms in a pile of compost material. Meanwhile, according to Amanillah (2011), states that Potassium (K2O) is a compound produced also by bacterial metabolism, where bacteria use free K + ions in fertilizer makers for metabolic purposes. So that the permentation results will increase along with the growing number of bacteria in the fertilizer constituents.

Based on the Quality Requirements for Solid Organic Fertilizer in SNI 7763-2018 (Table 1), it is known that the NPK quality standard value of organic fertilizer is at least 2%. It can be seen in table 10, that at the beginning of the observation the NPK values in P0 (Control), P1 (Yeast Tape), P2 (Tempeh Yeast), P3 (Stardec), P4 (EM-4), and P5 (M – 21 Decomposer), have met the standard, but at the end of the observation it was seen that in all treatment and control groups there was an increase. Sequentially, the increase in NPK levels is as follows: P4 (EM-4) > P5 (M – 21 Decomposer) > P1 (Yeast Tape) > P3 (Stardec) > P2 (Tempeh Yeast) > P0 (Control), with the highest NPK final value obtained at P4 (EM-4) of 10.32%. This can be because the microorganisms contained in the EM-4 bio activator best degrade organic matter. This can be caused because EM-4 contains the most complete compost-degrading microorganisms, namely lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria, and molds (Djuarnani, et al., 2005).

3.2.4 C:N Ratio

The average ratio of Carbon: Nitrogen (C: N) in the initial measurement ranged from 56 – 59%. In the final measurement, all treatment and control groups experienced a decrease in the C: N ratio with different levels. The highest decrease in C: N ratio was found in P4 (EM-4) with a final ratio of 7.70%, followed by P5 (M – 21 Decomposer) by 10.52%, P3 (Stardec) by 11.95%, P1 (Yeast Tape) by 13.95%, P2 (Tempeh Yeast) by 17.77% and the lowest decrease in carbon content was found in P0 (Control) with a final content of 25.24%. The C:N ratio is strongly influenced by the total Carbon and Nitrogen content in the compost. A low C: N value indicates a high level of nitrogen in the compost, the nitrogen content in organic matter can be increased by the addition of bio activators, since it contains high nitrogen in the form of protein and urea. While high C: N indicates a high organic C- content in compost. The value of the C: N ratio depends on the yield of carbon (C) and nitrogen (N) content in the compost. The C: N ratio is the most important indicator in determining the maturity of compost and is an important condition in the decomposition process, because a decrease in the C: N ratio indicates a decomposition process in the compost. This is in accordance with the theory that states that the C: N ratio will drop faster in compost base materials that have sufficient nitrogen content and get additional nitrogen. Bio activators contain high nitrogen in various forms such as proteins, amino acids, urea, and others (Manaputty, et al., 2012). Meanwhile, according to Sujonto, et al. (2014), a decrease in the C:N ratio in composting indicates that a decomposition process has occurred. Microorganisms will decompose organic material in compost by utilizing carbon content (C) as an energy source and utilizing nitrogen (N) as a cell constituent for microorganisms. This causes a change in the C: N ratio in the compost. Generally, the C: N ratio will continue to decrease in accordance with the decrease in C or N levels in compost (Widarti, et al., 2015).

Based on the Quality Requirements for Solid Organic Fertilizer in SNI 7763-2018, the allowed C: N ratio of mature compost is a maximum of 20%. In this study, treatment with the addition of bio activators, namely P4 (EM-4), P5 (M – 21 Decomposer), P3 (Stardec), P1 (Yeast Tape), and P2 (Yeast Tempeh) met the standards, while treatment without the addition of bio activators or P0 (Control) did not meet the standards. In order, the best C:N ratios are P4 (EM-4) > P5 (M – 21 Decomposer) > P1 (Yeast Tape) > P3 (Stardec) > P2 (Tempeh Yeast) > P0 (Control), with the best final value of C:N ratio obtained at P4 (EM-4) of 7.70%.

4. CONCLUSION

Based on the results of research and discussion that have been described, it can be concluded that the quality of compost with physical parameters in compost with the addition of bio activators Yeast Tape, Yeast Tempeh, Stardec, EM – 4, M – 21 Decomposer and compost without the addition of bio activators or controls has almost the same final result, namely blackish-brown color, texture or grain size 2 – 4mm, and has a smell like soil. EM-4 is a bio activator with the best compost quality, this is shown by the quality of compost with good physical parameters, the quality of compost with the best chemical parameters is shown by giving the best value in C, N, P, K, and C: N measurements that meet SNI 7763-2018, and the length of composting time is faster than treatment without the addition of bio activators. It is necessary to test the quality of compost with more complete parameters based on SNI 7763-2018, such as microbial contamination (E-coli and Salmonella sp.), heavy metals (Hg, Pb, Cd, As, Cr, Ni), and micronutrients (Fe total, Fe available, and Zn total), if compost is to be commercialized.

ACKNOWLEDGEMENTS

The author would like to thank Department of Biology Eduaction FMIPA UNY who have provided laboratory support and technique for this research.

REFERENCES

Badan Penelitian dan Pengembangan PT. Gula Putih Mataram. (2002). Hasil Analisis Bagase, Blotong, dan Abu. Lampung : PT. Gula Putih Mataram.

Badan Pusat Statistik. (2018). *Ngawi dalam Angka 2018*. Ngawi : Badan Pusat Statistik Kabupaten Ngawi.

Badan Standarisasi Nasional. (2018). Pupuk Organik Padat. Jakarta : Badan Standarisasi Nasional.

Cahaya, A., & D. A, Nugroho. (2008). Composting Organic Solid Waste (Vegetable Waste and Baggase). *Journal of Chemical Technology*. Semarang: Universitas Diponegoro.

Caesaria, R.Y., Wirosoedarmo, R. Dan Suharto, B. (2010). The Effect of Using Starter on the Qualitya of Tapioca Liquid Waste Fermentation asa an Alternative to Liquid Fertilizer. *Journal of Natural Resources and Environment*. Vol 8. Malang : Universitas Brawijaya.

Djuarnani, Kristian, dan Budi. (2005). *How to Make Quickly Compost*. Depok : Agro Media Pustaka.

Ekawandani, Nunik dan Alvianingsih. (2018). Leaf Compost Effectiveness Use EM-4 and Cow Dung. *Journal of TEDC*. Vol. 2 No. 2 Hal. 145-149.

Feng XM, Passoth V, Eklund-Jonsson C, Alminger ML, Schnürer J. (2007). Rhizopus oligosporus and yeast co-cultivation during barley tempeh fermentation-nutritional impact and real time PCR quantification of fungal growth dynamics. *Journal of Food Microbiology*. 24(4): 393–402.

Fitria, Restuti & Candrasari, Dewi. (2019). Kualitas Fisik Amoniasi Fermentasi (AMOFER) Janggel Jagung dengan Penambahan M21 Dekomposer pada Level yang Berbeda. *Bulletin of Applied Animal Research*. 1. 35-39. 10.36423/baar.v1i1.163.

Hartutik, Sri., Sriatun., dan Taslimah. (2009). Composting from Kenanga Flower Waste and the Effect of Percentage on Soil Nitrogen Availability. *Journal of Chemical Technology*. Semarang : Universitas Diponegoro.

Herdiyanto, Diyan. 2010. Mikrobiologi dan tekhnologi pengomposan. Bandung : Universitas Padjajaran.

Ismayana A, Indrasti NS, Suprihatin, Maddu A & FredyA. (2012). Initial C:N Ratio Factor and Aeration Rate in Bagasse and Blotong Composting Process. *Journal of Engineering Agricultural Industry*. Vol 22(3): 173-179.

Luu Hong, Man, Nguyen Thi Ngoc Han, and Takeshi Watanabe. (2015). *Improvement of Soil Fertility by Rice Straw Manure. Journal of Omonrice. Vol 17, 54- 66.*

Manuputty, M. C., Jacob, A. dan Haumahu. (2012). The Effect of Effective Inoculant Promi and EM-4 on Decomposition Rate and Quality Compost from Waste at Ambon City. *Juournal of Agrologia*. Vol. 1. Page 1 - 5.

Raabe, R.D. (2001). The *Rapid Composting Metode. Co- OperativeEkstension, devision of Agriculture and Natural Resources*. California : Univercity of California.

Ratna Stia Dewi, & Saefuddin 'Aziz. (2011). Isolasi Rhizopus oligosporus pada Beberapa Inokulum Tempe Di Kabupaten Banyumas. *Jurnal Bio Molekul*. Vol 6(2), 93–104.

Rosmarkam, A dan Nasih W. (2009). *Soil Fertility*. Yogyakarta: Kanisius.

Sanchez, O.J., Ospina, D.A dan Montoya, S. 2017. Compost Supplementation with Nutrients and Microorganisms in Composting Process Waste Management. *Journal of Biores technology*. Vol 98 (12) : 52-57.

Setyorini, Diah et al., (2006). *Kompos*. Diakses 12 Januari 2021, dari Departemen Pertanian. balittanah.litbang.deptan.go.id/dokumentasi/buku/pupuk/pupuk2.pdf.

Som M.-P., Lemée L., Amblès A., (2009), Stability and maturity of a green waste and biowaste compost assessed on the basis of a molecular study using spectroscopy, thermal analysis, thermodesorption and thermochemolysis. *Journal of Bioresource Technology*. Volume 100, Issue 19.

Sulistyorini, L. (2005). Pengelolaan Sampah Dengan Cara Menjadikannya Kompos. *Jurnal Kesehatan Lingkungan*. Vol. II, NO. 1, Juli 2005 : 77 – 84.

Supadma dan Arthagama D, M. (2008). Uji Formulasi Kualitas Pupuk Kompos yang Bersumber dari Sampah Organik dengan Penambahan Limbah Ternak Ayam, Sapi, Babi, dan Tanaman Pahitan. *Jurnal Bumi Lestari*. Vol 8(2): 113-121.

Suparta, I Nyoman Yogi. (2012). Aplikasi Jenis Pupuk Organik pada Tanaman Padi Sistem Pertanian Organik. *E-jurnal Agroteknologi Tropika* ISSN: 2301-6515 Vol. 1, No. 2.

Syukur, A., & I, Nur. (2006). Kajian Pengaruh Pemberian Macam Pupuk Organik Terhadap Pertumbuhan dan Hasil Tanaman Jahe. *Jurnal Ilmu Tanah dan Lingkungan.* 6(2): 124-131.

Trivana, Linda., dan Trivana Adhitya Yudha Pradhana. (2017). *Optimalisasi Waktu Pengomposan dan Kualitas Pupuk Kandang dari Kotoran Kambing dan Debu Sabut Kelapa dengan Bioaktivator PROMI dan Orgadec.* Manado : Balai Penelitian Tanaman Palma.

Widarti BN, Wardhini WK & Sarwono E. (2015). Pengaruh Rasio C/N Bahan Baku pada Pembuatan Kompos dari Kubis dan Kulit Pisang. *Jurnal Integrasi Proses*. 5(2): 75-80.

Widawati, S. dan Suliasih. (2005). The Application of Soil Microbe from Wamena Botanical Garden as Biofertilizer (Compost Plus) on Purple Eggplant (Solanum melongena L.). *Journal Agricultural Scientific*. Vol XI(3):20-24.

Widowati, L.R. (2004). Pupuk Organik dan Pupuk Hayati. Jakarta : Agromedia Pustaka