Vegetable Waste and Food Waste Treatment Using Modified Aerobic Composting Reactor

by Fina Binazir Maziya

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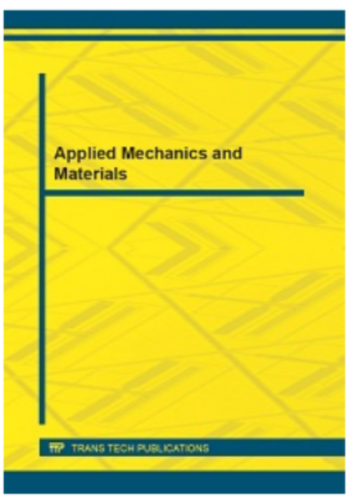

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Vegetable Waste and Food Waste Treatment Using Modified Aerobic Composting Reactor

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Abstract. Sleman Regency, Yogyakarta Province, Indonesia has around 1,056.87 tons of unmanaged waste per day, with 74.22% of its composition is food waste. This phenomenon can be reduced by using an efficient composting method using modified aerobic reactors. The purpose of this research is to identify the quality and quantity of compost as well as larvae (maggots) produced. The research was done for 30 days using two reactors that have different feedstock composition, i.e., the comparison of food waste: vegetable waste of 1:3 (first reactor) and 3:1 (second reactor). The initial mass of each feedstock was 8 kg. The result of composting showed that the compost weight was shrinking by 92.5% in reactor one and 89% in reactor two. The results of the analysis also showed that the second compost reactor had better qualities than reactor one, but the maggot protein content of the first reactor is better than the second reactor. The moisture content in the first reactor did not meet the standards (Indonesian National Standard/SNI of compost), whereas in the second reactor, the standards were achieved with the moisture content being 20.63%; P 1.55%; K 1.45% and C/N 14.03%. The content of NPK in liquid compost produced from the first reactor was 0.18% N; 0.05% P and 0.76% K, while the liquid compost in the second reactor contained 0.30% N; 0.04% P and 0.58% K.

Introduction

Based on the Ministry of Environment and Forestry [1], it is shown that there is more untreated Municipal Solid Waste (MSW) rather than waste that is managed or piled up in landfills. At about 174 tons/day of waste from Sleman Regency, Yogyakarta Province, Indonesia will be disposed to Piyungan landfill. The most significant waste composition was food waste about 74.22% of the total MSW in the Sleman regency. There are many ways to utilize the waste; one of the utilizations of organic waste is using composting method. In addition to reducing the waste accumulation and utilizing it as a planting media and fertilizer, processing organic waste into compost can provide economic value as well as assisting local government in reducing the amount of waste that disposed to a landfill [2].

In a particular case, composting produces larvae or maggots, which are commonly used as animal feed because of their high protein content. If the foodstuffs have a protein level higher than 19%, then it can be categorized as a source of protein [3]. The protein content in the maggot has many benefits, among them are as a source of amino acids and increasing cattle appetite [4]. Protein content in the traditional vegetable market waste was 12.64%, which can improve the level of maggots protein that will be the side product of composting [5].

This research was done to identify the quality and quantity of all composting products, not only liquid compost or solids, but also the maggots. This research was conducted by using a modified aerobic composting reactor, which is expected to be more efficient and portable.

Materials and methods

Reactor Manufacturing. Before doing the research, the modified composting reactor was prepared. Fig. 1 shows the modified aerobic composting reactor configuration.

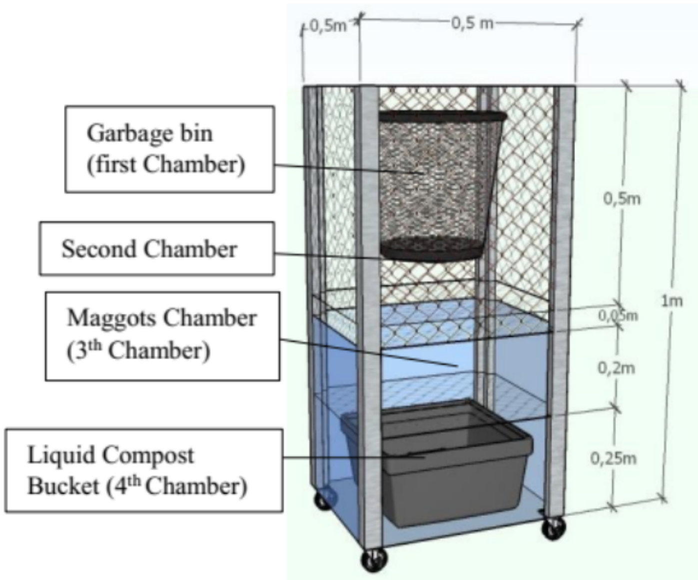

Fig. 1. Modified aerobic composting reactor used for vegetable waste and food waste

Reactors were constructed with dimensions of 1.0 x 0.5 x 0.5 m and divided into four chambers. Each chamber has different functions. The top space was used for composting by using an empty barrel garbage bin for its feedstock. This was done to keep the maggots remain in the reactor because the size of the barrel garbage bin was smaller than the main reactor. The second chamber was used as an air recirculation system because the composting was aerobic. Maggots produced from the composting process was collected in the third chamber, while the liquid compost produced was accumulated in the fourth chamber using the supplied bucket, as shown in Fig. 1.

Composting. Composting was done for 30 days with several parameters tested, including moisture content, temperature, solid compost mass, liquid compost volume, pH, Carbon (C), Nitrogen (N), Phosphorus (P), Potassium (K) and maggot protein content. The feedstock used in this composting was vegetable waste and food waste. Two reactors were used for two different composting methods. The first reactor (R1) used the ratio of vegetable waste: food waste = 1:3, whereas the second reactor (R2) used 3:1.

Test parameters. Each parameter was tested at several particular times. The parameters in the composting process were temperature, mass, pH, and moisture content. At the end of composting, measurement was conducted for temperature, pH, C/N ratio, moisture content, P, and K to determine the quality and the maturity of the compost. The mass and protein content of the maggots was tested to determine the quality of maggots produced from the composting of vegetable waste and food waste using two feed ratio variations.

Results and Discussion

Process of composting. Initial parameter measurement was conducted for temperature, pH, and moisture content, as a baseline of the composting process that occurs over 30 days. Meanwhile, the complete temperature profiles during composting is shown in Fig. 2.

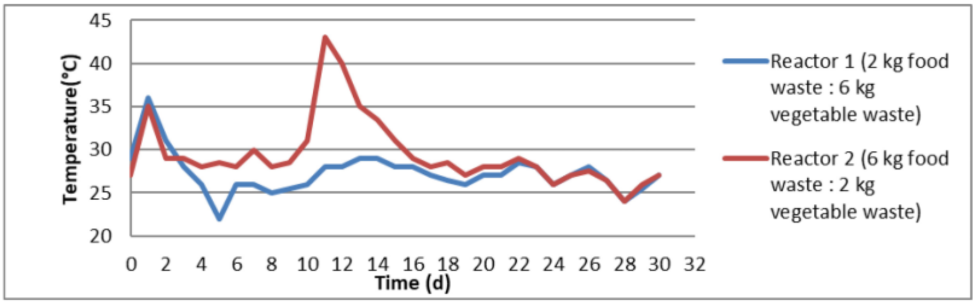

Fig. 2. Changes in temperature in the process of the 30 days of composting

In general, the composting process can be categorized based on the bacteria activity temperature which are *mesophilic* and *thermophilic* phases. The *mesophilic* phase is in the range of 23 to 45°C, while thermophilic phase is from 45 to 60°C. The result in Fig.2. shows that the reactors reached a temperature peak of about 36°C on the first day of the beginning of composting and then decreased. Then, the second reactor reached the highest temperature of about 43°C in the 11th day whie the first rector can only reach about 30°C. This result indicated that microorganisms growing on the composting process in both reactors are merely *mesophilic* bacteria.

Mesophilic conditions are more useful to degrade waste because *proteobacteria* and fungi dominated the composting process. The temperature rose from the beginning of composting indicated the presence of organic material decomposition by microbial activity in it [6]. The temperature was fluctuated and could not reach the *thermophilic* temperature because the compost pile was not thick enough to prevent a vast heat transfer to surrounding environment. Thus, due to the heat release, the high temperature of compost was finally not achieved. The ideal height of a compost pile is 1-1.2 m with a maximum of 1.5-1.8 m. The thermophilic temperature was not reached because the amount of waste could not insulate the composting process. Heat was released during the decomposition process of organic matter, so the process of the composting had a temperature increase [7]. Moreover, the fluctuating temperature during the composting process could have occurred because the reactor affected by the ambient temperature changes.

The reactors were placed in the space under the same roof. Weather conditions also affected the temperature in both reactors, when for instance, the temperature during a rainy day was lower than the dry ones. On the 9th to 11th days, the two reactors experienced a gradual rise in temperature. This was because the second reactor began to produce the maggots, and a few days after that, more maggots were produced. This temperature increase caused more waste to be decomposed with the conversion to CO_2, H_2O, and heat.

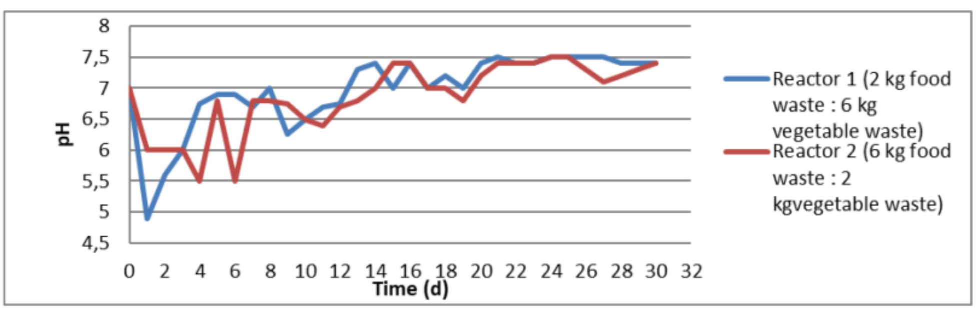

Fig. 3. Changes of the pH value in the process of the 30 days of composting

The optimum range of pH for bacteria was 6-7.5, while for fungi ranged from 5.5 to 8 [8], and the final stage of composting was 6.78-7.81 [9]. Data in Figure 3 shows that there is a decrease in pH at the beginning of the composting. The first Reactor decreased from day 0 to day 2 to reach pH 5.6, while the second reactor decreased in day 4 into pH 5.5. The pH value determined the optimum condition for the fungi. After that phase, the pH went back up or headed to a neutral pH, which indicates the increased of nitrogen-forming bacteria or the condition in which acid is formed in the form of carbon dioxide by microbes that resided in the compost. At the composting process, the pH tends to be neutral because ammonia was released into the atmosphere or it converted into new cells of microbes. Where the pH was 6 to 7.5, this indicated that the majority of the waste was degraded by bacteria. Approaching the maturation process or the end of the composting, the pH of both reactors was also close to neutral pH of 7.4.

Based on the initial measurement, the initial moisture content of 80.92% for R1 and 62.03% for R2. During the process of the composting, the average result of moisture content test in R1 was higher than the moisture content of R2 as shown in Fig. 3. This different result is due to the difference in the feedstock ratio. In R1, feedstock from vegetable waste was higher than food waste, as vegetable waste contains much water that will affect the moisture content. While the food waste contained oil or fat, not only water. There was an increase in water content on the 14th day in R2 and on the 21st day in reactor one. This could happen due to heavy rain and high humidity, that reactor being exposed to high humidity can take up moisture from the air.

Composting products. If the mixture of vegetable and food waste is composted by using a modified aerobic composting reactor, it will yield solid compost, liquid compost, and maggots. The evolution of solid mass during composting period is shown in Fig. 4.

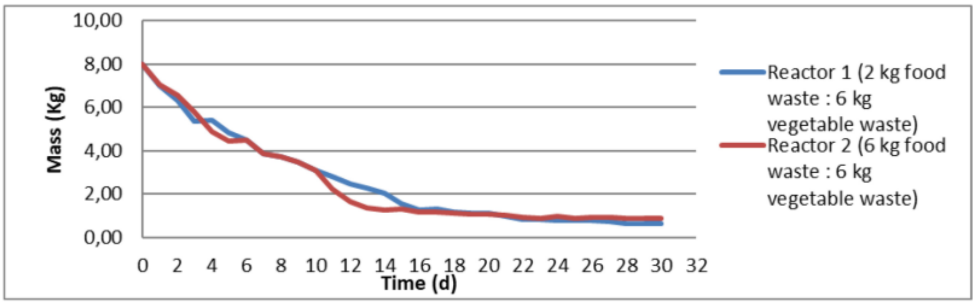

Fig. 4. Changes of solid mass production from the composting process for 30 days

The initial mass of feedstock on each reactor was 8 kg. The mass of both reactors continuously decreased until the last day of experiment. The first reactor solid mass was shrink up to 92.25% with the final mass of compost being 0.62 kg, while the final mass of the second reactor was 0.88 kg. The moisture released in the first reactor was higher than in the second reactor resulting the fewer mass produced in the first reactor. Those reactor allowed to drain the liquid product so that the liquid and solid materials could be separated and became different product [10]. The decrease in solid compost was also caused by the number of maggots in the compost. The more maggots means more waste was degraded, since maggots had bacteria in their abdominal fluid that was able to degrade the organic waste [11].

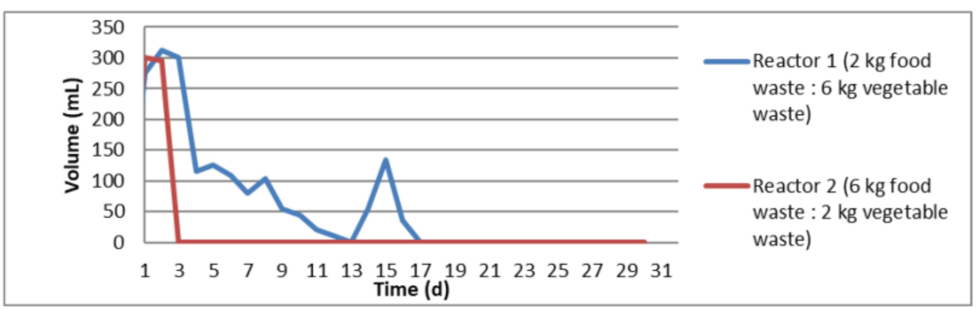

Fig. 5. Changes in liquid compost volume production from the composting process for 30 days

Fig. 5 shows that the aerobic reactor modified with the vegetable waste and food waste as feedstock could produce liquid compost quickly and efficiently, as indicated by the liquid compost volume since the first day of composting. The difference in the feedstock composition of both reactors affect the difference in volume and liquid compost color. Since R1 contained a lot of vegetable waste, the moisture content was more, so that the liquid compost produced more, while in R2, the production of liquid compost containing oil derived from food waste. Both reactors had a difference in the liquid compost color that was produced. In R1, the longer composting, the liquid compost produced, was increasingly green, derived from green substances that existed in the vegetable waste. While in R2, the final liquid compost produced was light brown, which indicated that the liquid compost R2 had a good physical compost characteristic [12].

The quality of solid compost produced. After 30 days of the composting process, final testing was conducted of the solid compost against the quality parameters of the standard compost, including the ratio of C/N, phosphorus, and potassium content. The results of the test were obtained for carbon level for the first reactor at 20.89% and 31.15% for the second reactor. Microorganisms required carbon (C) during the composting process. The more progressing the process of composting, the more carbon will be decreased. This because C is used by microbes to multiply, and the energy taken is used to degrade organic matter into H_2O and CO_2 [13]. While microbes use nitrogen (N) for protein synthesis or protoplasm formation, if the C level was too low, then the remaining N will be abundant and may produce gas ammonia (NH_3) that toxic to microorganisms and cause odor [14]. In this study, there was no smell of ammonia gas, which indicates that the remaining nitrogen produced was not excessive. Results of composting showed that the ratio of C/N to solid compost produced from the modified aerobic reactor fulfilled the quality standard of compost. The good quality standard of compost is 10%-20%, while the C/N ratio of the solid compost of the first reactor was 13.98% and the second reactor was 14.03%.

The waste-derived from plants (foliage) had a high phosphorus content [15]. The results of this research were evidenced by the level P solid compost in R1 being higher than the solid compost in 2. Solid compost R1 derived from feedstock that was dominated by vegetable waste, so the content of P solid compost in the first reactor was 1.61%, and the second reactor was lower at 1.55%.

Based on the potassium tested with the destruction of HNO_3 and $HClO_4$ method, obtained potassium levels in R1 were 2.48% and in R2 1.45%. The increase in K was improved as the decomposition process occurs [16]. Increased level of K is caused by bacterial solvent K in compost, one of which is *Bacillus mucilaginous*. The presence of this bacteria suggested that the availability of microorganisms during the composting process greatly affected the content of K produced compost. Nevertheless, due to the research, only done once the test of the K element was at the end of the composting, the value of K content during the composting process was not known.

Quality of liquid compost produced. Similar to solid compost, testing of the parameters was done to determine the liquid compost quality produced by the testing of nitrogen, phosphorus, and potassium levels (Table 1).

Table 1. Quality of liquid compost on the 30th day after the composting process

Liquid Compost			
Parameter	**Reactor 1**	**Reactor 2**	***Standard***
N	0.18%	0.30%	>0.4%
P	0.05%	0.04%	> 0.1%
K	0.76%	0.58%	>0.2%

Based on the data in Table 2, it can be seen that liquid compost had not fulfilled the quality standards of compost on SNI-19-7030-2004 for the parameters N and P. The difference between P and K in both reactors was caused by the difference in the feedstock used, because each feedstock used had a different P and K content. This difference will also affect the duration of the composting process. The longer the composting process, then the rate of P on the compost will increase [17].

Maggot protein content. There are many types of maggots that could be produced from the process of composting. The results obtained by maggots from the first reactor have a higher protein content than maggots in the second reactor, whereas the first reactor maggot had a protein value of 31.40% - 37.63%, while in the second reactor was 28.14% -32.02%. Fish cultivation required feed protein content ranging from 25-55% [18]. This suggested that maggots resulted from the composting of vegetable waste and food waste by using modified aerobic reactors was able to provide an alternative feed. Based on the maggot protein content, a feedstock that had higher protein produced maggots with higher protein content as well. This because maggots can store nutrients in its body from the culture using an organ called *trophocytes*.

Conclusions

The results of composting showed that the solid compost mass decreased by 92.5% for the first reactor and 89% for the second reactor. This decrease happened because microbes decomposed the waste or became food of maggots that lived in it. In addition, the decrease occurred due to solid waste, especially as vegetables have a lot of water content, so the reduced mass is due to moisture content in the trash being transformed into liquid compost as much as 1,775 mL and 596 mL for the first reactor and in the second reactor, respectively.

The results of the analysis showed that the solid compost the second reactor had a better quality than the first reactor. This was because the water content of did not meet the standard, while reactor two fulfilled the whole standard with the water content of 20.63%; P 1.55%; 1.45% K and C/N ratio of 14.03%. The liquid compost from both reactors did not fulfill the compost quality standards of SNI 19-7030-2004 on N and P parameters, which was still in line with the standard.

References

[1] Ministry of Environment and Forestry. Sistem Informasi Pengelolaan Sampah Nasional. Kementerian Lingkungan Hidup dan Kehutanan, 2018. .

[2] T. Suryati, Bijak dan Cerdas Mengolah Sampah. Jakarta: PT. Agromedia Pustaka, 2009.

[3] B. A. Murtidjo, Pedoman Meramu Pakan Ikan. Yogyakarta: Kanisius, 2001.

[4] F.-X. Zhu et al. Bioresource Technology Rapid production of maggots as feed supplement and organic fertilizer by the two-stage composting of pig manure. Bioresour. Technol., vol. 116, pp. 485–491, 2012.

[5] E. Suwatanti and P. Widiyaningrum. Pemanfaatan MOL Limbah Sayur pada Proses Pembuatan Kompos. J. Mipa 40 (1) 1–6, 2017.

[6] E. S. Pandebesie and D. Rayuanti. Pengaruh Penambahan Sekam Pada Proses Pengomposan Sampah Domestik. J. Lingkung. Trop. 6 (1) 31–40, 2012.

[7] B. N. Widarti, W. K. Wardhini, and E. Sarwono. Pengaruh Rasio C/N Bahan Baku Pada Pembuatan Kompos Dari Kubis dan Kulit Pisang. J. Integr. Proses 5 (2) 75–80, 2015.

[8] F. Anindita. Pengomposan Dengan Menggunakan Metode In Vessel System Untuk Sampah UPS Kota Depok. Universitas Indonesia, 2012.

[9] T. Liu, M.K. Awasthi, H. Chen, Y. Duan, S. K. Awasthi, and Z. Zhang. Performance of black soldier fly larvae (Diptera: Stratiomyidae) for manure composting and production of cleaner compost. J. Environ. Manage. 251 (3) 109593, 2019.

[10] S. Hadisuwito, Membuat Pupuk Kompos Cair. Jakarta: AgroMedia Pustaka, 2007.

[11] G. Yu et al., Inoculating Poultry Manure With Companion Bacteria Influences Growth and Development of Black Soldier Fly (Diptera: Stratiomyidae) Larvae. Environ. Entomol., 40 (1) 30–35, 2011.

[12] S. Hadisuwito, Membuat Pupuk Organik Cair. Jakarta: PT. Agromedia Pustaka, 2012.

[13] B. Subali. Pengaruh Waktu Pengomposan Terhadap Rasio Unsur C / N. no. April, pp. 49–53, 2010.

[14] W.I. Christina Maria Dewi, Dewi Mustika Mirasari, Antaresti. Pembuatan Kompos Secara Aerob Dengan Bulking Agent. J. Tek. Kim. 6 (1) 21–31, 2007.

[15] S. Anif, T. Rahayu, and M. Faatih. Pemanfaatan Limbah Tomat Sebagai Pengganti EM-4 Pada Proses Pengomposan Sampah Organik. J. Penelit. Sains Teknol. 8 (2) 119–143, 2007.

[16] R. Gunawan, R. Kusmiadi, and E. Prasetiyono. Studi Pemanfaatan Sampah Organik Sayuran Sawi (Brassica juncea L.) Dan Limbah Rajungan (Portunus pelagicus) Untuk Pembuatan Kompos Organik Cair. J. Pertan. dan Lingkung. 8 (1) 37–47, 2015.

[17] T. Nur, A.R. Noor, and M. Elma. Pebuatan Pupuk Organik Cair Dari Sampah Organik Rumah Tangga Dengan Bioaktivator Em 4 (Effective Microorganisms) 5 (2) 5–12, 2016.

[18] N.A. Giri, K. Suwirya, P. A.i, and M.M. Pengaruh Kandungan Protein Pakan Terhadap Pertumbuhan dan Efisiensi Pakan Benih Ikan Kakap Merah (Lutjanus argentimaculatus). J. Perikan. 9 (1) 55–62, 2007.

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