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Article

Assessing the Potentiality of Aerobic Rolling Composter to Hasten Vegetable and Fruit Waste

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Abstract. Organic waste is mainly categorized in recent days as household waste and city garbage. To meet eco-friendly waste management, incorrect composter or conventional composting methods do not fulfilling the demands even though sometimes the composting procedure is so lengthy. To speed up the composting process, our research team has developed an aerobic composter using microorganisms, e.g., Trichoderma, Effective Microorganism 4 (EM4), and a combination of Trichoderma. Three different aerobic rolling composters (ARC) were designed to speed up the composting process during the testing stage by employing EM4. It showed a greater reduction in waste height utilizing EM4 on the 15th day (3.8%-17.9%) than the conventional one (2%). In addition, inoculation of EM4 and Trichoderma in combination with EM4 caused a 45% reduction in weight. Thus, the composter (type 3) efficiently decomposes the waste with a shorter composting period.

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1. Introduction

Municipal Solid Waste (MSW), is produced in significant amounts each year. It has been noticed that Indonesia would generate more than 30 million tons of rubbish in 2021 despite a 15.6% annual reduction in waste [1]. Based on data from the Indonesian Ministry of Environment and Forestry, it was found that organic waste had the highest percentage, nearly 60% of the composition of Indonesian MSW, and the remaining from households (40%). The majority of this organic waste is made up of leftover food [1]. Fruit or vegetable waste and other food waste can majorly contribute to environmental [2] issues, including air pollution, vector-borne disease transmission and greenhouse gas emissions [3]. Several strategies, including composting, are being used globally to reduce the burden of organic waste.

Microorganisms play a crucial role in decomposing process of their capability for converting residual waste into soil organic matter following speed up or slowing down compost maturation. *Trichoderma sp*, producing cellulolytic and hemicellulolytic enzymes [4], as well as commercially effective microorganism 4 (EM4), which generates laccase and peroxidase enzymes that may digest and break down lignin [5], could be used in the composting process.

In order to regulate the quality, stability, and effectiveness of the composting process, moisture content, temperature, pH, oxygen content, and coliform bacteria usually consider as the criteria [6-7]. The effectiveness of the composting process depends on the availability of water in the waste materials. Liang et al. (2003) revealed that temperature (20–60 °C) is a regulatory factor that affects microbial activity during the composting process, though it was less influential than moisture content [8]. The composting process reaches the thermophilic stage (65–70 °C) and is finished with a pathogen-free final product [9-11]. Aeration impact also helps to keep the oxygen level constant while regulating the temperature and moisture content [12]. Thus, a strong correlation among physical factors could significantly impact how well compost turns out in the end [13].

To make nutrient-rich compost, it is important to find the composition of organic waste [14]. Based on composts' physical and chemical characteristics, Parveen et al. (2012) determined the composition of organic waste from household, farm, and market waste. It showed that compost made from cooked leftover food had higher nutrient contents and physiochemical characteristics than compost made from other wastes [15].

It has been reported that conventional aerobic and anaerobic decomposition processes can produce mature compost in a few months [16]. Takakura composter, a household composter, a recently created based on aerobic decomposition that shortened the composting period to around seven days employing EM4 [17-18]. However, the Takakura composter is less efficient due to the problems with trash mixing procedures. No such experiments were conducted using a low-capacity (20 L) rolling bucket composter for household waste to compost fruit and vegetable wastes mixed with the inoculum. Hence, this study aims to: (1) develop an aerobic rolling composter (ARC) using a second-hand bucket; (2) determine how the combined inoculum (*Tricoderma*, EM4, and EM4 incorporated with *Tricoderma Sp*.) in composting of fruit and vegetable wastes.

2. Experimental Section

2.1. Composting Material

This study uses garbage from traditional markets and juice vendors, including rice husk, vegetables (carrots, spinach, and cabbage), and fruit (orange and apple peel) peels. The rice husk, fruit and vegetable waste were collected from Lubuk Buaya Traditional Market and Tabing rice mill located in Padang Municipality, West Sumatera, Indonesia. A waste crusher reduced fruit and vegetable waste size into particles smaller than 50 mm.

2.2. Composting Process

The composting process lasted for 15 days, and the composts underwent physical analysis. Regarding biodegradable waste (BW), soil, rice husk, fruit peel, and vegetable peel comprised 20%, 20%, 12%, and 48% of the total. Compost compositions (EM4, *Tricoderma sp*., and EM4+*Tricoderma sp*.) were produced by adding microorganisms. Brown sugar, commercial EM4, and water were combined in a ratio of 1:10:10 to create the EM4 inoculant. *Tricoderma sp*. and water were combined in a ratio of 1:40 to create the *Tricoderma sp*. inoculant. *Tricoderma sp*. and EM4 were combined at a 1:1 ratio. All of the inoculants were homogeneously mixed.

Figure 1. Composting pile set

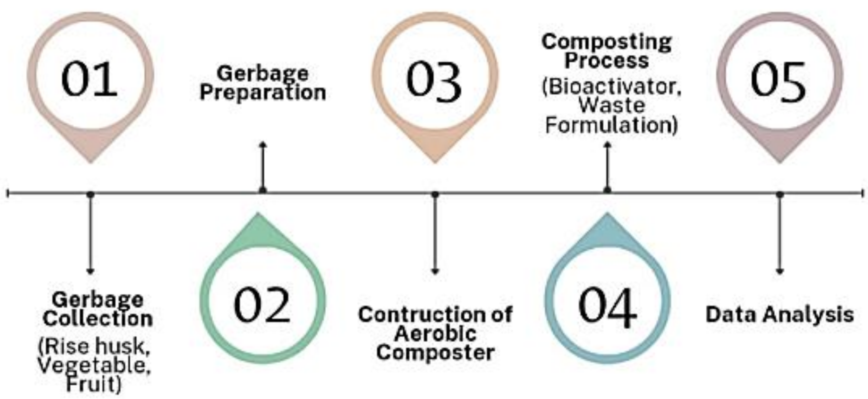

Figure 2. Research method flow chart

2. 3. Aerobic Rolling Composter Specifications

ARCs were constructed using a leftover bucket and wood stand. ARC-1 had a hole for aeration on the pipe, while ARC-2 and ARC-3 had holes in the line and bucket (Figure 2).

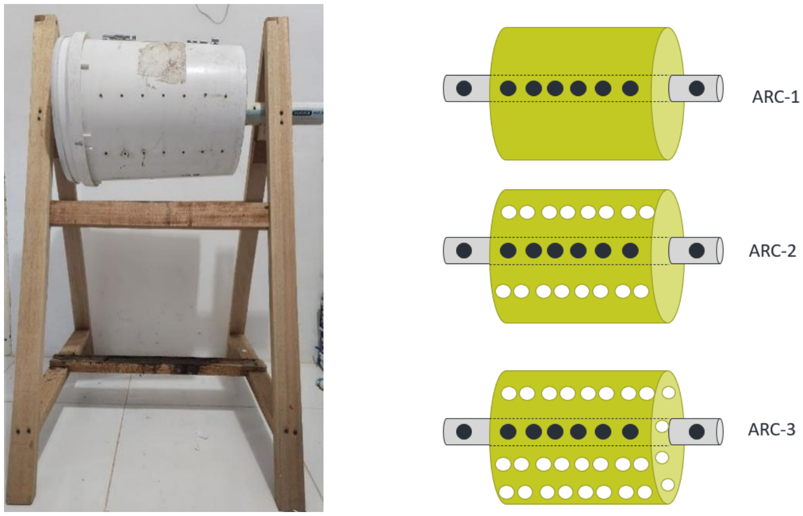

Figure 3. Construction of aerobic rolling composter type-1, -2, and -3. Aeration on pipe only, on the pipe and middle bucket, on the line, and on all side buckets are shown in ARC-1, ARC-2, and ARC-3, respectively.

3. Results and Discussion

Temperature is the most important element in controlling of the composting reaction due to its impact on microbial metabolic rate [19]. The microbial populations grew as the temperature rose until they reached a peak [20]. Each composter's maximum temperature was induced for the first 5-7 days of the composting process, and it started to fall around 29–30°C (Figure 4a). The capacity of bacteria to break down organic waste and the amount of moisture in the composter affects how well the garbage is reduced [7]. As the composting period lengthens, the height of the pile falls daily. The highest waste reduction is shown on ARC-3 (Figure 4b).

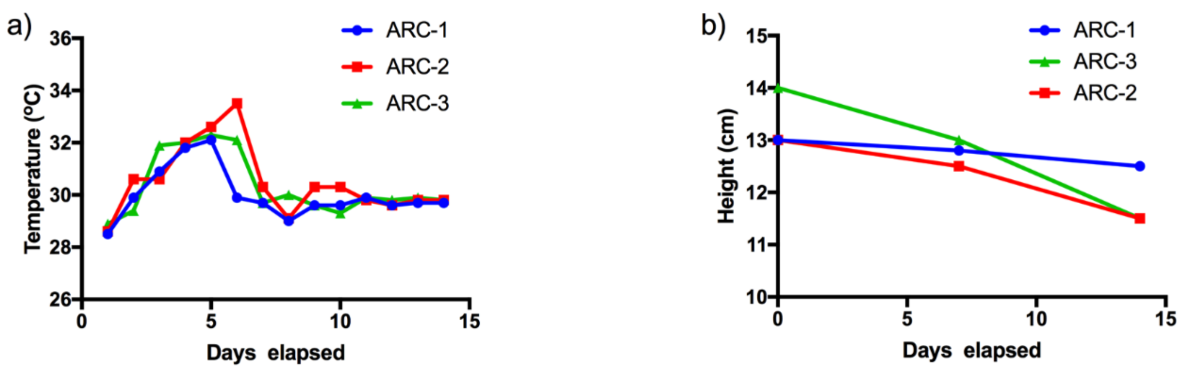

Figure 4. Physical parameters of compost in three different composters. Mixed BW, EM4 and soil were composted using EM4 as a bio activator for 14 days. a) temperature and b) height of BW

The ARC-3's numerous holes make oxygen, carbon dioxide, and moisture simple to move both within and outside the composter. Ge, *et.al* (2020) showed that the activity of cellulase, urease, alkaline, and acid phosphatases were all raised by high aeration rates, but invertase and catalase were lowered [7]. Fruit peel and vegetable waste (BW) contains a lot of water. The potential for biodegradation is decreased by the more extensive water content, reducing oxygen uptake [21]. This outcome is in line with studies by and Murugesan (2020) [16] that identify the Effect of temperature on composting. Taken together, increasing aeration and lowering water content are both done to maximize the composting process. Therefore, the bulking agent rice husk and ARC-3 were used with BW to lessen the moisture content effect in the next experiment.

This study showed that *Tricoderma sp.* hastened the pH neutralization process and reduced temperature, but the it had no discernible impact on the breakdown of waste compared with other bio activators (Figure 5). *Tricoderma* sp. and EM4 ini with *Tricoderma* sp. employing layer combination was able to lower the waste height (over 40%) more than EM4 alone (Figure 5d, e, f; sets A and C), however, the process was slowed down when waste and bioactivators were mixed (Figure 5 d, e, f; set B).

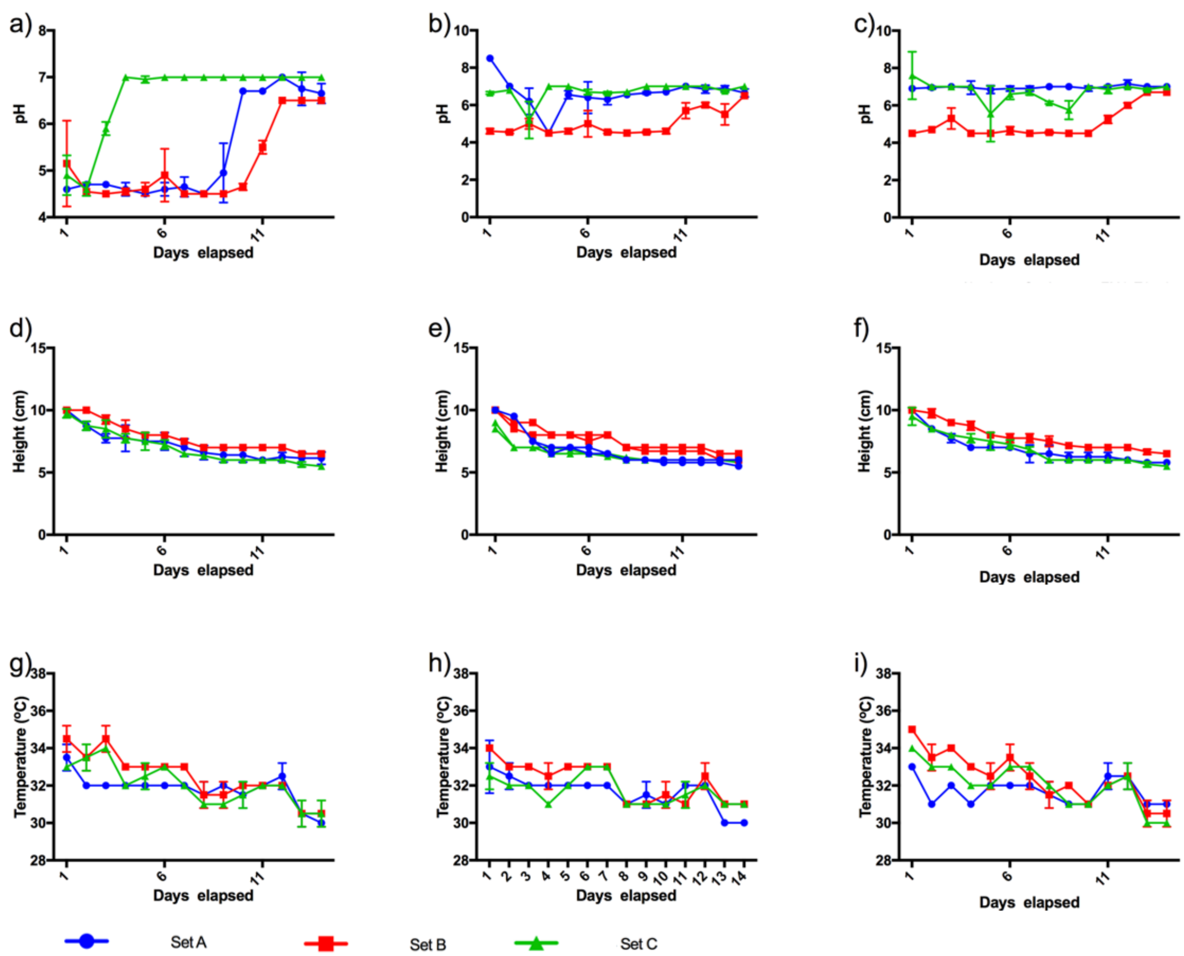

Figure 5. Physical parameters of compost in ARC-3 in different formulations. Mixed BWs were composted using EM4 a), d), g), *Tricoderma* sp. b), e), h) and *Tricoderma* sp. + EM4 c), f), i) as bio activator for 14 days.

The pH will decrease because fatty acids, CO_2, and nitrification are produced early in the aerobic breakdown process. However, it will increase once microorganisms break down organic materials. It has been suggested that Low pH in the first phases of composting is due to high concentrations of lactic acid bacteria [22]. A pH between 7.5 and 8.5 is thought to assist the microbial breakdown of organic waste during the composting process. More effective aeration was obtained to raise pH values and prevent the emergence of anaerobic conditions since a low pH. The appearance of unwelcome aromas caused by the production of fermentation products indicate the need for oxygen [23]. Consistent with our data, neutral pH composted the BW higher than low pH in both EM4, and *Tricoderma* sp. and EM4 ini with *Tricoderma* sp (Figure 5a, b, c, d, e, f).

Cellulose (50%), lignin (25–30%), silica (15–20%), and moisture (10–15%) make up the rice husk [17] [24] [25]. In the dry matter of selected plant samples, the percentage of crude fibre NDF fraction (hemicelluloses, celluloses, and lignin) was 18.23% for carrot, 19.77% for tomato, 24.97% for cucumber, and 17.22% for apple pomaces [26]. As a result, composting rice straw is far more challenging than composting fruits and vegetables. On the other hand, the bioactivator composed vegetable and fruit waste effectively due to separating the rice husk layer. As a result, the compost maturation induced by bio activators in ARC-3 Set A and C is the most potent and effective among the other sets.

4. Conclusion

In conclusion, using an ARC-3 cultured seed inoculum of EM4 and *Tricoderma sp.,* the traditional composting time was significantly reduced for the aerobic composting process. Although rice husk is crucial for lowering water content, it should also be considered the amount of Rice husk in the waste. The chemical properties and fungus or bacterial population may need to be determined through additional studies to be useful for the ensuing composting.

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