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Utilization of cassava peel waste as an organic fertilizer to build a sustainable cassava production center

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Abstract. *The cassava production center in Bogor City is produced by Ciluar Village. Based on the potential of Ciluar Village, which has a lot of cassava agricultural land, cassava peel waste has the potential to be used as organic fertilizer. The aims of this paper are (1) to find out the minimum time to produce compost with the basic ingredients of cassava peels and goat manure with pH parameters according to Indonesian National Standard (SNI) standard; (2) to find out the best composition between cassava skin and goat manure to produce compost. There were three types of treatment based on weight composition comparison between cassava skin and goat manure. The results of the compost quality test were analyzed (statistical test) using analysis of variance (ANOVA) and LSD test (Lessest Significant Difference) to determine the effect of treatment on the observed variables with the help of IBM SPSS 26 software. The conclusions of this study include: (1) the minimum time to produce compost made from cassava peels and goat manure with pH parameters according to SNI is 42 days; (2) the best composition between cassava skin and goat manure to produce compost is a ratio of 7:3.*

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is the third staple food for Indonesian people; besides rice and corn, it is also a long-lived plant that is very easy to grow in the tropics and can adapt to the environment (Hermanto and Fitriani 2019). The cassava production center in Bogor City is produced by Ciluar Village. According to Priyono (2011), the tapioca industry made from cassava is the third largest industry in Bogor City. As a center for cassava production, the people of Ciluar Village not only work in processing cassava into products but also some others as cassava farmers. In fact, as a center for cassava production and its processing in Bogor City, the sub-district government has branded the Ciluar Village as “Cassava Village” (Andareswari et al. 2019).

So far, the waste of cassava peels produced by tapioca flour and tapai in Ciluar Village is very abundant. Cassava peel is part of the outer skin of cassava tubers, it is not used when using cassava tubers, and a small portion is used for animal feed ingredients without being processed. According to Sriyana and Nasita 2019, the percentage of outer skin waste is 0.5–2% of the total weight of fresh cassava and 8–15% of inner skin waste. The process of decomposition of cassava peel waste is very disturbing to the environment because it creates an unpleasant odor, has the potential to release methane gas so that it pollutes the air and becomes a breeding ground for plant-disturbing organisms or human health (Obueh and Odesiri-Eruteyan 2016; Aisien and Aisien 2020; Yuhanna et al. 2021).

Many studies and implementations of processing cassava peel waste have been carried out, including animal feed processing (Rahayu et al. 2019; Nasiu et al. 2020; Arginta and Noviana 2021; Harmoko et al. 2021; Nurlaeni et al. 2022; Yuhanna et al. 2021), cassava peel crackers (Ulya and Hidayat 2018; Rohimah and Kurnia 2021; Indriyati et al. 2022; Rustantono et al. 2022), liquid sugar (Budiarti et al. 2018; Ulya and Hidayat 2018), bioethanol (Adekunle et al. 2016; Erna et al. 2016; Aruwajoye et al. 2020; Sriyana and Nasita 2019; Widyastuti 2019), biogas (Aisien and Aisien 2020), mocap flour (Sari and Astili 2019), paving block (Artiyani 2012), compost and fertilizer liquid (Martana et al. 2016; Aisien and Aisien 2020; Yuhanna et al. 2021; Susilowati et al. 2022) and activated carbon (Kayiwa et al. 2021). Without realizing it, waste is actually an opportunity to add economic value (Ulya and Hidayat 2018; Kayiwa et al. 2021).

Meanwhile, in Ciluar Village, the utilization of cassava peel waste has not been optimally pursued. Based on the potential of Ciluar Village which has a lot of cassava agricultural land, cassava peel waste has the potential to be used as organic fertilizer. According to Priambodo et al. (2019), many people still use inorganic fertilizers (N, P, K) which, if used continuously and not in balance with the use of organic fertilizers or biological fertilizers, can cause the soil to harden and decrease productivity. The importance of public and farmer awareness of the negative impact on the environment and excessive pesticide residues in agricultural products, when consumed, is one of the driving forces to switch to a green farming system. Musnamar (2007) stated that organic fertilizers can improve soil fertility and do not leave a negative impact on crop yields, so they are safe for human health. Cassava peel waste has the potential to be composted because cassava peel waste still contains several nutrients needed by plants (Oghenejoboh et al. 2021). Fitriani and Ciptandi (2017) reported that 100 grams of cassava peel waste contains 8.11 grams of protein, 15.20 grams of crude fiber, 0.22 grams of pectin, 1.29 grams of fat, and 0.63 grams of calcium. Cassava peel contains 36.5% starch (Artiyani and Soedjono 2011).

The aims of this paper are (1) to find out the minimum time to produce compost with the basic ingredients of cassava peels and goat manure with pH parameters according to SNI; (2) to find out the best composition between cassava skin and goat manure to produce compost. The contribution of this research is that the findings can be used as guidelines for the production of compost fertilizers based on cassava skin and goat waste, which can benefit the community by lowering fertilization costs and dealing with cassava skin waste and goats.

METHOD

Study Area

This activity was carried out in July–August 2018. The research was conducted in Ciluar Village, North Bogor District, Bogor City, West Java. The map of the research location can be seen in Figure 1.

Materials

The materials used in this study include cassava skin waste, goat manure, Effective Microorganism 4 (EM4), water for mixing, pH meter. The tool for composting consists of 10 drum composting. The appliance is equipped with an internal limiting filter and an external small window, which is tightly closed. This small window serves to observe the composting process and the maturity level of the compost. Figure 2 shows the composting drum. The design of composting drum in this research was referenced by Akhmad et al. (2022).

Compost Making Process

Before the cassava peel is processed into organic fertilizer, the cassava skin is first cut into small pieces of about 2–3 cm, then dried or air dried (Figure 3). The goal is to lower the water content and HCN (Cyanide Acid). Cyanide levels will evaporate at a temperature of 25–30 ^oC (Sandi 2012).

The steps for processing cassava skin waste and goat manure into organic fertilizer are as follows: (1) Mix cassava skin and goat manure that has gone through the drying process; (2) Spray the mixture using EM4 liquid using a sprayer evenly with a composition of 1 liter of water mixed with 2 EM4 bottle caps. It is better to use groundwater because tap water contains chlorine, which can kill bacteria; (3) Close the composter bin tightly. As long as the barrel is closed, the maggots will die. Entering the second week the number of maggots begins to decrease due to the influence of the EM4 bioactivator starting to work so that more decay is carried out by the microorganisms contained in EM4 rather than natural decay which causes caterpillars/maggots. In the first week, there is usually an unpleasant odor. If the smell is sufficiently strong, sufficient EM4 liquid is sprayed into the composter.

Experimental design

The research conducted was experimental. The treatments given in this study were used to compare the composition of cassava skin and goat manure, which were different for each treatment. In this study, there were three types of treatment based on weight composition comparison between cassava skin and goat manure, namely, P1 (7:3), P2 (5:5), and P3 (4:6). Each treatment was repeated 3 times, so there were 9 experimental units.

Observed Variables

Indicators for determining compost maturity time are the temperature of mature compost, which drops close to ambient temperature; the color of mature compost generally has a blackish brown color resembling the color of the soil and has a crumbly/loose texture (Atmaja et al. 2017). The pH was measured when the characteristics of the compost were close to those of mature compost. The pH was measured every 2 days by plugging the pH meter into the homogenized compost.

Statistic Test

The results of the compost quality test were analyzed through statistical tests. The analysis used were variance (ANOVA) and LSD test (Lessest Significant Difference). A statistical test was conducted to determine the effect of treatment on the observed variables with the help of IBM SPSS ((Statistical Program for Social Science) 26 software.

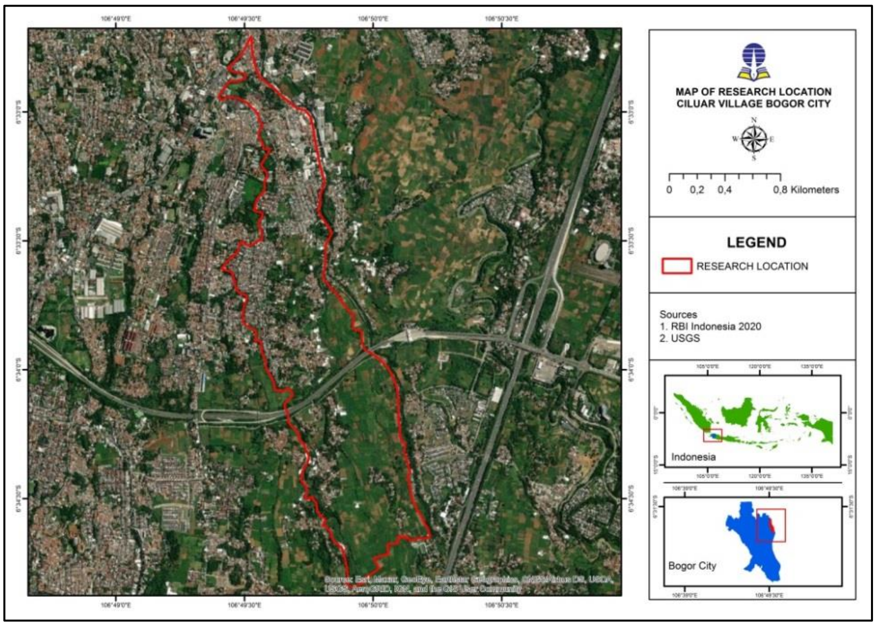
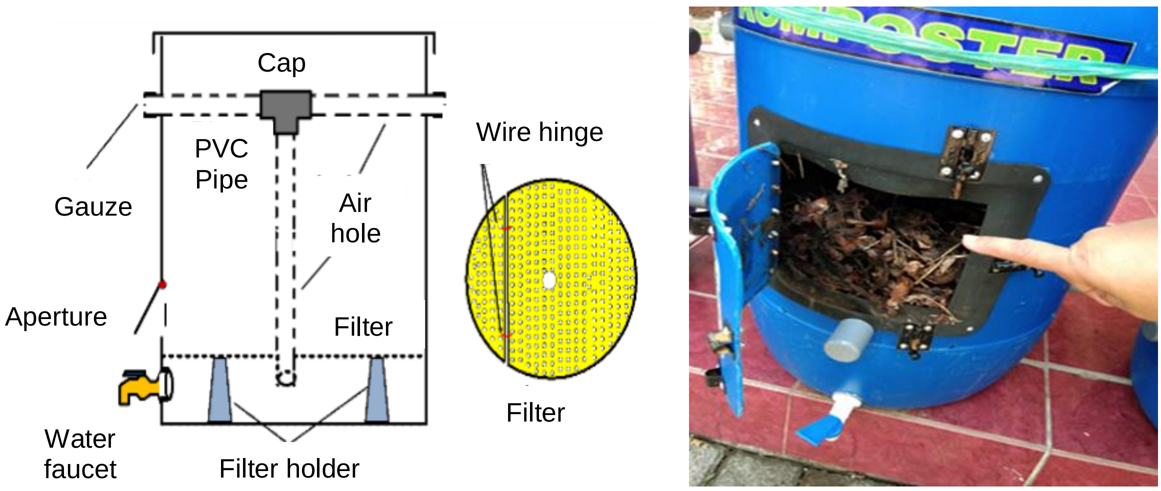


Figure 1 Research location



(a) (b)

Figure 2 (a) The structure of the composting drum, (b) composting drum used in this research.

RESULT AND DISCUSSION

Result

After the composting process lasted for 42 days, the pH measurement results were obtained as shown in Table 1. Based on Table 1, the largest average value of pH is at P3 and the smallest is at P1. The pH value indicates that the greater the percentage of cassava peel, the lower the pH value. The result of the one-way ANOVA pH test was 0.001, which was less than the significance level of 0.05. It was concluded that there was a real difference between H0 rejected and H1 accepted. Duncan's test was carried out to determine the differences in each treatment, and to show that treatment P1 was significantly different from P3. P2 treatment was significantly different from P3, and P3 treatment was significantly different from P1 and P2.

Table 1 The pH value in the effect of differences in the composition of cassava skin and goat manure

Treatment	pH	Notation	SNI Standard
P1 a. Cassava skin (70%) b. Goat manure (30%)	6.67	b	6.80–7.49
P2 a. Cassava skin (70%) b. Goat manure (30%)	6.68	b	
P3 a. Cassava skin (40%) b. Goat manure (60%)	7.30	a	

Note:
- Similar letter notations: not significantly different at p = 0.05
- Different letter notations: significantly different at p = 0.05

Discussion

Based on the observations, in addition to working as farmers and cassava processors, many people also raise goats. Goat dung produced has not been used specifically. Therefore, goat dung has the potential to be a mixture of compost and cassava peel waste. Trivana et al. (2017) stated that the processing of livestock waste needs to be done so that it is not wasted to produce products that have selling value and reduce environmental pollution. Livestock waste is used as manure because it contains nutrients, such as nitrogen (N), phosphorus

(P), and potassium (K), which are needed by plants, soil fertility, and micronutrients, including calcium, magnesium, sulfur, sodium, iron, and copper. In addition, Rahmah et al. (2014) stated that the addition of goat dung is necessary because of the nitrogen content and microorganisms that can accelerate composting. Before being processed into organic fertilizer with cassava peel, goat dung first goes through a process of refining and drying (Figure 3).

(a)

(b)

Figure 3 (a) Goat dung that has been mashed and dried, (b) Goat dung refining process

The degree of acidity (pH) is a parameter to determine the amount of acid or base in the material being tested. Based on SNI 19-7030-2004, the allowable pH range for compost quality standards is a minimum of 6.80 and a maximum of 7.49. The results showed that the pH value was influenced by differences in the composition of cassava skin and goat manure according to the standard, namely the P3 treatment or the composition of cassava skin (30%) and goat manure (70%). According to Suwatanti and Widiyaningrum (2017), the initial composting pH of the compost material is acidic. A decrease in pH is formed by the presence of acid-forming bacteria. Microorganisms will also convert organic nitrogen into ammonium so that there is an increase in pH or alkalinity. The released ammonia becomes nitrate and nitrate is denitrified by bacteria so that the pH of the compost becomes neutral. A neutral pH value will be easy to use and absorbed by plants and is good at reducing soil acidity which is the original nature of acidic soil.

pH measurements were carried out every 2 days and the best composition comparison was obtained on day 42. The results of a study conducted by Aisien and Aisien 2020 showed that anaerobic composting of cassava peels and cow dung after 40 days produced good quality organic fertilizer which increased soil fertility and hence enhanced the growth of corn plants. According to Siagian et al. (2021), research results in the composting process for 30 days resulted in a change in the pH value. From day 20 to 30, the pH value is close to neutral, ranging from 7–7.4. This process causes other types of microorganisms to change the organic acids that are formed in such a way that the waste has a high degree of acidity and is almost neutral. During the composting process, the decomposition rate of each treatment gradually decreased until the end of composting. Because the available organic matter is decreasing due to microbial activity that decomposes organic waste. The rate of degradation of organic matter is determined by the organic matter itself and external environmental factors. Environmental factors act through their influence on the growth and metabolism of spoilage microorganisms. Especially environmental factors that have an influence, namely the pH value (Andriany et al. 2018).

According to Suwatanti and Widiyaningrum (2017), an ideal composting process must also have daily pH fluctuations that are still within the normal range. The pattern of changes in compost pH begins with a slightly acidic pH owing to the formation of simple organic acids, followed by the formation of simple organic acids. The increase and decrease in pH are also indicators of microbial activity that decomposes organic matter. Changes in pH also indicate the activity of microorganisms in organic decomposition products. The ideal compost pH based on SNI compost quality standards:19-7030-2004 is between 6.8 and 7.49. According to

Tantri et al. (2016), the composting process is better if pH can be maintained in a neutral area. Because the pH is neutral, microbial activity in organic fertilizers works perfectly, so the nutrients released from organic fertilizers are also improving.

According to Erickson et al. (2013), organic materials cannot be directly used or utilized by plants because the C/N ratio of these raw materials is relatively high or not the same as the soil C/N ratio. The C/N value of the soil was approximately 10–12. If the C/N content of organic matter is close to or equal to the C/N of the soil, the material can be used or absorbed by plants. The principle of composting is to reduce the C/N ratio of organic matter so that it is equal to that of the soil (< 20). The higher the C/N ratio of the material, the longer the composting process, because the C/N ratio must be reduced. According to Erickson et al. (2013), manure with composting times of 10, 20, and 30 days produced manure of quality according to SNI 19-7030-2004 (C/N ratio, levels of N, P, K, water, and C-organic). The time required for composting goat dung with coconut coir dust and a good EM4 bioactivator was < 30 days. Cassava peel is also known to possess the content required by plants. Cassava peel contains 28.74% Oxygen, 2.06% Nitrogen, 0.11% Sulfur, 59.31% Carbon, 9.78% Hydrogen, and 11.4% Water (Suherman et al. 2009).

The conventional composting process without an activator mixture takes a long time to complete. The liquid bioactivator EM4 is commonly used (Liu et al. 2011; Martana et al. 2016). Effective Microorganism 4 (EM4) is an activator that plays a role in accelerating the composting process and is useful for increasing nutrients (Siswanti 2009; Adeleke et al. 2017). EM 4 is a mixed culture of microorganisms that can be used as an inoculant to increase the diversity and population of microorganisms. The microorganisms in EM 4 were photosynthetic bacteria (*Rhodopseudomonas* sp.), lactic acid bacteria (*Lactobacillus* sp.), yeast (*Saccharomyces* sp.), *Actinomycetes* sp., and fermented fungi (*Aspergillus* sp. and *Penicillium* sp.). The presence of these microorganisms can accelerate composting to overcome the problem of the old factor of conventional composting (Rahmah et al. 2014). Microbes in the fermentation process grow and produce cellulolytic enzymes that break the cell walls of cassava coolies (Budiarto 2011).

The results of this composting also produced leachate that can be used as a liquid fertilizer. New leachate can be harvested for the first time after approximately 2 weeks (depending on the volume of cassava peels per day). The first leachate should not be used as fertilizer. They can be flushed into the toilet hole to facilitate the toilet channel. Furthermore, leachate can be harvested every two days. It is advisable not to harvest all of the resulting leachate because the remaining leachate in the composter can accelerate the subsequent decomposition process. The leachate can be used as a liquid organic fertilizer by adding a cap of the EM4 bottle into the leachate bottle and then leaving it for one night. Subsequently, 1 liter of leachate was mixed with 5 liters of water to water the plants.

(a) (b)

Figure 4 (a) Lemongrass plants without organic fertilizer; (b) Lemongrass plants with organic fertilizer

The products produced from composting cassava peel waste and goat dung are solid organic fertilizers and liquid organic fertilizers (*Pupuk Organik Cair* / POC). POC has many uses, including improving soil properties, providing nutrients, suppressing pest and disease populations, and accelerating growth

(Purnamasari et al. 2020). The resulting solid fertilizer was dark brown in color, odorless, and harvested after the composting process for more than 42 days. While POC is black and smells of fertilizer. After approximately two months obtained 100 liters of POC was obtained. The results of this composting process have been applied to vegetables, lemongrass, and flowers. The results showed better growth. When liquid fertilizer was tested on citronella plants with a dose of 5 bottle caps in one liter of water, citronella plant growth was better. The indicators included citronella plant density, leaf growth, plant fertility, number of tillers, composted fertilizer, better growth, fertility, greener leaf color, a greater number of leaves, and larger and more tillers (Figure 4).

CONCLUSION

Cassava (*Manihot esculenta* crantz.) is widely consumed by Indonesian people in various processed forms. Ciluar Village, Bogor City is one of the cassava production centers, for cassava farmers and industries. One of the cassava production issues in this area was the waste of cassava tuber outer peel, which has an impact on the ecological and social environment. Based on the potential of Ciluar Village, which has a lot of cassava farmland, cassava peel waste has the potential to be used as organic fertilizer. Therefore, it is necessary to know the minimum time to produce compost and know the best composition for making compost. The conclusions from the study on the potential utilization of waste into organic fertilizer in Ciluar Village include: (1) the minimum time to produce compost made from cassava peels and goat manure with pH parameters according to SNI standards is 42 days; (2) the best composition between cassava skin and goat manure to produce compost is a ratio of 7:3.

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