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Comparative analysis of Baglog waste management and effect on bok choy (*Brassica rapa* var. *chinensis*) plant

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Original research

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Abstract:

Purpose: This study was conducted to compare BSF larvae flooding technique and goat manure application for baglog waste bioconversion. The compared parameters were the effectiveness of technique, the quality of compost produced, and the suitability as a growing media and nutrients supplier.

Method: A total of four treatments were applied to assess the bioconversion process and the resulting compost quality. The effectiveness of compost application as a growing media and nutrient supplier for cultivating Bok choy (*Brassica rapa* var. *chinensis*) was also evaluated.

Results: The results showed that the highest waste reduction percentage was found in treatment P2 (D = 54.48%; WRI = 2.59%/day). Furthermore, BSF larvae flooding technique was identified as the most effective in reducing the fly population index. Goat manure application in treatment P4 (−0.2) yielded the lowest odor of hedonic scales. The quality of compost produced by all treatments was analyzed, and the results showed conformity with the Indonesian National Standard for N, P, K, and Ca content. Bok choy cultivated using compost treatment P2 had the highest plant height (16.3 ± 1.5^b cm), leaves count (13 ± 2^a leaves), wet weight (187.7 ± 5.8^b g).

Conclusion: BSF larvae flooding technique was more effective in reducing the fly population index and provided a significant reduction in baglog and food waste. On the other hand, goat manure application was more effective in reducing odor levels. Compost produced by treatment P2 showed the best growth parameters for cultivating bok choy.

Keywords: Baglog; Bioconversion; Black soldier fly; Compost; Food waste; Manure

1. Introduction

The generation of waste is a persistent worldwide problem requiring attention from various stakeholders. In Indonesia, the amount of waste produced experienced a increase from 38,480,443.03 tonnes in 2022 to 40,799,956.85 tonnes in 2023 (SIPSN, 2022, 2023a). Improper and delayed management of waste generation can result in the incidence of environmental hazards. Specifically, food accounts 39.85% of all waste globally, followed by plastics at 19.16% as well as wood and branches at 11.99% (SIPSN, 2023b). As stated by SIPSN (2023c), food waste is responsible for the most substantial proportion of organic waste, surpassing that of households (60.42%) and markets (11.61%). Organic waste consists of food (spoiled fruits and vegetables), garden (dry leaves and twigs), and tree-cutting waste (cut wood). Critical measures to address waste challenges include regulating the sources, types, and composition. Reduction and reuse initiatives have a negligible effect on waste generation, while recycling efforts substantially diminish production (Minelgaite and Liobikiene, 2019). Processing waste produced by production activities, such as baglog from edible mushroom cultivation, can also contribute to reduction.

The edible mushroom production experienced a significant surge from 20,179,342 kg in 2022 to 35,887,518 kg in 2023 (ODJ, 2022, 2023), resulting in baglog waste. Baglog is a growing media for edible mushroom culture packaged in polypropylene plastic bags in a sterilized condition. It is composed of the following components: 60 – 70 L of clean water, 1.5 kg gypsum ($CaSO_4$), and 1.5 kg agricultural lime ($CaCO_3$) (Yani and Mukti, 2020). Baglog is typically used four to five times during edible mushroom cultivation, and after harvest, the media is disposed of in waste disposal facility. An environment contaminated with baglog debris is characterized by a pungent, unpleasant odor. The unsanitary surroundings have the potential to contaminate the groundwater and attract a variety of insects that may choose to reside in the vicinity of waste disposal facility. Consequently, baglog waste must be processed appropriately, such as through bioconversion into compost. Several studies have documented the significant impacts of compost application on soil pH improvement as well as Fe and Al solubility reduction (Wahyudianur et al., 2022). In line with the SNI regulation for compost nutrient composition, Rahmat et al. (2022) found that combining baglog waste and poultry manure contained the highest concentrations of macronutrients N (1.01%), P (1.06%), and K (1.51%), as well as secondary nutrients Ca (1.48%) and Mg (0.4%). Based on the treatment that has been carried out, only the treatment of used baglog waste processed with chicken manure produced a C/N ratio of 16.97%, this indicates that the compost is mature.

Bioconversion using the Black Soldier Fly (BSF; *Hermetia illucens* species) is one method of converting food waste into compost. A study conducted by Liu et al. (2020) reported that BSF larvae increased total nitrogen by 23.15% and converted 14.51–21.98 percent of food waste. This study also shows the ability of BSF larvae to process waste through a composting process for 9 days and produce biofertilizer. Total N serves as the quality standard for compost generated through the bioconversion of dietary waste. However, the development of BSF larvae is impacted by macronutrients that degrade biologically, including lipids, carbohydrates, and proteins (Nguyen et al., 2015). Insect frass, extensively used as compost, is also generated through bioconversion (Klammsteiner et al., 2020). The physicochemical properties of BSF larvae frass include temperature (24 – 27 °C), pH (5.6 – 8.0), water content (30 – 72%), and C/N ratio (8:1-27:1), with the highest concentrations of nitrogen, phosphorus, and potassium at 5,695.9 ppm, 825.0 ppm, and 44.6 g/kg, respectively (Basri et al., 2022). Different waste from human activities, animal, fruit, vegetables, as well as milling and brewing waste from sorghum and wheat, alongside poultry feed are all converted by BSF larvae (Gold et al., 2018). In the refining of food waste and faces, BSF larvae are regarded as the most profitable and cost-effective option (Lalander et al., 2018; Liu et al., 2021).

Compost may be derived from manure of animals, including pigs, chickens, goats, cows, and lambs. As stated by Mahendra et al. (2020), compost obtained from goat manure had the most significant influence on the quantities and weight of red chilies, along with plant height, leaf count, and stem diameter (Sudita et al., 2021).

Baglog waste containing a mixture of sawdust, rice bran, corn flour, gypsum ($CaSO_4$), and agricultural lime ($CaCO_3$). BSF larvae with the help of food waste were proven to have the capability in converting the baglog waste, which was usually relatively difficult to degrade. Preliminary tests have been carried out using only biological agents in the form of black soldier fly (BSF) larvae placed on baglog waste without the addition of food waste for 30 days, showing no effect on reducing baglog waste. The color of the baglog waste does not change to black, indicating that the composting process does not occur. This preliminary test shows that biological agents cannot digest or eat baglog waste just like that. So additional materials are needed as the main feed in the form of organic solid waste.

The BSF larva flooding technique shows the use of BSF larvae in very large quantities. This aims to accelerate the process of bioconversion of waste into compost. Therefore, this BSF larva flooding technique is a breakthrough in the processing of baglog waste and organic solid waste in the form of food waste. Meanwhile, the bioconversion of baglog waste using goat manure is considered conventionally practical in reducing baglog waste and livestock waste. This study aimed to investigate alternative techniques for effectively managing baglog and food waste, as well as goat manure to produce compost, both environmentally benign and suitable for the cultivation of bok choy.

2. Materials and methods

The equipment used were digital and analog scales, rulers, plastic containers with wire covers, a thermometer, a fly grill, composting tanks with wire covers, an insectarium, and a camera. Baglog and food waste, BSF eggs, goat manure, bok choy seeds, and rock wool cubes were used as materials. Baglog waste was collected from waste disposal facility close to the cultivation site of edible mushrooms. Households, food vendors, and fruit beverage stalls contributed food waste in the form of spoiled fruits, vegetables, and leftovers.

This study was performed between March and August of 2023, and the bioconversion procedure was carried out at Waste Management School/SPenSa, Sekolah Pengelolaan Sampah, situated in the Margajaya District of Bogor City. Two distinct techniques were used for the bioconversion of baglog waste: (1) BSF larvae flooding technique using food waste, and (2) the application of goat manure. The process of bioconversion of baglog waste is carried out by repeating the treatment, namely 3 times. The data obtained will be averaged. The effectiveness of the two techniques was compared based on the qualities and characteristics of compost produced, alongside its efficacy as a growing medium and nutrient supplier for bok choy culture.

Evaluation of waste production

Before refining of baglog waste, preparations were executed using BSF larvae. Observation of food waste generation collected from a variety of sources and monitoring BSF eggs were components of the preparations. BSF larvae were nourished with food waste, while the weight, composition, and diversity of food waste added to composting tanks were recorded over seven days. The purpose of this waste generation activity was to gather data regarding the process. The activity was carried out following SNI 19-3964-1994, Procedures for Collecting and Measuring Sample Generation

and Composition of Municipal Waste. The amount of waste generated was determined by using an analog scale.
The light bricks used to construct composting containers ($1 \times 1 \times 0.4$ m) were overlapping and had an aperture ranging from $1-2$ centimeters (Fig. 1). A wire was used to enclose composting containers to prevent the ingress of animals.

The bioconversion methodology

About 10 g BSF eggs were hatched to produce the required number of larvae for flooding technique. These larvae spent seven days in plastic containers at the insectarium, being reared with a diet consisting of 1 kg food waste and 150 g rice bran. After the seven-day rearing period, larvae were used in flooding technique.
The bioconversion of baglog waste was accomplished through the application of goat manure and BSF larvae flooding technique using food waste. Composting containers were subjected to flooding technique through the introduction of baglog waste containing 7-day-old BSF larvae along with food waste in a 1:1 and 1:2 ratio, respectively. Therefore, this study used four distinct treatments namely P1 (BSF larvae, 5 kg baglog waste, and 5 kg food waste), P2 (BSF larvae, 2.5 kg baglog waste, and 5 kg food waste), P3 (5 kg baglog waste and 5 kg goat manure), and P4 (2.5 kg baglog waste and 5 kg goat manure).
A daily influx of baglog waste, food waste, and goat manure was implemented for two weeks, commencing at the age of eight days and continuing until larvae reached the age of 21 days. Waste reduction index (WRI) and degradation or waste reduction percentage (D) were computed using the subsequent equations derived from Diener et al. (2009):

$$D = \frac{W - R}{W} \times 100\% \quad (1)$$

where:
D: Degradation or waste reduction percentage
W: Initial waste mass (kg)
R: Final waste mass (kg)

$$WRI = \frac{D}{t} \times 100\% \quad (2)$$

where:
WRI: Waste reduction index (%/day)
D: Degradation or waste reduction percentage
t: Required duration for waste bioconversion process (days)

Following SNI 16-7061-2004, temperature measurements were conducted using four thermometers positioned in the vicinity of composting containers during the bioconversion process. A dry and moist bulb thermometer was used, while temperature measurements were conducted on a tri-daily basis: between 08:00 to 09.00 local time in the morning, 12:00 to 13:00 in the afternoon, as well as 16:00 to 17:00 in the late afternoon.
Goat manure and waste generation have the potential to attract house and green flies, which serve as vectors for a variety of diseases. Consequently, the fly population index was used in this investigation to ascertain the quantity of flies encircling composting containers. The index was calculated in adherence to Regulation No. 2 Year 2023 of the Ministry of Health of the Republic of Indonesia. This regulation stipulates that an area can be considered fly-free when its average quality standard for fly populations is below two flies.
The fly population index was determined with a fly grill, also known as a fly trap, positioned directly above the area where waste was generated in composting containers. Images of house flies and green flies that landed on the fly barbecue were captured for 21 seconds, with 10-second intervals and 10 replications. The images were used to identify the five flies with the highest count, and the resulting averages were computed.
The odor test is essential to fulfill the feasibility requirement in designing an odor-free waste bioconversion facility. The test was performed by measuring the odor hedonism scale with an arrangement showing liking or disliking. The hedonic scale (odor concentration) was tested to determine the evaluation index reflecting the psychological impact of odors, using panelists with various concentrations according to the nine-point scale with a value range of $-4 \leq x \leq 4$ (Li et al., 2019) (Table 1). A total of 10 panelists participated in the odor test and filled out online questionnaires. The odor-smelling activity was carried out for 15 seconds for each treatment by using a simple set of tools (Fig. 2).
After the bioconversion process had been completed, compost was harvested and the outcomes of BSF larvae flooding technique were categorized as follows: (1) unconverted waste; (2) BSF larvae; and (3) compost. Unconverted waste consisted of undegraded materials remaining nearly intact, while the prepupal phase had commenced in BSF larvae at the time of harvest. The primary byproduct of waste bioconversion process was compost, and a weight assessment test

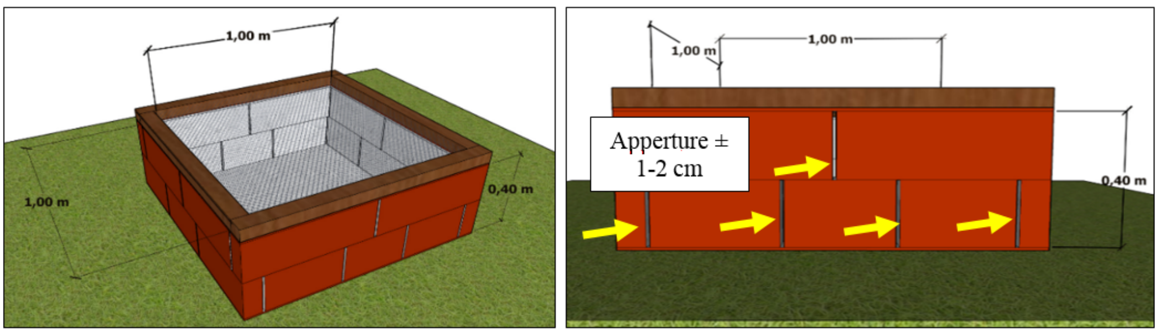

Figure 1. Design of construct composting containers.

Table 1. Hedonic scale for odor impressions.

Scale	Odor impression
+4	Extremely pleasant
+3	Moderate pleasant
+2	Pleasant
+1	Slightly pleasant
0	Odorless/neutral
−1	Slightly unpleasant
−2	Unpleasant
−3	Moderate unpleasant
−4	Extremely unpleasant

was performed on the three byproducts generated. In the decomposition process using goat manure (treatments P3 and P4), no product separation was performed since all byproducts of these two treatments were composted. Compost generated from each of the four treatments was subjected to a seven-day air-drying period to decrease the moisture content and achieve a suitable pH level for use as a growing medium. The air-drying procedure was completed before commencing the analysis of compost quality.

Compost quality analysis

Compost quality analysis was conducted at the Testing Laboratory of the Agronomy and Horticulture Department, the Faculty of Agriculture, IPB University. The tested chemical parameters were macro and micro elements considered as standard provisions for compost quality, including N, P, K, C, Zn, Fe, Ca, and Mg. Meanwhile, the tested physical parameter observed was compost color. These parameters were compared for conformity with SNI 19-7030-2004 regulation on Compost Quality Standards.

Evaluating compost for plant growth

Bok choy was used as the experimental plant, and for each treatment, seedlings derived from 50 seeds were used. As the initial planting medium, $3 \times 3 \times 3$ cm rock wool cubes were used to distribute the seeds. Two to four-leaved seedlings were transplanted into planting pots lined with compost medium. Furthermore, five distinct varieties of compost were evaluated, including one commercial and the products of the four interventions in this study. The commercial compost was produced by SPenSa under SNI regulation and used as a comparison. The plant testing was conducted in a greenhouse at approximately 08:00-10.00 local time each morning with routine irrigation. The observed growth parameters were plant height, and number of leaves, determined by using a leaf-color diagram. At the time of harvest, root length and moist weight were also assessed.

3. Results and discussion

Assessment of organic waste generation

Food waste from households, stalls, and fruit beverage stalls was used in this study. Food waste comprises inedible and discarded components, such as leftovers and other residues generated during preparation, heating, and consumption. Additionally, any inedible food was considered waste, including uneaten fruit rind, seeds, as well as bones, spoiled food, and expired or damaged ingredients.

Based on the results, the combined weight of food waste from fruit and beverage stalls was comparable to that of food stalls. However, the total weight of food waste from fruit and beverage stalls was twice that of households.

The composition of food waste originating from households showed the greatest diversity compared to fruit, beverage stands, and food vendors. In contrast, the composition of food waste derived from fruit and beverage stands was comparatively more restricted in scope compared to that of households. Food waste generated at food stalls and fruit beverage stalls comprised rice, vegetables, bones, animal protein residue, and peeled fruit skin. Food waste derived from households was comparable but varied significantly, with a relatively consistent daily turnover rate. In this investigation, food waste accumulated in composting tanks for eight days weighed a total of 43.7 kg. The composition and total weight of the collected food waste in eight days were presented in Table 2.

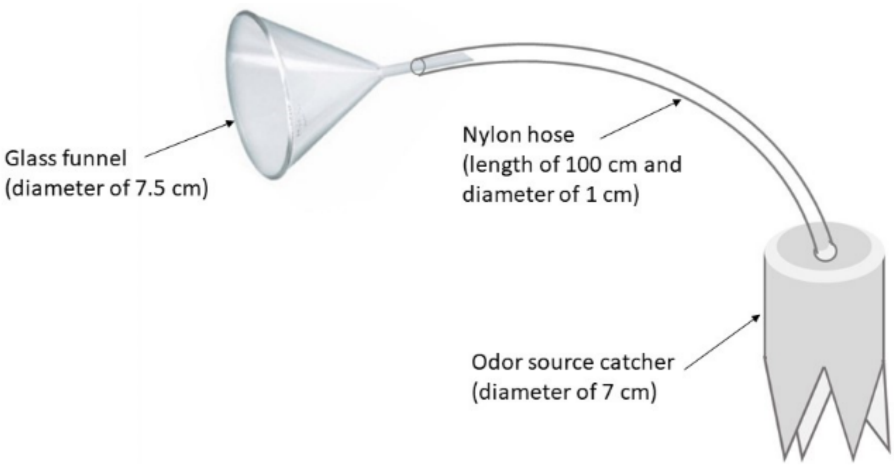

Figure 2. Design of an odor-smelling tool.

Table 2. Food waste collected for 8 days.

Day-	Total weight of food waste (kg)				Food waste composition		
	Households	Food stalls	Fruits beverage stalls	Total weight	Households	Food stalls	Fruits beverage stalls
1	0.7	1.3	1.6	3.6	Rice, meat, chicken bones, fish bones, carrots, potatoes, corn, sweet potatoes, tomatoes, long beans, mushrooms, noodles, bread, and peeled fruit skins from dragon fruits, melons, bananas, oranges, and pears	Rice, fish bones, chicken bones, cucumber, cabbage, lemon, basil leaves, tempeh, tofu, and squeezed oranges	Peeled fruit skins from bananas, melons, watermelons, mangoes, oranges, avocadoes, and soursops
2	1.2	1.5	2.1	4.8			
3	1.0	2.7	2.9	6.6			
4	1.0	2.5	3.1	6.6			
5	0.7	1.8	2.7	5.2			
6	1.3	2.5	2.6	6.4			
7	1.1	2.7	3.1	6.9			
8	1.0	1.3	1.3	3.6			
Total	8.0	16.3	19.4	43.7			

The bioconversion process on Baglog waste, food waste, and goat manure

The experimental conditions comprised the daily addition of baglog, food waste, and goat manure for two weeks to the corresponding treatments. A week before the commencement of the study, food residue was gathered to nourish BSF larvae used in treatments P1 and P2.

Treatments P1 and P2 caused a larger reduction in waste mass than P3 and P4, as depicted in Table 3. The larger reduction in waste mass was attributed to BSF larvae flooding technique, which expedited the bioconversion procedure. This technique was carried out by inoculating baglog waste with a substantial quantity of BSF larvae in conjunction with food waste.

Waste reduction percentage (D) and WRI are two metrics used to assess the efficacy of the bioconversion process. These variables are subject to the impact of waste type, mass, and bioconversion time.

Temperature and relative humidity measurements were additionally conducted in the vicinity of composting containers throughout the bioconversion procedure. The temperature range assessed using a dry bulb thermometer was 24.5 to 32.2 °C, while the range determined with a moist bulb thermometer was 23.3 to 29.1 °C. The relative humidity varied between 61% and 84%.

The environment has a significant impact on both the temperature and relative humidity. Extremely high temperatures prevailed from midmorning until midafternoon, or precisely between 10:00 and 14:00 local time but dropped during the late afternoon due to moderate-heavy precipitation. Temperature and relative humidity fluctuations impacted the life cycle of BSF larvae. Chia et al. (2018b) and Chia et al. (2018a) showed that the growth duration of BSF larvae was influenced by both temperature and feed. Additionally, elevated temperatures accelerated the hatching process, suggesting that BSF larvae had a greater lifespan at medium temperatures as opposed to extremely high levels.

The fly population index was calculated using a fly grill constructed from white-painted wood sections measuring 80×80 cm. The white color was selected to obtain contrast with the colors of the flies, ensuring that those landing on the grill were clearly seen and easier to calculate (Fig. 3).

The calculation of the fly population index serves as the foundation for fly control in the vicinity of composting containers. Flying insects served as vectors of numerous diseases, and at the outset, the fly population index in the vicinity of treatments P1 and P2 was greater than that of P3 and P4. Treatments P1 and P2 used food waste for feeding BSF larvae, and based on a previous study, organic waste from households contained water at 68.2%, while vegetable and fruit waste was composed of water at 85.3% (Ho and Chu, 2019). Organic waste containing water between 80% and 90% is considered suitable for feeding BSF

Table 3. Percentage of waste reduction and WRI.

Treatment	Average of initial waste weight (kg)	Average of final waste weight (kg)	Average of waste mass reduction (kg)	Percentage of waste reduction (%)	WRI (%/day)
P1*: 5 kg BW + 5 kg FW	179.93	93.73	86.20	47.90 ± 1.58	2.28 ± 0.08
P2*: 2.5 kg BW + 5 kg FW	145.50	66.23	79.27	54.48 ± 1.14	2.59 ± 0.05
P3: 5 kg BW + 5 kg GM	140.00	138.27	1.73	1.24 ± 0.43	0.09 ± 0.03
P4: 2.5 kg BW + 5 kg GM	105.00	103.90	1.10	1.05 ± 0.19	0.08 ± 0.01

Notes: BW: baglog waste; FW: food waste; GM: goat manure; * BSF larvae flooding technique; WRI: Waste Reduction Index.

Figure 3. Design of fly grill.

larvae (Salam et al., 2022). Similar results also showed that suitable feed for BSF larvae had an optimum water content of 65 – 90% (Liu et al., 2021). The water content in food waste generated an unpleasant odor, which attracted the flies to come near the composting tanks of treatments P1 and P2. On the other hand, treatments P3 and P4 used relatively dry goat manure, which did not generate odor. Baglog waste added to these treatments was able to absorb the unpleasant odor.

The fly population index decreased significantly after the bioconversion process, from 38.80 to 1.60 for treatment P1 and 46.20 to 1.80 for treatment P2. The decrease in biomass production was attributed to the bioconversion process accelerating as BSF larvae in composting containers grew in size. The greater the size of BSF larvae, the greater the food requirement. Consequently, the bioconversion process showed an accelerated rate for treatments P1 and P2.

From day two, treatments P3 and P4 had a low fly population, then by day 13, the index showed a significant decrease. In this investigation, composting tanks showed great capacity to absorb wastewater originating from both the bioconversion process (internal factor) and rainwater infiltrating the tanks (external factor) when baglog waste was added daily for two weeks. Additionally, temperature, relative humidity, the state of wastewater channels, and the condition of waste containers affected the fly population index (Ihsan, 2016). Towards the conclusion of this study, the fly population index for each treatment was below two flies (Fig. 4), complying with the Ministerial Decree No. 2 Year 2023 of the Ministry of Health of the Republic of Indonesia.

The odor hedonic scale showed that treatments P1 and P2 produced a rather unpleasant odor at a scale of -1.5 ± 1.1 and -1.4 ± 1.2 respectively. In contrast, the odor was almost undetected for treatments P3 and P4 at a scale of -0.7 ± 0.8 and -0.2 ± 0.4 respectively, showing that both treatments had experienced the bioconversion with near-zero odor. The results of the odor hedonic scale in this study are presented in Fig. 5.

The source of odor in treatments P1 and P2 was BSF larvae and the unconverted food waste. Local weather, geographical location, size and management of waste processing

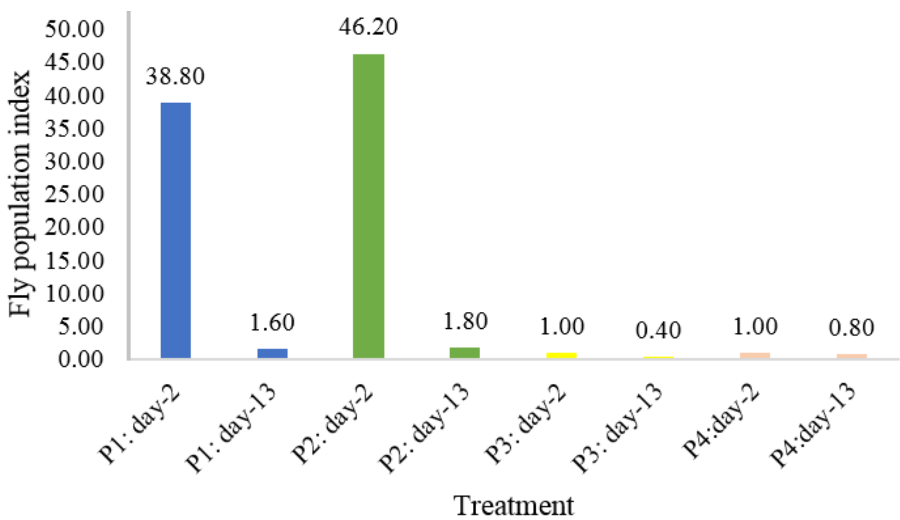

Figure 4. Fly population index.

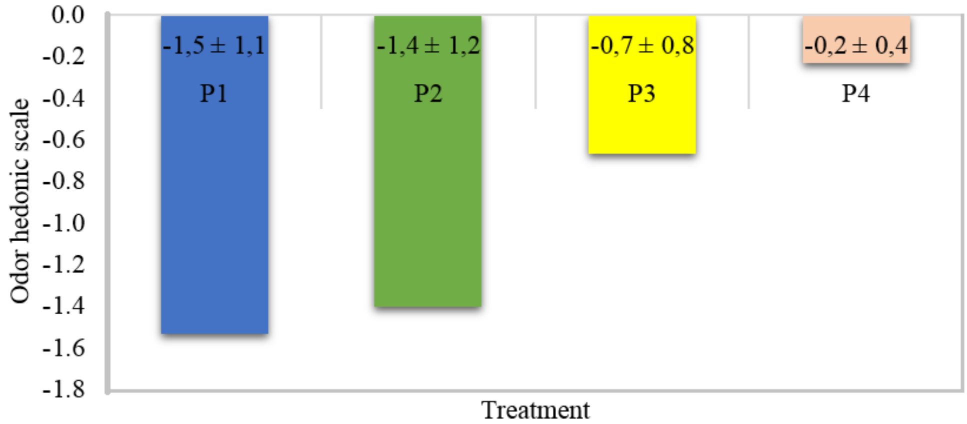

Figure 5. Results of odor hedonic scale determination.

facility, ventilation, as well as human factors determine the odor hedonic scale (Bokowa et al., 2021). The bioconversion process on waterlogged food waste caused a higher negative value on the odor hedonic scale. One of the alternatives to overcome such problems is using baglog waste to absorb stagnant water and excessive wastewater.

Harvesting activity was carried out after the bioconversion process was completed. The activity included separating the results into unconverted waste, BSF larvae, and compost. Treatments P1 and P2 still showed unconverted waste, leading to color change (Fig. 6 (a)). On the other hand, treatments P3 and P4 produced a higher amount of compost because all products from the bioconversion process were considered compost (Fig. 6 (b)). The amount of compost produced for treatments P1, P2, P3, and P4 was 69.20 kg, 38.30 kg, 138.27 kg, and 103.90 kg.

Compost quality analysis

Compost produced by the bioconversion process is capable of minimizing the risks of toxic substances existing in an environment, such as pesticides, and also has the potential to support economic agriculture efforts (Lalander et al., 2016; Beesigamukama et al., 2021). In this study, four types of compost were produced from the respective treatments. Laboratory tests were conducted on a total of 11 parameters, while the other two were directly tested in composting tanks at the bioconversion area. The results of these tests were compared for conformity with the SNI 19-7030-2004 regulation regarding Compost Specification from Domestic Organic Waste. The quality analysis showed that compost produced by the four treatments was all in conformity with the standard stated in the SNI regulation for parameters N, P, K, and Ca, except for pH and C/N ratio (Table 4).

After 14 days of the bioconversion process, compost color was observed as a key indicator of maturity. Carbon content in compost is closely related to the color (Palechor-Tróchez et al., 2018). The brown color showed high carbon content, suggesting compost had not reached maturity level. Meanwhile, the black color implied compost had reached maturity level with lower carbon content, as observed in the results of this study. The compost color in treatments P1 and P3 was dark brown compared to P2 and P4, which had a black color (Table 3). Treatments P2 and P4 produced mature compost under SNI regulation for organic-C and color parameters compared to P1 and P3. The presence of unconverted waste hindered compost from reaching maturity level. Compost stability and maturity were closely related to the quality, types, and composition of organic waste, including food (Azim et al., 2018).

Figure 6. Harvesting products from the bioconversion process (a) and compost (b).

Table 4. Quality analysis of compost produced.

Parameter	**Compost**				**Quality standard (SNI 19-7030-2004)**		**Unit**
	P1	**P2**	**P3**	**P4**	**Minimum**	**Maximum**	
Organic-C	35.92*	29.95	34.66*	23.95	9.80	32	%
C/N Ratio	27*	23*	23*	34*	10	20	-
Water content	73*	63*	71*	44	-	50	%
Nitrogen (N)	1.33	1.28	1.49	0.71	0.40	-	%
Phosphorus (P_2O_5)	1.08	0.84	1.29	0.62	0.10	-	%
Kalium (K_2O)	1.38	1.06	2.40	1.68	0.20	-	%
Calcium (Ca)	8.10	3.97	8.25	3.41	-	25.50	%
Magnesium (Mg)	0.41	0.26	0.87*	0.41	-	0.60	%
Iron (Fe)	0.68	0.54	4.40*	2.18*	-	2.00	%
Zinc (Zn)	92	71	680*	106	-	500	mg/kg
pH	8.71*	8.75* 9.11*	7.56*	6.80	7.49	-	
Color**	10YR 2/2 Very dark brown*	10YR 2/1 Black	10YR 2/2 Very dark brown*	10YR 2/1 Black	Blackish		-

Notes: * exceeding quality standard; **not being analyzed at the testing laboratory.

Compost application for growing plant

The compost used for growing the test plant was 100% produced by the four treatments namely P1, P2, P3, and P4, without adding any soil or nutrients. The best growth parameters were found in treatment P2, with an average plant height of $16,3 \pm 1,5^b$ cm, leaf count of 13 ± 2^a, root length of $7,0 \pm 1,5^b$ cm, and wet weight of $187,7 \pm 5,8^b$ g (Table 5).

Treatments P1, P3, and P4 also showed that compost produced by the bioconversion process was suitable as a growing media and nutrient supplier for bok choy. However, the growth was not optimal compared to that of the commercial compost "SPenSa" (Fig. 7).

The commercial compost known as "SPenSa" was subjected to a degradation process lasting two months, followed by a natural air-drying phase of one to two weeks. In contrast, compost used in this study was generated from four different treatments through a two-week bioconversion process and a seven-day air-drying phase. To enhance nutrient and water absorption, rice husk charcoal was incorporated to augment porosity.

4. Conclusion

In conclusion, Baglog waste was effectively reduced through the bioconversion process by using two techniques, namely BSF larvae flooding and goat manure application. The bioconversion process produced compost consistent with SNI 19-7030-2004 regulation for N, P, K, and Ca, except for pH and C/N ratio, which showed non-conformity. BSF larvae flooding technique was more effective in reducing the fly population index, as well as baglog and food waste. On the other hand, the application of goat manure was more efficient in decreasing the emanating odor from the bioconversion process. In both

Table 5. Growth parameters of bok choy as a test plant in compost application.

Treatment	**Plant height (cm)**	**Numbers of leaves**	**Root length (cm)**	**Wet weight (g)**
P1	15.7 ± 2.5^b	12 ± 2^a	7.4 ± 0.6^b	179.8 ± 7.0^c
P2	16.3 ± 1.5^b	13 ± 2^a	7.0 ± 1.5^b	187.7 ± 5.8^b
P3	13.3 ± 1.9^c	10 ± 2^b	6.9 ± 0.4^b	173.1 ± 3.2^c
P4	8.6 ± 0.9^d	7 ± 1^c	4.9 ± 0.4^c	155.6 ± 1.9^d
Commercial compost "SPenSa"	22.8 ± 1.3^a	14 ± 1^a	13.5 ± 0.6^a	263.6 ± 7.7^a

Notation a, b, c, d shows significantly different data ($P < 0.05$).

Figure 7. Planting Bok choy using rockwool (seeding) and compost (growing medium and source nutrient).

composting techniques, the use of 2.5 kg baglog waste resulted in compost quality consistent with the SNI regulation compared to the use of 5 kg baglog waste. The results also showed that compost produced by the bioconversion process was suitable as a growing media and nutrient supplier with the best growth found in treatment P2.

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Authors contributions
RH designed experiments, data collection, analysis and interpretation of results, and also writing the manuscript. All authors contributed, read and approved the final manuscript.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Conflict of interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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