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Aerobic processing of sheep farming faeces using indigenous microorganism decomposers and maggot *black soldier fly* detritivors

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Abstract. Sheep solid waste in feces can be processed and converted using indigenous microorganisms and the Black Soldier Fly (BSF) maggot detritivore. The results of the decomposition of organic material from sheep feces can be BFS maggot biomass and BSF frass. The research involved combining sheep feces with milk processing industry sludge and organic kitchen waste and aerobically processing them using indigenous microorganism decomposers and BSF maggot detritivores. This research aims to convert sheep feces into BSF maggot and BSF frass biomass using various waste materials, indigenous bacteria, and fungi using exploration methods. The method used was exploration, and data was obtained in a descriptive. Beginning with a 7-day initial decomposition process by microorganism decomposers, the process of processing sheep feces then continues for 21 days by maggot detritivores. The research showed that indigenous bacteria and fungi in the substrate amounted to 5×10^{10} cfu/g and 3×10^{5} cfu/g. Processing sheep feces could reduce the amount of waste, which resulted in a reduction of 63,87%, resulting in BSF maggot biomass of 1042±98.4631 g and Frass BSF of 1084±55.8345 g.

1 Introduction

Sheep farms produce waste in the form of feces and urine, and apart from meat, sheep also produce waste in the form of feces. Sheep feces contain complex and unstable organic materials and have a number of microorganisms, so management is needed to avoid polluting the environment [1]. Sheep farming waste management can be done using a bioconversion process. Aerobic processing of sheep feces by utilizing the decomposer activity of microorganisms (bacteria, fungi) and BSF maggot detritivores can convert sheep feces into BSF maggot biomass and BSF frass. Maggot biomass can be used as animal feed, and BSF frass can be used as organic fertilizer [2]. Bioconversion of sheep feces by utilizing the activity of indigenous decomposer microorganisms and aerobic BSF maggot detritivore activity requires paying attention to factors that influence the success of the bioconversion process, including nutrient content in the substrate, water content (50–60%), oxygen, pH, temperature, quantity.

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Microorganisms (bacteria, fungi) and BSF maggot detritivores [3, 4]. The results of the proximate analysis show that sheep feces contain carbohydrates, crude fiber, protein, and fat, which microorganisms can utilize for growth and activity, but contain *low-fiber* and *high-water* content so that maggot activity is less than optimal, for this reason, it is necessary to add other ingredients containing fiber. High because the growth and activity of BSF maggots require *high-fiber* [5]. Materials that can be added include milk processing industry waste and kitchen organic waste. [6] stated that the quality and quantity of larval development media greatly influence BSF frass's nutrient content, maggot biomass's nutritional quality, and larval survival in each instar. According to [7, 8], growing media with high fiber content produces the best. According to [9, 10] that the growth and development of BSF maggots is influenced by substrate nutrition, while according to [11] BSF maggots can decompose organic waste.

Based on the factors that influence the bioconversion process, the number of Indigenous microorganisms in the substrate needs to be considered; for this reason, this research also isolated the number of Indigenous bacteria and fungi in the substrate; this is to ensure that the bioconversion process will run *"optimally. ["*12] BSF larvae can bioconvert organic material into high-quality BSF biomass. The activity of Indigenous microorganisms (bacteria, fungi) and BSF maggot detritivores in the substrate can reduce the amount of organic waste *"generate"* [13], which states that local microorganisms (MOL) can decompose organic waste and improve the quality. In a maggot planting medium, the maggot production will be higher. BSF maggots grow and develop by utilizing nutrients from the substrate, which will cause a reduction in substrate volume and produce maggot frass characterized by a low C/N ratio content. This research aimed to process sheep farm waste aerobically and convert it by utilizing indigenous microorganism decomposers and BSF maggot detritivore, which produces maggot biomass and BSF frass.

2 Materials and methods

The materials used in this research were fat tail sheep feces, milk processing industry sludge waste, kitchen organic waste consisting of various kinds of vegetables, indigenous microorganisms, and BSF maggots. Materials used for proximate analysis: concentrated H_2SO_4, NaOH 40%, Boric Acid, Methyl Red Indicator, Cressol Green Bromine Indicator, $H_2SO_4$0.01N, Acetone, and H_2O. Materials used to isolate fungi and Bacteria: Potato Dextrose Agar (PDA) and Nutrient Agar (NA) media, physiological NaCl, H_2O. The research method used was exploratory; data was obtained descriptively.

Each waste sample was tested to assess its nutritional composition during the research. Additionally, the quantity of indigenous bacteria and fungi in each waste sample was calculated. Then, weigh the substrate consisting of 1 kg of sheep feces, 1 kg of sediment waste from the milk processing industry, and 1 kg of organic kitchen waste, mix it until homogeneous, put it in a sack, and then incubate it for seven days (initial decomposition). Observations were made of temperature changes during the initial decomposition process to ensure that the initial decomposition process was running optimally. Furthermore, after the initial decomposition, 1 gram of maggot egg, hatched for 4 days (baby maggot), is added to the substrate. Then, the maggot growth is observed for 21 days, and the temperature achieved during the maggot growth process is also observed to ensure the maggot can grow and be active. The parameters measured were the amount of BSF maggot biomass produced and the amount of BSF frass and substrate shrinkage.

$$\text{shrinkage} = \frac{\text{initial substrate weight} - \text{final substrate weight}}{\text{initial substrate weight}} \times 100\% \qquad (1)$$

3 Results

Processing of sheep feces is carried out aerobically, utilizing the activity of indigenous microorganisms (bacteria, fungi) and BSF maggots, by mixing milk processing industry sludge waste, kitchen organic waste, subsrat which is an organic material that contains nutritional value, to determine the nutritional content in the waste, it is carried out proximate analysis, the results of which are presented in Table 1.

Table 1. Proximate Analysis of Sheep Feces, Milk processing industry sludge waste and Kitchen Organic Waste

Sample	Water %	Ash %	Protein %	Fiber %	Fat %	Carbohydrate %	Energy Kcal/kg
Sheep feces	71.28	27.45	14.37	19.83	3.54	34.81	3511
Milk processing industry sludge waste	81.87	3.12	13.41	6.34	9.48	67.66	4308
Kitchen organic waste	81.36	11.87	19.41	13.38	3.87	51.47	4193

The number of indigenous microorganisms in the substrate will influence the initial decomposition process, changing complex organic material into simple organic material, which maggots can then consume. Table 2 presents the number of bacteria and fungi in each waste used in this study.

Table 2. Number of Bacteria and Fungi in each waste used in this research (sheep feces, dairy industry processing sludge waste and kitchen organic waste)

Sample	Number of Bacteria (cfu/g)	Number of Fungi (cfu/g)
Sheep Feces	5×10^{10}	3×10^{5}
Dairy industry processing sludge waste	12×10^{9}	11×10^{5}
Kitchen organic waste	14×10^{9}	5×10^{5}

A noticeable rise in temperature characterizes the decomposition process of organic material. The data on these temperature changes during the initial decomposition process are detailed in Fig. 1, providing a clear understanding of the process.

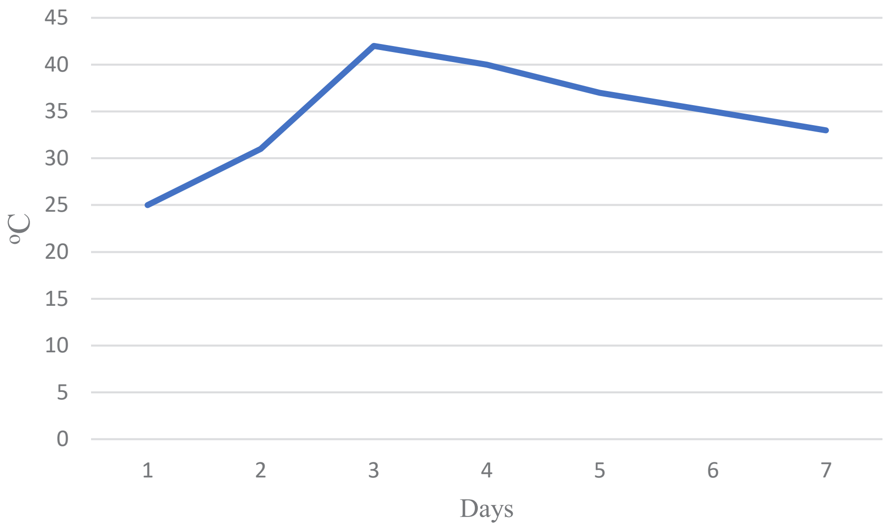

Fig. 1. Temperature changes during the initial decomposition process.

The results of observations of temperature changes during maggot growth are presented in Fig. 2.

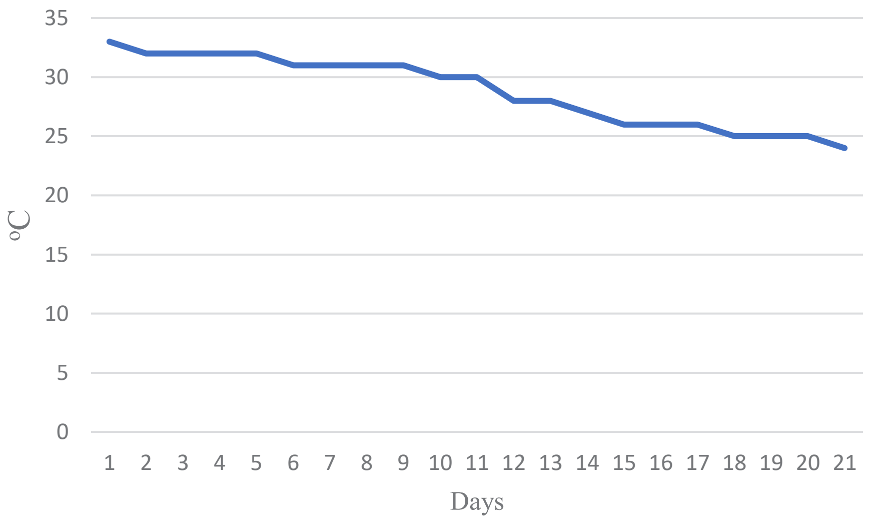

Fig. 2. Average temperature during the Maggot detritivore activity process.

Processing sheep feces mixed with milk processing industry sludge waste and organic kitchen waste aerobically, with the active participation of indigenous microorganisms and BSF maggot detritivores, leads to the production of BSF maggot biomass and frass, and a reduction in waste generation (substrate shrinkage). The role of indigenous microorganisms in this process is particularly intriguing and warrants further research, as presented in Table 3.

Table 3. BSF Maggot Biomass Production, BSF Maggot Frass and Substrate Depreciation

Initial weight of substrate (g)	BSF maggot biomass production (g)	BSF maggot frass production (g)	Shrinkage (%)
3000	1042 ± 98,4631	1,084 ± 55, 8345	63,87

The results of the proximate analysis on the BSF maggot are presented in Table 4, and the results of the C/N ratio analysis on the Frass BSF are presented in Table 5.

Table 4. Proximate Analysis of Maggot

Sample	Water %	Ash %	Protein %	Fiber %	Fat %	Carbohydrate %	Energy Kcal/kg
Maggot BSF	73,89	28,79	38,80	2,88	9,26	20,27	4053

Table 5. C, N content and C/N ratio in Frass BSF mixed with sheep feces, dairy industry processing sludge waste and kitchen organic waste, with maggot detritivore

Sample	C organic %	Nitrogen (%)	C/N rasio
Frass BSF	17,47	2,30	7,60

4 Discussion

Based on the proximate analysis of organic waste, sheep feces contain 71.28% water content, 27.45% ash, 14.37% protein, 19.83% fiber, 3.54% fat, 34.81% carbohydrates, and 3511 Kcal energy. /kg; solid waste from the milk processing industry contains 81.87% water content, 3.12% ash, 13.41% protein, 6.34% fiber, 9.48% fat, 67.66% carbohydrates, 4308 Kcal/kg energy; kitchen organic waste contains water content 81.36%, ash 11.87%, protein 19.41%, fiber 13.38%, fat 3.87%, carbohydrates 51.47%, energy 4193 Kcal/kg, this shows the content nutrients that can be converted into maggot BSF and Frass BSF biomass products. The nutritional value of the substrate greatly influences the growth of BSF maggots. The mixture of the three organic wastes used in this research enriches the nutritional content of the substrate, so it is hoped that the bioconversion process of sheep feces will run optimally, reducing the amount of waste generation (shrinkage) and producing high amounts of BSF maggot biomass and produces quality BSF frass. Indigenous microorganisms and BSF maggots need the nutritional value of the substrate. This is in line with the opinion of Lestari et al. (2020), who stated that the quality and quantity of larval development media greatly influence the nutrient content of BSF frass and the nutritional quality of maggot biomass as well as larval survival in each instar. According to Weko et al. and Sari et al. [7, 8], growing media with high fiber content produces the best. According to Mirwandhono et al. and Syahrizal et al. [9, 10] growth and development of BSF maggots is influenced by substrate nutrition.

Bacteria and fungi in each waste amounted *approximately* 12 x 10^9 to 5 x 10^{10} and 3 to 11 x 10^5cfu/g. The number of bacteria and fungi is sufficient for the initial decomposition process. The number of bacteria needed in the initial decomposition process of waste organic material is > 10^7 cfu/g. This is in line with the opinion of Ghazali et al. [13] who stated that the addition of starter microorganisms in the composting process would speed up the degradation time of organic materials and according to Sihombing, S. M., & Mirwandhono, E [14] which stated that local microorganisms (MOL) can decompose organic waste.

In the observation results, temperature changes occurred at the beginning of decomposition, and the temperature increased until day 3, when the temperature reached 42ºC, then decreased until day 7, when the temperature reached 34ºC. This indicates that the process of degradation of waste organic material occurred; at the end of this process, the temperature was still higher than the ambient temperature, which indicates that the substrate still contains organic material. Wahyusi also presented changes in temperature during the decomposition process, [15, 16] which states that temperature changes occur during composting. After the initial decomposition process, the detritivore process continues with BSF maggots (BSF maggot growth process); this process will degrade the organic substrate by BSF maggots and convert them into BSF maggot biomass and BSF frass. In the maggot growth process, the temperature of the substrate changes.

The results of observations of the temperature achieved during maggot growth are between 33 – 24ºC. This temperature is in accordance with the temperature that maggots need to live, namely 24 – 30ºC. This is in line with the opinion of Chia et al. [17] who stated that BSF maggots grow and develop at a temperature of 30ºC. According to Shumo et al. [18], BSF maggots will grow optimally at temperatures of 25 – 30ºC.

The initial substrate as a growth medium for BSF maggots was 3000 grams, the production of BSF maggots was 1042 ± 98.4631 grams, and BSF Frass was 1.084 ± 55.8345 grams. Based on the results of calculations using the shrinkage formula, it was found that the maggot growth process could reduce waste generation (shrinkage) by up to 63.87%. This is thought to be because the nutritional content of the substrate can be utilized by maggots to grow and develop, resulting in substrate shrinkage. This is in line with the opinion Diener, S., et al [19] stating that the reduction in maggot growth media reached 65.5% - 78.9%, and the opinion of Lestari et al. [6], The individual who made the statement is that the quality and amount of the media in which the larvae develop has a significant impact on the nutrient content of black soldier fly (BSF) frass, the nutritional quality of maggot biomass, and the survival of larvae in each developmental stage.

Maggots produced from substrate bioconversion have a high nutritional content, specifically having 38.80% protein, which makes it suitable for use as animal feed. This is in line with the opinion of Azizah et al. [20] who stated that the proximate analysis of BSF larvae had a protein content of 50.88%. According Zamri et al. [21] BSF maggot has the potential to reduce the cost of chicken feed formulation by replacing some of the soybean meal and/or fish in the chicken ration.The BSF frass produced has a C/N ratio of 7.60, this indicates that BSF frass can be used as organic fertilizer. According to Lomonaco et al. elia et al. and Lopes et al. [22-24] claims that the nutrients N, P, K, Ca, and Mg are present in Frass BSF and that it may be used as a natural fertilizer for farming.

5 Conclusion

Processing sheep farm waste by mixing milk processing industry sludge waste and organic kitchen waste, obtained aerobically by utilizing indigenous microorganism decomposers and BSF maggot detritivores, can reduce waste generation by 63,87% and produce BSF maggot biomass of 1042 ± 98.4631 grams and produced BSF Frass as much as 1,084 ± 55, 8345 grams, and BSF maggot has the potential to be a source of animal nutrition and BSF Frass has the potential to be used as organic fertilizer.

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