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SHORT COMMUNICATION

Changes in Decomposition Rate and Ammonia Content upon the Addition of Black Soldier Fly Larvae to Poultry and Cow Manures

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Abstract

In this study, decomposition ability and ammonia content changes were evaluated when 4th instar black soldier fly (BSF) larvae were added to poultry and cow manures. The experimental setup included two treatment groups with three repetitions, and the addition ratios were as follows: 1) poultry manure group, 200 g of poultry manure + 40 g of 4th instar BSF larvae and 2) cow manure group, 200 g of cow manure + 40 g of 4th instar BSF larvae. The decomposition ability of the 4th instar BSF larvae showed similar trends in both treatment groups for up to 6 days. However, subsequently, an increased decomposition ability was observed in the poultry manure group. Lower ammonia levels were detected in the cow manure group, whereas higher nitrogen content was observed in the poultry manure group. These results align with our expectations and provide a representative reflection of the specific characteristics of the two types of manure. In addition, addressing livestock manure issues by processing 4th instar BSF larvae with poultry manure instead of cow manure appears to be a more viable solution for resolving environmental problems arising from livestock farming.

Key words : Ammonia, Black soldier fly larvae, Cow manure, Decomposition ability, Poultry manure

1. Introduction

Livestock manure produced in areas with high concentrations of livestock can be, if managed well, a valuable source of nutrients for plants and a beneficial organic fertilizer when used as compost. However, if discarded into the soil, rivers, etc., without any countermeasures, they become a major cause of environmental pollution and a threat to public health (Strokal et al., 2016; Xie et al., 2018). Although Flotats et al. (2011) and Hou et al.(2017) presented various methods for treating livestock manure, factors such as high investment costs, low profitability, and a lack of understanding or social acceptance act as constraints on the adoption of new technologies. Thus, it is recommended to emphasize the significance of integrated solutions linking carbon neutrality with sustainable nutrient cycling, the importance of eco-friendly disposal methods utilizing the decomposition ability of black soldier fly larvae, and the critical need for pre-treatment of livestock manure to facilitate nutrient recycling. This is particularly relevant in light of national statistics, which indicate that close to 90% of livestock waste is self-managed, underscoring the necessity for practical and sustainable alternatives. Especially, an approach to achieving carbon neutrality involves improving the quality of livestock manure with black soldier

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fly (BSF) larvae is gaining attention as a method that offers environmental and social benefits. BSF larvae consume livestock manure and convert it into biomass needed by the larvae. This process is composed of several steps, starting with the first step of reducing particle size. Subsequently, livestock manure is treated by these larvae, and, finally, through a refining process, stable and sustainable composting is achieved (Dortmans et al., 2017). For these reasons, the use of BSF larvae grown on organic waste, such as livestock manure and food waste, as animal feed is a sustainable method for recycling potential resources (Schiavone et al., 2017). However, few studies have compared the addition of BSF larvae to various livestock manures.

In this study, changes in decomposition ability and ammonia content were measured by adding 4th instar BSF larvae to poultry and cow manures. The results of this study can be used to provide indicators for the environmental impact assessment of BSF larvae at each stage.

2. Materials and Methods

For the insect-rearing test, 4th instar BSF larvae were purchased from Circular Bio Co., Ltd. in Anseong, Gyeonggi-do, to evaluate their ability to decompose poultry and cow manures and their impact on ammonia content. The poultry and cow manures were supplied from a poultry farm in Uiseong, Gyeongsangbuk-do, and a Hanwoo farm in Yeongju, respectively, and used for the insect-rearing test. The BSF larvae were reared under the following conditions: 24°C temperature, 55% relative humidity, and a photoperiod of 16D:8L. The insect-rearing container was a rectangular transparent plastic box measuring 12 × 6 × 11 cm, and the lid had four holes drilled in two directions to allow for fresh air circulation. The treatment was designed with 2 treatment groups and 3 replications, and the addition rates were as follows.

Poultry manure group =
200 g of poultry manure + 40 g of 4^{th} instar BSF larvae
Cow manure group =
200 g of cow manure + 40 g of 4^{th} instar BSF larvae

The ability of 4th instar BSF larvae to decompose poultry and cow manures was measured and recorded by weighing every 3 days. Ammonia measurements were performed every 3 days by using a kit with an attached detector tube. Statistical analysis was performed using the SAS (Version 9.4) package program, with a two-tailed t-test. The significance of the mean differences between treatment groups was set at 95% level.

3. Results and Discussion

The results of adding 4th instar BSF larvae to poultry and cow manures on decomposition ability are presented in Table 1. On days 3, 9, 12, and 15, the decomposition ability of 4th instar BSF larvae showed a statistically significant difference between the poultry and cow manure treatment groups ($p<0.05$). When the decomposition ability of livestock manure was compared, both treatment groups showed similar trends up to day 6; later, a clear difference emerged, with the decomposition ability tending to increase in 4rd instar BSF larvae treated with poultry manure. These differences can be found in the nutrient content of poultry manure. Specifically, since BSF larvae, which are environmental remediation insects, only feed for growth during their larval stage and prefer poultry manure, which is more nutritious than cow

Table 1. Changes in the decomposition rate when adding Black soldier fly larvae to poultry and cow manure

Day	Treatment[1]		*p*-value
	Poultry manure group	Cow manure group	
0	240.00±0.00	240.00±0.00	-
3	236.67±0.33	239.33±0.33	0.0120
6	236.00±0.58	236.67±0.33	0.1896
9	229.67±0.33	234.67±0.33	0.0002
12	223.67±0.88	232.33±0.88	0.0011
15	217.00±1.15	228.00±0.58	$p<0.0001$

Data are expressed as mean± the standard error of the mean (SEM, $p<0.05$)
[1]Poultry manure group = 200 g of poultry manure + 40 g of 4th instar BSF larvae; Cow manure group = 200 g of cow manure + 40 g of 4th instar BSF larvae

Table 2. Changes in ammonia content (ppm) when adding Black soldier fly larvae to poultry and cow manure

Day	Treatment[1]		*p*-value
	Poultry manure group	Cow manure group	
0	154.81±0.03	38.63±9.28	$p<0.0001$
3	154.74±0.03	25.03±1.05	$p<0.0001$
6	155.07±0.04	50.32±3.93	$p<0.0001$
9	154.12±0.43	48.29±3.63	$p<0.0001$
12	152.12±0.88	52.05±0.78	$p<0.0001$
15	153.34±0.55	48.58±0.59	$p<0.0001$

Data are expressed as mean± the standard error of the mean (SEM, $p<0.05$)
[1]Poultry manure group = 200 g of poultry manure + 40 g of 4th instar BSF larvae; Cow manure group = 200 g of cow manure + 40 g of 4th instar BSF larvae

manure, their decomposition ability is considered to have increased. Generally, when compared with other livestock manure, the N:P:K ratio of laying hen manure is 6:2:2 and broiler bedding materials is 6:2:3 (Nicholson et al., 1998). According to the study by Lee et al.(2016), the elemental composition of cow manure is mostly carbon and oxygen, with C ranging from 35.72% to 45.68%, O from 29.48% to 50.43%, and N from 0.86% to 2.53%. This suggests that poultry manure has a higher nutrient content because the evaluation of organic fertilizers from livestock manure is based on nitrogen.

The results regarding ammonia production when 4th instar BSF larvae were added to poultry and cow manures are summarized in Table 2. During the experimental period, statistically significant differences were observed between the two treatment groups; these results are expected and can be considered typical data that reflect the characteristics of both livestock manures. The lower ammonia content in cow manure is due to its lower nitrogen content, which can be attributed to the differences in feed given to both livestock. In addition, the fact that 4th instar BSF larvae utilized nitrogen components in poultry manure more actively as a nutrient source than those in cow manure during the experimental period indirectly suggests that this may have contributed to the increase in ammonia concentration. Ultimately, it is assessed that treating livestock manure with 4th instar BSF larvae, rather than cow manure, may offer a viable solution to the environmental issues arising from livestock farms.

4. Conclusions

This study was conducted to investigate the decomposition rate and changes in ammonia content when BSF larvae were added to poultry and cow manures. The ability of BSF larvae to decompose livestock manure was similar for up to 6 days between the two treatment groups; thereafter, the decomposition ability of the 4th instar BSF larvae increased in the poultry manure group. Ammonia production was lower in the cow manure group, whereas nitrogen content was higher in the poultry manure group. These results are expected and can be considered typical data that reflect the characteristics of the two livestock manures. In conclusion, it is considered that using 4th instar BSF larvae to treat manure from poultry farms, rather than farming operations involving cow manure, could offer a viable solution to addressing environmental issues arising from livestock farming.

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