Effect of fermented laying hen manure and starter feed as growing media on black soldier fly larvae development

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Abstract. This study aimed to evaluate the development of Black Soldier Fly (BSF) larvae when reared on different feeding media, specifically using varying ratios of fermented laying hen manure and starter feed. The study employed a completely randomized design with five treatments and four replications. The treatments were as follows: T0: 100% fermented laying hen manure, T1: 75% fermented laying hen manure + 25% laying hen starter feed, T2: 50% fermented laying hen manure + 50% laying hen starter feed, T3: 25% fermented laying hen manure + 75% laying hen starter feed, and T4: 100% laying hen starter feed. Parameters measured in the study included larvae length and larvae width at 10 and 17 days. Data were analyzed using one-way analysis of variance followed by the Duncan post-hoc test. The study demonstrated that BSF larvae were successfully reared on growing media comprising 100% fermented laying hen manure (T0). However, the development of larvae in T0 remained relatively low. Notably, the use of laying hen starter feed particularly at 75% (T3) and 100% (T4) significantly improved ($P<0.05$) all larvae development parameters. It can be concluded that the Black Soldier Fly has significant potential as a bioconversion agent for laying hen manure. Moreover, the use of laying hen starter feed can be considered as a supplemental feeding media to enhance larvae development of Black Soldier Fly.

1 Introduction

The layer farms continue to face significant challenges in managing waste in the form of manure. Accumulated manure poses a considerable risk to animal health, which leads to the reduction of farm productivity [1]. Moreover, unproperly processed manure can also lead to environmental pollution [2]. The repercussions of this pollution have adverse effects on the environment, water sources, and can potentially cause health issues for communities [3]. This demands the development of sustainable solutions for the management of laying hen manure, striking a balance between farm productivity, environmental protection, and community welfare.

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Black Soldier Fly (BSF, *Hermetia illucens* L.) farming is a key aspect of organic waste management. BSF can be reared on various types of organic substrates, such as food and household waste, abattoir waste, as well as livestock manure [4]. BSF farming results in BSF larvae, which can be used as an alternative feed for various livestock [5]. Additionally, the residual media from BSF farming can serve as organic fertilizer [6]. Implementing BSF farming with manure as a feeding media is expected to foster circular economies in the laying hen farming sector.

One crucial factor affecting BSF larva development is the nutrient content in the feeding media. On one hand, the use of laying hen manure can help mitigate environmental pollution. However, it is suspected that using laying hen manure may not optimally support larval growth due to suboptimal nutrient content [7]. An approach to address this issue is by supplementing the substrate with media containing more comprehensive nutrients. The laying hen starter feed is one such feed with well-balanced nutrients [8]. The use of laying hen starter feed as a supplement on the laying hen manure is expected to optimize larval development. The information on the use of laying hen manure and starter feed mixture as a feeding media for BSF is currently not available in the literature. Therefore, this study aimed to evaluate the development of BSF larvae when reared on different feeding media, specifically using varying ratios of fermented laying hen manure and starter feed.

2 Materials and methods

2.1 Experimental design

The study employed a completely randomized design with five treatments and four replicates. The treatments were different feeding media, specifically using varying ratios of fermented laying hen manure and starter feed. The treatments were as follows: T0: 100% fermented laying hen manure, T1: 75% fermented laying hen manure + 25% laying hen starter feed, T2: 50% fermented laying hen manure + 50% laying hen starter feed, T3: 25% fermented laying hen manure + 75% laying hen starter feed, and T4: 100% laying hen starter feed.

2.2 Fermentation of laying hen manure

Laying hen manure was obtained from a local laying hen farm. A batch of 6 kg of laying hen manure was mixed with 2 liters of a 2.5% sugar solution. It was stirred until evenly distributed and then tightly sealed in a plastic container. The fermentation process was carried out for 3 weeks with stirring done every 3 days. After 3 weeks, it is aerated and used as a feeding medium for BSF larvae.

2.3 Hatching process of BSF eggs

The hatching medium was prepared by mixing 200 grams of rice bran with 200 ml of milk waste. This hatching medium was then placed in a plastic container. A plastic cup with a 5 cm diameter was placed in the center of the hatching medium. A total of 0.5 grams of BSF eggs were placed on top of the plastic cup, lined with tissue. BSF eggs were then left to hatch for 3-4 days. Once the BSF larvae have hatched, they will descend into the hatching medium. The larvae were then kept in the hatching medium up to 7 days of age.

2.4 Growing process of BSF larvae

After 7 days of age, larvae were transferred to the separate plastic container containing different feeding medium in accordance with the experimental treatment. A total of 250 g feeding media was added once a week. Additionally, 50 ml of milk waste was also poured into feeding media every two days. At 10 and 17 days of age, a total of 25 larvae were carefully collected from each replicate for the evaluation of larvae development.

2.5 Evaluation of BSF larvae development

Parameters measured in the study included larvae length at 10 days, larvae width at 10 days, larvae length at 17 days, and larvae width at 17 days. The larvae development was evaluated using a ruler with centimeter units.

2.6 Data analysis

Data were tabulated in Microsoft Excel Program. After that, statistical analysis was conducted using IBM SPSS Statistics 22. Data were analyzed using one-way analysis of variance followed by the Duncan post-hoc test. $P<0.05$ was considered as a significant difference.

3 Results and Discussion

Effect of feeding media consisting of varying ratios of fermented laying hen manure and starter feed on BSF larvae length and larvae width at 10 and 17 days are presented on Table 1. The study demonstrated that BSF larvae were successfully reared on growing media comprising 100% fermented laying hen manure (T0). In line with this finding, other studies also acknowledged the potential for rearing BSF larvae on chicken manure [9, 10]. The use of chicken manure as feeding media of BSF larvae is logical since manure serves as the primary food source for many insects in their natural habitat [11]. However, it is crucial to note that despite this success, the developmental progress of larvae in T0 was comparatively lower than that observed in other treatments. Previous studies also noted that the growth response BSF larvae under chicken manure growing medium was relatively modest [7, 12]. The apparent limitations in BSF larvae development on this feeding media may be attributed to deficiencies in essential nutrients or an imbalance in the overall nutritional profile. These findings emphasize the importance of optimizing feeding media to enhance the BSF larvae development.

Table 1 showed a promising result for enhancing BSF larvae development through the use of laying hen starter feed as feeding media. Notably, as the proportion of laying hen starter feed increased, so did the positive impact on various parameters of larvae development. In particular, the inclusion of 25% laying hen starter feed (T1) resulted in a significant improvement ($P<0.05$) in larvae length at 17 days. Moving forward, at 50% inclusion (T2), a more substantial enhancement was noted ($P<0.05$) in larvae length at both 10 and 17 days, as well as larvae width at 17 days. The most significant improvements were witnessed with T3 (75% laying hen starter feed) and T4 (100% laying hen starter feed), where all larvae development parameters exhibited substantial enhancements ($P<0.05$).

Table 1. Effect of feeding media composition on Black Soldier Fly larvae development[1]

Treatments	LL10 (cm)[3]	LW10 (cm)[3]	LL17 (cm)[3]	LW17 (cm)[3]
T0[2]	0.34[a]	0.11[a]	0.93[a]	0.22[a]
T1[2]	0.42[ab]	0.11[a]	1.06[b]	0.24[ab]
T2[2]	0.49[bc]	0.13[a]	1.16[c]	0.25[b]
T3[2]	0.56[c]	0.17[b]	1.18[c]	0.29[c]
T4[2]	0.65[d]	0.24[c]	1.49[d]	0.39[d]
SEM	0.027	0.012	0.043	0.014
P value	0.001	0.001	0.001	0.001

[1]Data were presented as means of four replicates and each replicate consisted of 25 larva length and width measurement
[2]T0: 100% fermented laying hen manure, T1: 75% fermented laying hen manure + 25% laying hen starter feed, T2: 50% fermented laying hen manure + 50% laying hen starter feed, T3: 25% fermented laying hen manure + 75% laying hen starter feed, T4: 100% laying hen starter feed
[3]LL10: larvae length at 10 days, LW10: larvae width at 10 days, LL17: larvae length at 17 days, LW17: larvae width at 17 days
[a-d]Different superscripts in the same column showed significant differences ($P<0.05$)

The utilization of laying hen starter feed is postulated to offer additional sources of protein. Chicken manure was reported to have a total Kjeldhal nitrogen of 2.28% which was equivalent to 14.25% of crude protein [9]. Whereas, laying hen starter feed containing 20.15% of crude protein [8]. Improvement of protein in the feeding media could contributing to the observed improvements in larval development. These findings align with previous research by Logan et al. [7], who reported similar positive effects when incorporating chicken meat and egg wastes into chicken manure, thereby promoting BSF larvae development. Widyaswara et al. [13] also reported improvements in BSF larvae development by adding organic household waste into chicken manure. Moreover, Schreven et al. [14] also noticed that supplementation of camelina oilseed press cake into chicken manure could improve BSF larvae development. The consistent pattern of positive outcomes across different studies underscores the robustness of the observed effects.

4 Conclusion

It can be concluded that the Black Soldier Fly has significant potential as a bioconversion agent for laying hen manure. Moreover, the use of laying hen starter feed can be considered as a supplemental feeding media to enhance larvae development of Black Soldier Fly. Further investigations into the economic feasibility of combining laying hen manure and starter feed as feeding media of Black Soldier Fly are warranted for a comprehensive understanding of its practical applications in waste management and alternative feed production.

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