JAPR

Vol. 03, Issue, 01, pp. 25-29, 29 March, 2026
https://doi.org/10.66553/japr.2026.116

RESEARCH ARTICLE

Effect of Black Soldier Fly Larvae Meal Inclusion on Broiler Chicken Growth Performance and Carcass Quality

Aftab Shaukat [a]*, Talat Bilal Yasoob [b], Zarak Khan [c],

[a] *College of Veterinary Medicine, South China Agricultural University, Guangzhou 510642, China.*
[b] *Department of Veterinary and Animal Sciences, Faculty of Livestock and Rangeland Management, Ghazi University, Dera Ghazi Khan, Pakistan.*
[c] *Department of Poultry Science, University of Agriculture Peshawar,25130, Khyber Pakhtunkhwa, Pakistan.*

ARTICLE INFO

Article History:
Received 2 *February*, 2026
Received in revised form 20 *February*, 2026
Accepted 27 *February*, 2026
Published online 29 *March*, 2026

Keywords:
Alternative protein
Broiler chicken
Carcass quality
Growth performance
Hermetia illucens

Corresponding authors: **Aftab Shaukat**
Email**:** dr.aftabshaukat@scau.edu.cn

ABSTRACT

A study was conducted to assess the effect of feeding graded inclusion of black soldier fly larvae meal (BSFLM; *Hermetia illucens*) on growth performance and carcass quality of broiler chickens. A total of 160 broiler chicks of Ross 308 strain were randomly allocated to four dietary treatments; each treatment contained 0% (control), 5% BSFLM, 10% BSFLM or 15% BSFLM, with 4 replicate pens for each treatment (n = 40 birds/treatment) and these were fed for 35 days. The growth performance parameters final body weight, average daily gain, feed intake, and feed conversion ratio were evaluated as were carcass traits, dressing percentage, breast meat yield, abdominal fat, and meat drip loss. The final body weight, average daily gain and feed conversion ratio remained unaffected by the inclusion of BSFLM at 5% and 10% of the control diet, establishing that BSFLM can be used to replace up to 50% of the soybean meal and fishmeal protein without any negative effects on growth performance. However, 15% inclusion significantly decreased the final body weight, average daily gain and increased feed conversion ratio compared with that of the control, indicating a threshold level where growth performance is negatively influenced by the inclusion of chitin and negative effect on amino acid digestibility at higher inclusion levels. Carcass quality was mostly preserved in the low to moderate levels of BSFLM inclusion, with a slight dose-dependent decrease in abdominal fat percentage as BSFLM inclusion increased, but a significant decrease in dressing percentage and breast meat yield was only found at the 15% inclusion level. Up to 10% of the protein in broiler diets can be replaced by BSFLM with no significant impact on growth performance and carcass quality, thus providing a sustainable protein source alternative.

1. Introduction

Soybean meal and fishmeal have been the main dietary protein sources for poultry in the world but the environmental impacts of soybean production (agriculture land use change and deforestation) and the unsustainable exploitation of wild fish stocks for fishmeal production have caused concern for the long-term sustainability of these traditional protein sources [1]. On top of these challenges, the rising demand for animal protein worldwide and the volatility of commodity and animal protein prices have further intensified the interest in the search for alternative, sustainable, and more competitive protein sources for animal protein production, such as livestock and poultry [2]. The nutritional composition, feed-conversion efficiency during rearing and the potential to use organic waste streams for insect feed production make insect meal a promising alternative protein source that supports circular economy [3]. However, the black soldier fly (Hermetia illucens) has gained significant interest as a feed insect species due to its ability to rapidly grow and convert a wide variety of organic by-products such as food waste and agricultural residues into high quality larval biomass, with the additional benefit of its high crude protein content (typically 40-45% on a dry-matter basis) and favourable amino acid profile [3,4].

Black soldier fly larvae meal (BSFLM) despite its nutritional benefits, has a relatively high chitin content, which is present in the exoskeleton, thus digestibility and impacts on nutrient utilization and growth performance at higher inclusion rates have been a concern [5]. Chitin is a poorly-digestible structural polysaccharide that can negatively affect protein digestibility and gut morphology, and nutrient absorption, if included at high enough levels, but the practical limit of inclusion where these effects become apparent is an active area of research [6].

There are a number of reports on the performance of broilers with BSFLM, but the optimum inclusion rates range greatly, perhaps due to variations in processing methods of BSFLM (defatting and/or drying) as well as basal diet formulation and broiler strain [4,5,7,8]. This study is designed to systematically assess the effects of various levels of BSFLM inclusion (0%, 5%, 10% and 15%) on growth performance and carcass quality of broilers, to establish a practical level of inclusion that allows to preserve the growth performance of the broilers while maximizing the use of conventional protein sources.

2. Materials and Methods

2.1. Plant Material and Growing Conditions

A total of 160 one-day-old male Ross 308 broiler chicks were bought from a commercial hatchery, individually weighed and randomly distributed among the four dietary treatments in a completely randomized design with four replicate pens (floor, nest) with ten birds per pen (n = 40 broilers/treatment). Birds were housed in the environmentally controlled facility and kept on wood-shaving litter with ad libitum feed and water supplies and a standard temperature and lighting program for 35 days (starter phase: 1–10 days; grower phase: 11–24 days; and finisher phase: 25–35 days).

2.2 Dietary Treatments

Black soldier fly larvae were reared on a standardized organic substrate, collected at the prepupal stage, oven dried, defatted and milled to meal, before formulation of the diets. The four isonitrogenous and isocaloric diets were designed to incorporate 0% (T0) (control), 5% (T1), 10% (T2) and 15% (T3) BSFLM, respectively, of the total content of digestible AA of soybean meal and fishmeal in each feeding phase. The diet formulations and the levels of inclusion for BSFLM are summarized as shown in Table 1.

2.2 Growth Performance Measurements

Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR = feed intake / weight gains) were determined weekly for individual body weights and weekly for feed intake per pen and overall for the 35-day trial. Mortality was daily and used to adjust feed conversion calculations.

Table 1. Dietary treatment groups and black soldier fly larvae meal (BSFLM) inclusion levels used in the 35-day broiler feeding trial.

Treatment	BSFLM Inclusion (% of diet)	Soybean/Fishmeal Replaced (%)	Birds per Treatment (n)
T0 (control)	0%	0	40 (4 pens × 10)
T1	5%	25	40 (4 pens × 10)
T2	10%	50	40 (4 pens × 10)
T3	15%	75	40 (4 pens × 10)

2.4 Carcass Quality Assessment

Eight birds (two in each pen), whose body weight was similar to the pen average, were selectively slaughtered for each treatment at day 35 after feed-withdrawing for 8 hours, weighing, and slaughtering the birds under standard commercial procedures. Carcass weight was measured to obtain dressing percentage and breast muscle (pectoralis major and minor) was dissected and weighed to calculate the yield of breast muscle as a % of live weight. Abdominal fat pad weight was expressed as percentage of live weight and meat drip loss was determined on breast fillet sample after 48 hours of refrigeration.

2.5 Statistical Analysis

One-way analysis of variance (ANOVA) was used to analyses the data, diet being the main effect and pen the unit of experiment for performance data. Tukey's Honestly Significant Difference (HSD) was used to separate means for treatment where $p \leq 0.05$. Increasing levels of BSFLM were contrasted using polynomial contrasts to determine the linear and quadratic effects. Data are expressed as mean

± standard error (SE) and means with different superscript letters in a column are statistically different.

3. Results

3.1 Growth Performance

There were no significant differences in final body weight, average daily gain, or feed conversion ratio in either the control (T0) or the 5% (T1) or 10% (T2) BSFLM inclusion treatments after 35 days ($p > 0.05$). On the other hand, birds with 15% BSFLM diet (T3) had significantly lesser final body weight (2,289 ± 38 g) and ADG (54.1 ± 0.9 g/day) than the control (2,415 ± 32 g and 57.5 ± 0.8 g/day, respectively), and were also significantly poorer at FCR (1.87 ± 0.04 vs. 1.71 ± 0.03), although they had a slightly higher, but non-significant, feed intake. The polynomial contrast analysis showed that the final body weight and FCR were both significantly affected by the linear and quadratic effects of BSFLM inclusion level, suggesting that both maintained the same performance level at low- to moderate levels before decreasing at the highest level of inclusion. Summary of the growth performance results is given in Figure 1 and 2.

Figure 1 and 2. Growth performance of broiler chickens fed graded levels of black soldier fly larvae meal (BSFLM) over a 35-day feeding trial.

Fig 1.

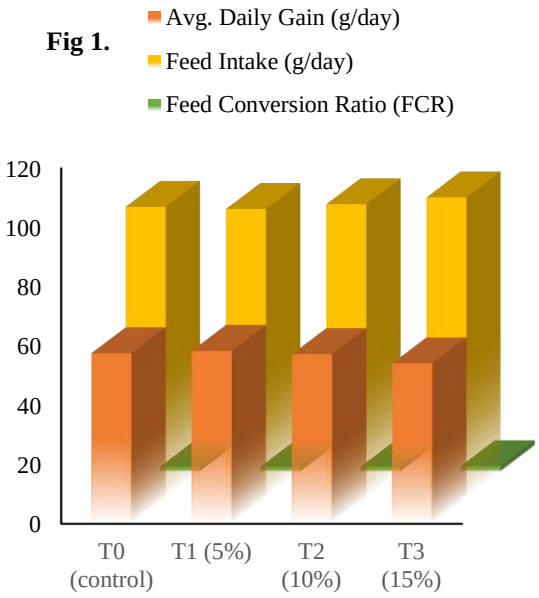
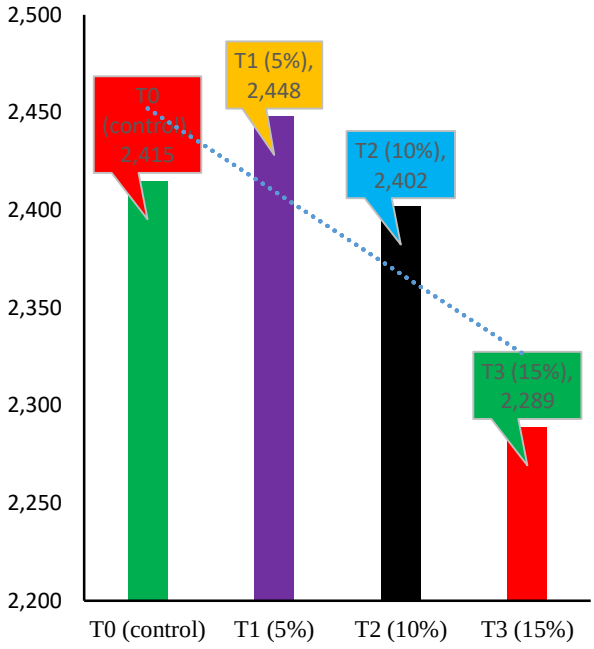


Fig 2. Final Body Weight (g)



3.2 Carcass Quality

Dressing percentage and breast meat yield were not significantly affected by the 5% and 10% BSFLM treatments compared to the control, but were significantly lower with the 15% inclusion treatment. As BSFLM inclusion rate increased, the reduction in abdominal fat percentage was dose-dependent, where the 10% and 15% levels of inclusion significantly reduced abdominal fat compared to the control, possibly due to the comparatively lower fat content of the defatted BSFLM compared to the protein source that it replaced. There were no significant differences in meat drip loss. The carcass quality results are given in Table 2 and Figure 3.

Figure 3. Dressing Percentage (%)

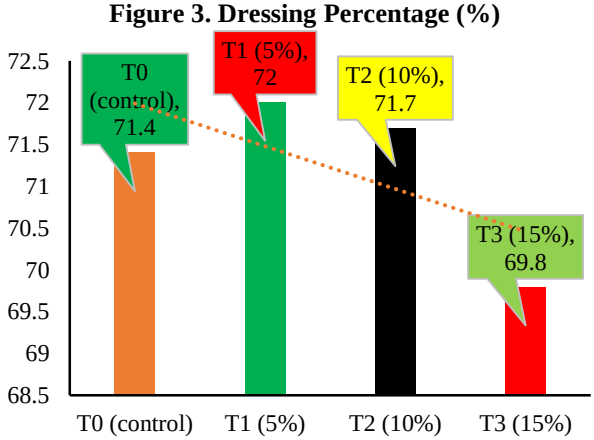


Table 3. Carcass quality traits of broiler chickens fed graded levels of black soldier fly larvae meal (BSFLM) at day 35 (mean ± SE, n = 8 birds/treatment). Different superscript letters within a column indicate significant differences (Tukey's HSD, $p \leq 0.05$).

Treatment	Breast Meat Yield (%)	Abdominal Fat (%)	Meat Drip Loss (%)
T0 (control)	21.8 ± 0.5^{a}	1.92 ± 0.10^{a}	3.1 ± 0.2^{a}
T1 (5%)	22.3 ± 0.4^{a}	1.78 ± 0.09^{ab}	2.9 ± 0.2^{a}
T2 (10%)	21.9 ± 0.5^{a}	1.61 ± 0.08^{b}	2.8 ± 0.2^{a}
T3 (15%)	20.4 ± 0.6^{b}	1.55 ± 0.09^{b}	3.4 ± 0.3^{a}

4. Discussion

Based on the findings of this study, replacing up to 50 % of soybean meal and fishmeal protein fraction (corresponding to 10 % of dietary inclusion) with black soldier fly larvae meal in broiler diets could be a good option for sustainable alternative protein source [6, 8]. This result agrees with other reports in which BSFLM, after correct processing (drying and defatting), and formulated on digestible amino acid basis, was found as a nutritionally sound protein source for broiler chickens when including at moderate percentage [9,10].

The large reduction in growth performance at 15% inclusion level is most likely due to the high overall chitin load from the higher BSFLM inclusion. The chitin present in the larva exoskeleton is poorly digested by the monogastric digestive system of poultry, and has been shown to decrease nutrient digestibility and protein utilization, and, at high enough levels, adversely affects gut morphology and the dynamics of microbial fermentation [11]. The decreased feed efficiency at 15% inclusion, which occurred at a similar or higher feed intake compared to the other treatments, supports the idea that the nutrient digestibility and utilization was reduced, not the palatability of the feed [12].

It is interesting to note that with the inclusion of BSFLM in the diet, the abdominal fat percentage reduced with the dose, which has commercial importance as the excessive deposition of abdominal fat is generally considered an undesirable carcass characteristic in broiler production [4]. This decrease could be due to the different fatty acid composition and/or energy level of defatted BSFLM compared to the soybean meal and fishmeal that it replaced, but additional studies of the physiology of lipid metabolism and fatty acid deposition would be required to fully understand the reasons for this reduction [11,12].

Reductions in dressing percentage and breast meat yield at the 5% and 15% inclusion levels are probably more a reflection of the general growth performance impairment at those inclusion levels than a direct effect of the inclusion on the carcass as breast meat yield is closely associated with overall body weight and lean tissue accretion. Taken together, the results confirm that 10% dietary level is a practical maximum for BSFLM when using this dietary protein source in broiler diets, as above this amount growth performance will be sacrificed [12].

This study evaluated a single BSFLM processing method (oven-dried, defatted) and a single broiler strain over a standard 35-day production cycle; different processing methods (e.g., enzymatic chitin reduction, fermentation) or broiler genetics could alter the inclusion threshold at which negative effects emerge [13]. Additionally, this study did not directly assess nutrient digestibility, gut morphology, or intestinal microbiota composition, which would provide mechanistic insight into the cause of reduced performance at higher inclusion levels. Future studies should incorporate digestibility trials, gut health assessments, and economic feasibility analyses to further refine practical recommendations for BSFLM inclusion in commercial broiler production [12].

5. Conclusion

This study demonstrates that black soldier fly larvae meal can be included in broiler diets at up to 10% (replacing approximately 50% of soybean meal and fishmeal protein) without compromising growth performance or carcass quality, while providing the additional benefit of reduced abdominal fat deposition. Inclusion at 15% significantly impaired growth performance and select carcass traits, likely due to elevated dietary chitin content and reduced nutrient digestibility. These findings support BSFLM as a nutritionally viable and sustainable alternative protein source for broiler production at moderate inclusion levels, contributing to the diversification of poultry feed ingredients and the reduction of reliance on conventional soybean- and fishmeal-based protein sources.

Funding

This research received no external funding.

Declaration of conflict of interest

All authors hereby declared that, there were no conflict of interest was so ever.

References

[1]. Cullere, M., Tasoniero, G., Giaccone, V., Miotti-Scapin, R., Claeys, E., De Smet, S., & Dalle Zotte, A. (2016). Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits. Animal, 10(12), 1923–1930.

[2]. Fu, C., Cheema, W. A., Mobashar, M., Shah, A. A., & Alqahtani, M. M. (2025). Insects as Sustainable feed: Enhancing animal nutrition and reducing livestock environmental impression. *Journal of animal physiology and animal nutrition*, *109*(2), 280-290.

[3]. Dabbou, S., Gai, F., Biasato, I., Capucchio, M. T., Biasibetti, E., Dezzutto, D., ... & Gasco, L. (2018). Black soldier fly defatted meal as a dietary protein source for broiler chickens: Effects on growth performance, blood traits, gut morphology and histological features. Journal of Animal Science and Biotechnology, 9(1), 49.

[4]. Maurer, V., Holinger, M., Amsler, Z., Fruh, B., Wohlfahrt, J., Stamer, A., & Leiber, F. (2016). Replacement of soybean cake by Hermetia illucens meal in diets for layer hens. Journal of Insects as Food and Feed, 2(2), 83–90.

[5]. Fu, C., Shah, A. A., Alissa, M., Alsuwat, M. A., Ullah, S., Khan, M. S., & Zaman, A. (2024). Exploring the potential of insect gut microbes for advancing renewable energy production. *Journal of Applied Entomology*, *148*(8), 928-937.

[6]. Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., Bergagna, S., ... & Dalle Zotte, A. (2017). Partial or total replacement of soybean oil by black soldier fly larvae (Hermetia illucens L.) fat in broiler diets: effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. Italian Journal of Animal Science, 16(1), 93–100.

[7]. Shah, A. A., Totakul, P., Matra, M., Cherdthong, A., Hanboonsong, Y., & Wanapat, M. (2022). Nutritional composition of various insects and potential uses as alternative protein sources in animal diets. *Animal Bioscience*, *35*(2), 317.

[8]. Sedgh-Gooya, S., Torki, M., Darbemamieh, M., Khamisabadi, H., & Abdolmohamadi, A. (2021). Black soldier fly, Hermetia illucens (Diptera: Stratiomyidae) larvae used as an alternative protein source in the diet of broiler chickens: A review. Journal of Applied Animal Research, 49(1), 358–366.

[9]. van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., & Vantomme, P. (2013). Edible Insects: Future Prospects for Food and Feed Security (FAO Forestry Paper 171). Food and Agriculture Organization of the United Nations.

[10]. Mohammad, S. F., Shah, A. A., Wanapat, M., El-Mogy, M. M., Al-Hoshani, N., & Alyami, E. M. (2026). Utilizing insects to convert waste into nutrients for sustainable feed and food production. *Entomological Research*, *56*(2), e70105.

[11]. Bingqian, N., Ali Shah, A., Matra, M., Wanapat, M., Ullah Khan, R., Ahmad, S., ... & Kamal Shah, M. (2023). Insect bioactive compounds and their potential use in animal diets and medicine. *Entomological Research*, *53*(11), 429-443.

[12]. Bingqian, N., Shah, A. A., Ullah, S., Khan, R. U., Khan, M. S., Zaman, A., & Muhammad, K. (2024). Exploring the role of insects as sustainable feed in aquaculture nutrition and enhancing antioxidant capacity, growth and immune response. *Turkish Journal of Fisheries and Aquatic Sciences*, *24*(5).

[13]. Fu, C., Shah, A. A., Alissa, M., Alsuwat, M. A., Ullah, S., Khan, M. S., & Zaman, A. (2024). Exploring the potential of insect gut microbes for advancing renewable energy production. *Journal of Applied Entomology*, *148*(8), 928-937.