



Evaluation of Innovative Approaches to Monogastric Animal Nutrition: Insect Larvae Inclusion in Feed

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Abstract

This study was conducted to evaluate the effects of Black Soldier Fly Larvae Meal (BSFLM) as a replacement for conventional protein source on the growth performance and carcass characteristics of broiler chickens over a 42-day feeding period. A total of broiler chickens were randomly allotted to five dietary treatments designated T1, T2, T3, T4 and T5, representing 0%, 25%, 50%, 75% and 100% replacement of the conventional protein source with BSFLM, respectively. The experimental diets were fed to the birds from day 1 to day 42. Growth performance parameters evaluated included initial body weight, final body weight, weight gain, average daily weight gain, feed intake, average daily feed intake and feed conversion ratio, while carcass characteristics assessed included live weight, slaughter weight, de-feathered weight, carcass weight, dressing percentage and relative weights of selected carcass parts. The results showed that initial body weight did not differ significantly among the treatment groups. However, final body weight, total weight gain, average daily weight gain and feed conversion ratio were significantly affected by dietary treatment. Birds fed T5 (100% BSFLM replacement) recorded the highest final body weight (1990.00 g), weight gain (1792.50 g) and average daily weight gain (42.68 g), while T3 recorded the lowest values for these parameters. Feed intake and average daily feed intake were not significantly affected by dietary treatment. The best feed conversion ratio was recorded in T5 (2.18), compared with 2.42, 2.38, 2.44 and 2.40 for T1, T2, T3 and T4, respectively. Carcass evaluation showed significant differences in live weight, slaughter weight and de-feathered weight, with birds on T5 recording the highest values. Carcass weight, dressing percentage, head, breast, thigh, wing, neck, shank and back percentages were not significantly affected by dietary treatment, except drumstick percentage, which differed significantly among treatments. The study concluded that BSFLM can serve as an effective alternative protein source in broiler diets. Under the conditions of the present 42-day study, complete replacement of the conventional protein source with BSFLM resulted in superior growth performance and feed utilization while maintaining generally comparable carcass characteristics. The use of BSFLM may therefore contribute to reducing dependence on conventional protein ingredients and provide a potentially sustainable alternative for broiler production.

Keywords: Black Soldier Fly Larvae Meal, unconventional, growth performance, carcass.

1.0 Introduction

With the escalating global population, feed resource scarcity has intensified, particularly for protein sources where traditional ingredients face biological and geopolitical constraints. As traditional protein sources approach ecological carrying capacity thresholds, the FAO's projections of accelerating feed demand expose critical vulnerabilities in monoculture-dependent production systems. The current crisis is further exacerbated by the metabolic constraints of livestock species when it comes to utilizing plant-derived proteins (Khalifah *et al.*, 2023).

Animal products supplied 31 % of dietary protein and 15 % of the global food energy. The consumption of animal products is increasing in line with the global population and average lifespan, which has serious implications for the resources, socioeconomic development, and ecological sustainability of the world (Godde *et al.*, 2021). It is also becoming increasingly clear that the animal production system should improve its efficiency and environmental sustainability to keep up with the increasing demand (Willett *et al.*, 2019., Bruinsma, 2003., Thornton, 2021).

High feed cost particularly from conventional protein sources such as soybean meal and fishmeal account for 60 – 70% of the total cost of production expenses and threaten sustainability (Ayieko *et al.*, 2023). This challenge has increased interest in alternative, affordable, locally available protein sources.

75 % of all species on Earth are made up of insects, which are one of the most potential sources of sustainable protein for satisfying protein demand while minimizing environmental impact and resolving the worldwide problem of animal feed production (Jantzen *et al.*, 2020., Khan, 2018). The majority of insects are rich in nutrients and are also a natural food source for many animals (Orkusz , 2021). They can be used as a supplement to traditional feed sources such as soy, corn, wheat, and fishmeal (FM) to help animals get the nutrients they need (van Raamsdonk, 2017).

Black soldier fly larvae meal ((*Hermetia illucens* larvae, BSFLM) has emerged as a promising option due to its high crude protein content (40 – 60%) and balanced essential amino acid profile, making it suitable for monogastric diets (Chia *et al.*, 2024). In addition to its nutritional value, the larvae can be reared on organic waste, contributing to environmental sustainability and circular bio economy systems (Moretti *et al.*, 2024).

Studies indicate that BSFLM can maintain growth performance, nutrient utilization, feed efficiency, gut efficiency, and gut health in broilers without adverse effects, reducing reliance on imported protein sources (Ayieko *et al.*, 2023).

In recent years, insect resources have gained attention as a nutritious, environmentally friendly and low-cost animal feed ingredient. Research on the numerous varieties of insects has increased, and the worldwide insect farming sector is rapidly expanding (Buzz, 2023). Therefore, this study was conducted to evaluate the effect of black soldier fly larvae meal-based diet on the growth performance, and carcass characteristics of broiler chickens.

2.0 Materials and Methods

2.1 Experimental Site

The study was conducted at the experimental site of the School of Agriculture, Federal Polytechnic Wannune, Benue State. Wannune is located within the Guinea Savannah zone of West Africa at latitude 7°23' North and longitude 9°10' East. The area is characterized by about 6-7 months of rainfall, the annual rainfall ranges from 1350-1400mm. the ambient temperature is highest around March and ranges from 34-36°C. The lowest mean monthly temperature range of 26-28°C occur around January. The relative humidity is highest between August/September and lowest in January/February. Average radiation received is lowest in August and highest in April (GPS). The research was carried out in an open-sided, deep-litter poultry house that was thoroughly cleaned and disinfected two weeks prior to the arrival of the experimental birds to ensure optimal hygienic conditions, following standard biosecurity protocols as described by Adene and Oguntade (2019). The poultry house was well-ventilated and equipped with linear feeders and bell-type drinkers.

2.2 Experimental Birds and Management

A total of 240-day-old broiler chicks were purchased from a reputable commercial hatchery and used for the experiment. On arrival, the chicks were weighed individually to obtain their initial body weights and randomly distributed into five dietary treatment groups. Each treatment consisted of 48 birds.

The birds were housed in a well-cleaned, disinfected and properly ventilated poultry house. The experimental house was thoroughly washed and disinfected before the commencement of the experiment. Wood shavings were used as litter material and were maintained in a clean and dry condition throughout the experimental period.

The chicks were provided with adequate feed and clean drinking water ad libitum throughout the 42-day experimental period. Appropriate brooding temperature was maintained during the brooding stage and gradually reduced as the birds grew. Routine management practices, including litter management, cleaning of drinkers and feeders, and general observation of the birds, were carried out throughout the experiment. Vaccination and other preventive health measures were administered according to the recommended broiler management program.

2.3 Experimental Design

The experiment lasted for **42 days** and was conducted using a Completely Randomized Design (CRD). The 240 day-old chicks were randomly allocated to five dietary treatment groups, with 48 birds per treatment. Figure 1 presents the experimental distribution of broiler chickens across the five dietary treatments used in the study. A

total of 240 birds were randomly assigned to five treatment groups (T1–T5), with 48 birds allocated to each treatment. The treatments represented different replacement levels of the conventional protein source with Black Soldier Fly Larvae Meal (BSFLM), ranging from 0% BSFLM inclusion (control group) to 100% BSFLM replacement. This experimental arrangement allowed the effect of increasing BSFLM inclusion levels on growth performance and carcass characteristics of broiler chickens to be evaluated over the feeding period.

Treatment	BSFLM Replacement Level	Number of Birds
T1	0% BSFLM (Control)	48
T2	25% BSFLM replacement	48
T3	50% BSFLM replacement	48
T4	75% BSFLM replacement	48
T5	100% BSFLM replacement	48
Total	–	240

Figure 1: Experimental Treatment Allocation and Black Soldier Fly Larvae Meal (BSFLM) Replacement Levels

The birds were randomly assigned to the treatments to ensure that each bird had an equal chance of receiving any of the experimental diets.

2.4 Experimental Diets

Table 1 presents the formulation of the broiler finisher diets containing graded replacement levels of the conventional protein source with Black Soldier Fly Larvae Meal (BSFLM). The dietary treatments ranged from T1 (0% BSFLM, control diet) to T5 (100% BSFLM replacement). Progressive inclusion of BSFLM resulted in a gradual reduction in soybean contribution and a corresponding increase in BSFLM inclusion. The calculated nutrient composition showed that crude protein and metabolizable energy increased slightly with increasing BSFLM inclusion, indicating the potential of BSFLM as a protein-rich alternative ingredient in broiler finisher diets.

Table 1: The Composition (%) of Broiler Finisher Diets

Experimental Diets					
Ingredients	T₁(0%)	T₂ (25%)	T₃ (50%)	T₄ (75%)	T₅
(100%)					
Maize	59.07	56.12	54.35	50.75	
50.25					
Soybeans	30.88	25.00	17.55	9.68	-
BSFLM	-	8.33	17.55	29.03	
39.20					
Fish Meal	1.50	1.50	1.50	1.50	1.50
Maize Bran	2.00	2.00	2.00	2.00	2.00
Rice Offal	3.00	3.00	3.00	3.00	3.00
Bone Meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00
Common Salt	0.30	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	
100.00					
Calculated Nutrients					
Crude protein	20.19	20.82	21.38	21.71	
21.98					
ME kcal/kg	3210.68	3238.40	3275.10	3244.40	
3296.30					
Crude fibre	3.70	3.75	3.91	4.16	4.23
Calcium	0.76	0.90	1.09	0.94	1.00
Phosphorus	0.60	0.62	0.64	0.65	0.65
Lysine	1.12	1.00	0.92	0.96	0.98
Methionine	0.54	0.57	0.60	0.66	0.70

Composition of vitamin premix per kg of die: vitamin A, 12500 I.U; vitamin E, 400mg; vitamin K, 2mg; vitamin B1, 3mg; vitamin B2, BSLFM; Black Soldier Fly Larvae Meal.

2.5 Black Soldier Fly Larvae Meal

Black Soldier Fly Larvae (BSFL) were obtained from an established source and processed into larvae meal for incorporation into the experimental diets. The larvae were harvested, cleaned to remove adhering substrate, and processed appropriately before being milled into meal. The processed BSFLM was stored in clean, dry and airtight containers until required for diet formulation.

Representative samples of the BSFLM and experimental diets were retained for proximate analysis to determine their nutrient composition.

2.6 Growth Performance Trial

After a one-week acclimatization period, initial body weights were recorded on day 7, and experimental diets were fed from day 7 to day 42. Feed and water were provided *ad libitum*, and performance parameters including feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) were calculated.

2.7 Carcass Evaluation

At the end of the 42-day feeding trial, representative birds were selected from each treatment for carcass evaluation. The selected birds were weighed individually to obtain their live weights and were then humanely slaughtered following standard poultry slaughter procedures.

After slaughter, the birds were allowed to bleed properly. They were subsequently scalded and defeathered. The defeathered carcasses were weighed to obtain the defeathered weight. The carcasses were eviscerated and the carcass weights were recorded.

The head, breast, thigh, drumstick, wing, neck, shank and back were separated and weighed. Their relative weights were expressed as percentages of the live body weight or carcass weight, according to the adopted experimental procedure.

2.8 Statistical Analysis

All data collected on growth performance parameters including weight gain, feed intake, and FCR were subjected to a one-way Analysis of Variance (ANOVA) using SPSS Statistics version 25.0. Where significant differences were observed, means were separated using Duncan's New Multiple Range Test. Statistical significance was declared at $p < 0.05$, and all results were presented as means $\pm$ standard error of the mean.

3.0 Results and Discussion

3.1 Discussion of Growth Performance of Broiler Chickens Fed BSFLM-Based Diets

The initial body weights of the broiler chickens ranged from 197.50 to 210.00 g and did not differ significantly among the treatment groups. The relatively similar initial weights indicate that the birds were reasonably homogeneous at the beginning of the experiment, thereby providing a suitable basis for evaluating the effects of dietary BSFLM on subsequent growth performance. Similar experimental approaches have been used in BSFLM studies to ensure that differences observed at the end of the feeding period are attributable primarily to dietary treatments rather than initial body-weight differences (Kirimu *et al.*, 2023).

Final body weight differed significantly among the treatment groups. Birds fed T₅, in which BSFLM completely replaced the conventional protein source, recorded the highest final body weight (1990.00 g), while T₃ recorded the lowest value (1799.46 g). The significantly greater final weight obtained in T₅ indicates that the birds were able to utilize the nutrients supplied by the BSFLM-based diet effectively. This finding agrees with Kirimui *et al.* (2023), who evaluated 0, 25, 50, 75 and 100% replacement of soybean meal with BSFLM and reported that birds

receiving complete replacement recorded a relatively high overall body weight. The authors concluded that BSFLM could partially or completely replace soybean meal in broiler diets.

The result, however, differs from the findings of Facey *et al.* (2022), who observed that increasing BSFLM replacement beyond 50% reduced body weight and weight gain and increased FCR in broilers. Their study reported that birds receiving 50 and 100% BSFLM had lower overall weight gain than those receiving lower replacement levels. The difference between their findings and the present study may be associated with differences in the nutritional composition of the BSFLM, processing method, larval rearing substrate, broiler strain, dietary formulation and the extent to which amino acid and energy requirements were met. The nutrient composition of BSFLM can vary considerably depending on the substrate on which the larvae are reared and their stage of development (Baderuddin *et al.*, 2024).

Weight gain followed a similar pattern to final body weight. Birds in T₅ recorded the highest weight gain (1792.50 g), which was significantly greater than the values recorded in T₁–T₄. The superior weight gain in T₅ suggests that complete replacement with BSFLM supported efficient deposition of body tissue. Kirimi *et al.* (2023) similarly reported satisfactory growth when BSFLM replaced soybean meal, including at complete replacement. In contrast, Facey *et al.* (2022) reported depressed weight gain at 50 and 100% replacement, indicating that the response to BSFLM may depend strongly on the characteristics of the BSFLM and the formulation of the experimental diets.

Average daily weight gain also differed significantly among treatments, with T₅ recording the highest value (42.68 g/day), compared with 38.49, 38.90, 38.08 and 38.74 g/day in T₁, T₂, T₃ and T₄, respectively. The increased daily weight gain in T₅ is consistent with its higher final body weight and total weight gain. The result suggests that the complete BSFLM-based diet was capable of supplying adequate nutrients for tissue growth throughout the 42-day experimental period. BSFLM contains substantial protein and energy, although its nutritional value varies according to processing and rearing substrate (Baderuddin *et al.*, 2024).

Feed intake was not significantly affected by dietary treatment. Total feed intake ranged from 3895.85 to 3909.10 g, while average daily feed intake ranged from 92.76 to 93.07 g/day. The similarity in feed consumption among the treatments indicates that incorporation of BSFLM did not negatively affect palatability or voluntary feed consumption under the conditions of the present study. This observation is partly consistent with Baderuddin *et al.* (2024), who reported that inclusion of up to 12% BSFLM did not reduce feed intake in broilers. Similarly, Cömert Acar *et al.* (2024) reported no significant effect of a BSF-containing diet on total feed consumption and feed conversion in broilers.

The absence of significant differences in feed intake is particularly important because the superior growth of T₅ was not accompanied by increased feed consumption. Therefore, the greater weight gain observed in T₅ appears to have resulted from more efficient utilization of the consumed feed rather than increased feed intake.

Feed conversion ratio differed significantly among treatments. The best FCR was recorded in T₅ (2.18), whereas T₁, T₂, T₃ and T₄ recorded 2.42, 2.38, 2.44 and 2.40, respectively. The lower FCR in T₅ indicates that birds fed the complete BSFLM diet required less feed to produce a unit of body-weight gain. Since feed intake was statistically similar among treatments while T₅ had considerably greater weight gain, the improvement in FCR is biologically consistent with the observed growth response.

This finding is comparable with the report of Kirimi *et al.* (2023), who demonstrated that BSFLM could be used as a replacement for soybean meal without compromising broiler performance. However, it contrasts with Facey

et al. (2022), who found that increasing BSFLM replacement increased FCR, particularly at 50 and 100% replacement. The contrasting findings further emphasize that the response of broilers to high levels of BSFLM may depend on the quality of the larvae meal and the overall nutrient balance of the diets.

A recent study by Abdel-Wareth *et al.* (2026) also demonstrated that increasing BSFLM replacement of soybean meal could negatively affect body weight, weight gain and FCR at higher replacement levels, although moderate replacement produced satisfactory responses. The fact that the present study recorded the best performance at 100% replacement may therefore indicate that the BSFLM used in the present experiment had suitable nutritional characteristics or that the experimental diets were appropriately formulated to compensate for possible nutrient limitations.

Overall, the growth-performance results indicate that T₅ (100% BSFLM replacement) produced the best growth response and feed utilization efficiency, without significantly increasing feed consumption. The findings demonstrate the potential of BSFLM as an alternative protein ingredient for broiler chickens. However, the marked differences between studies indicate that the optimum level of BSFLM cannot be generalized and may depend on larval substrate, processing method, nutrient composition, dietary formulation, bird strain and feeding duration. Table 2 shows that the initial body weights were relatively comparable across treatments.

Table 2: Broiler Performance of Broiler Chickens Fed Black Soldier Fly Larvae Meal-Based Diet (1-42 Days)

Parameters	T ₁ (0%)	T ₂ (25%)	T ₃ (50%)	T ₄ (75%)	T ₅ (100%)	SEM
Initial Weight (g)	200.00	197.50	200.00	210.00	197.50	
	2.85					
Final Weight (g)	1816.50 ^b	1831.15 ^b	1799.46 ^b	1837.19 ^b	1990.00 ^a	24.01
Weight Gain (g)	1616.50 ^b	1633.65 ^b	1599.46 ^b	1627.19 ^b	1792.50 ^a	24.81
Average Weight Gain	38.49 ^b	38.90 ^b	38.08 ^b	38.74 ^b	42.68 ^a	0.59
Feed Intake (g)	3906.30	3895.85	3898.58	3900.15	3909.10	
	4.04					
Average Feed Intake	93.01	92.76	92.82	92.86	93.07	0.09
FCR	2.42 ^b	2.38 ^b	2.44 ^b	2.40 ^b	2.18 ^a	0.04

^{a, b and c} Mean across rows with different superscripts differ significantly at P<0.05; FCR: Feed Conversion Ratio, SEM: Standard Error of Mean.

3.2 Discussion of Carcass Characteristics

The carcass characteristics of broiler chickens fed BSFLM-based diets are presented in Table 3. Live weight followed the same trend observed for final body weight in Table 3. Birds in T₅ recorded the highest live weight (1990.00 g), which was significantly greater than the values obtained in T₁–T₄. This finding is expected because live weight at slaughter generally reflects the cumulative growth response of the birds during the feeding period. The result is consistent with the superior weight gain recorded by T₅.

Slaughter weight also differed significantly among treatments, with T₅ recording the highest value (1908.44 g), while T₃ recorded the lowest value (1717.90 g). The higher slaughter weight of T₅ is consistent with its higher final and live body weights. Kiriimi *et al.* (2023) also investigated slaughter and carcass characteristics of broilers fed 0–100% BSFLM replacement diets and demonstrated the potential of BSFLM to support acceptable carcass production.

De-feathered weight differed significantly among treatments. T₅ recorded the highest de-feathered weight (1842.60 g), whereas T₃ had the lowest value (1652.06 g). The higher de-feathered weight observed in T₅ corresponds with its greater slaughter weight. This suggests that the enhanced growth associated with the T₅ diet was retained following removal of the feathers.

Carcass weight ranged from 1176.65 g in T₃ to 1242.85 g in T₅, but the differences were not significant. Although T₅ had the highest numerical carcass weight, the absence of statistical significance indicates that BSFLM replacement did not substantially alter absolute carcass weight. This observation is in agreement with Baderuddin *et al.* (2024), who found no significant differences in carcass percentage among broilers receiving control and BSFLM diets.

Dressing percentage was not significantly affected by dietary treatment and ranged from 62.45% in T₅ to 66.29% in T₁. Interestingly, T₅, despite having the highest live and carcass weights, recorded the lowest numerical dressing percentage. Dressing percentage is influenced by the relative proportions of edible carcass and non-carcass components, including the head, feet, viscera and feathers. Thus, an increase in live body weight does not necessarily result in a corresponding increase in dressing percentage. Baderuddin *et al.* (2024) similarly reported that BSFLM inclusion did not significantly alter the percentage carcass yield of broilers.

The head percentage was not significantly affected by dietary treatment. The values ranged from 3.56% in T₅ to 3.82% in T₁. Although T₅ recorded the lowest numerical head percentage, the lack of statistical significance suggests that BSFLM did not materially influence head development relative to body size.

Breast percentage also did not differ significantly among treatments, with values ranging from 29.13% to 29.93%. This indicates that dietary BSFLM did not adversely affect the development of the breast muscle, which is one of the most commercially important portions of the broiler carcass. Baderuddin *et al.* (2024) similarly observed that BSFLM inclusion did not adversely affect overall carcass characteristics, although they reported a reduction in breast weight as a percentage of live weight at their highest inclusion level.

Thigh percentage was likewise not significantly influenced by the dietary treatments, although T₄ recorded the highest numerical value (20.69%) and T₃ the lowest (18.68%). The lack of statistical significance indicates that the differences were insufficient to demonstrate a dietary effect. This agrees generally with recent evidence showing that BSFLM can be incorporated into broiler diets without major alterations in most carcass-part yields at moderate inclusion levels (Baderuddin *et al.*, 2024).

Drumstick percentage was the only major carcass-part measurement that showed a significant dietary effect. T₁, T₃, T₄ and T₅ recorded statistically similar values, whereas T₂ recorded the lowest value (13.34%). The absence of a progressive response with increasing BSFLM inclusion suggests that the difference may not represent a consistent dose-dependent effect of BSFLM. Rather, it may reflect biological variation among birds within the experimental treatments.

Wing percentage was not significantly affected by dietary treatment, with values ranging from 14.09 to 14.65%. Similarly, neck percentage showed no significant differences, although T₅ recorded the highest numerical value

(8.99%). These results indicate that BSFLM replacement did not substantially alter the proportional development of these carcass components.

Shank percentage was also not significantly affected by dietary treatment. Although T₂ had the lowest numerical value (5.81%) and T₄ the highest (7.27%), these differences were not statistically significant. Back percentage similarly showed no significant dietary effect, despite T₅ recording the highest numerical value (23.45%). These findings demonstrate that the inclusion of BSFLM generally did not produce major changes in the distribution of carcass components.

The general absence of significant differences in most carcass parameters is consistent with Baderuddin *et al.* (2024), who reported that BSFLM inclusion up to 12% did not significantly affect carcass percentage, fat pad or gizzard percentage. However, it differs from the findings of Facey *et al.* (2022, 2024), who reported that high levels of BSFLM replacement could influence growth and some physiological and carcass-related traits. Facey *et al.* (2024), for example, reported linear reductions in breast weight and other responses as BSFLM replacement increased, particularly at ≥50% replacement. Table 3 presents the carcass characteristics of broiler chickens fed diets containing different replacement levels of Black Soldier Fly Larvae Meal (BSFLM) from day 1 to day 42.

Table 3: Carcass Characteristics of Broiler Chickens Fed Black Soldier Fly Larvae Meal-Based Diet (1-42 Days)

Parameters	T ₁ (0%)	T ₂ (25%)	T ₃ (50%)	T ₄ (75%)	T ₅ (100%)	
SEM						
Live Weight (g)	1816.50b	1831.15b	1799.46b	1837.19b	1990.00a	
24.01						
Slaughter wgt. (g)	1734.94 ^b	1749.59 ^b	1717.90 ^b	1755.63 ^b	1908.44 ^a	23.38
De-feathered wgt. (g)	1669.10 ^c	1683.75 ^b	1652.06 ^c	1689.79 ^b	1842.60 ^a	22.87
Carcass Weight (g)	1204.17	1206.54	1176.65	1212.45	1242.85	
20.55						
Dressing (%)	66.29	65.89	65.39	66.00	62.45	
0.40						
Head (%)	3.82	3.80	3.64	3.79	3.56	0.11
Breast (%)	29.93	29.13	29.47	29.85	29.92	0.64
Thigh (%)	19.01	19.68	18.68	20.69	19.05	0.39
Drumstick (%)	15.42a	13.34b	14.85a	15.29a	15.95a	0.32
Wing (%)	14.35	14.41	14.09	14.34	14.65	0.96
Neck (%)	8.42	8.79	8.13	8.94	8.99	
0.16						
Shank (%)	6.95	5.81	6.81	7.27	7.22	0.32
Back (%)	21.64	20.47	20.45	19.84	23.45	0.45

3.3 Conclusion

The present study demonstrates that complete replacement of the conventional protein source with BSFLM (T₅) produced superior growth performance, weight gain and feed conversion efficiency while maintaining most

carcass characteristics. The highest final weight (1990.00 g), weight gain (1792.50 g), average daily weight gain (42.68 g/day) and best FCR (2.18) were recorded in T₅, without a corresponding increase in feed intake.

The response observed in this study is particularly noteworthy because some previous studies have reported reduced performance at high BSFLM replacement levels (Facey *et al.*, 2022; Abdel-Wareth *et al.*, 2026), whereas other studies have demonstrated satisfactory performance even at complete replacement (Kirimi *et al.*, 2023). Therefore, the present results add to the growing evidence that the response to BSFLM is not determined by inclusion level alone, but is also influenced by the quality and processing of the larvae meal, nutrient composition of the complete diet, amino acid balance, energy concentration, rearing substrate, broiler genotype and duration of feeding.

The carcass results further indicate that the higher live weight achieved with T₅ did not translate into a significantly higher dressing percentage. Nevertheless, the absence of significant differences in carcass weight, breast, thigh, wing, neck, shank and back percentages suggests that the use of BSFLM did not adversely alter carcass composition. Thus, under the conditions of this experiment, BSFLM appears to have considerable potential as an alternative protein source for broiler chickens.

3.4 Recommendation

Based on the findings of this study, the following recommendations are made:

Black Soldier Fly Meal (BSFLM) can be used as an alternative protein source in broiler diets. The results demonstrated that BSFLM was capable of supporting satisfactory growth performance and carcass development during the 42-day production period. Complete replacement (100%) of the conventional protein source with BSFLM is recommended under similar experimental conditions, as birds fed the T₅ diet recorded the highest final body weight (1990.00 g), weight gain (1792.50 g), average daily weight gain (42.68 g/day) and the best feed conversion ratio (2.18)

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