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EVALUATION OF SLAUGHTER PERFORMANCE AND CARCASS TRAITS IN POULTRY FED *Hermetia illucens* – BASED DIETS

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Abstract

The rising demand for sustainable protein sources in poultry production has highlighted insects as promising feed alternatives. This study assessed the effects of dietary inclusion of Black Soldier Fly (BSF) larvae on slaughter performance and carcass traits in broilers. Birds were assigned to a control group and three experimental groups receiving 2.0%, 3.5%, or 5.0% Hermetia illucens larvae meal. Haematological and biochemical parameters remained within physiological ranges, indicating normal health and metabolic status. Experimental lines showed improved carcass composition, with increased breast muscle weight, progressive sternum growth, and enhanced thigh and shank musculature. Combined hip and thigh weights and shank muscle mass were higher in experimental groups. These results demonstrate that BSF larvae can be safely incorporated into broiler diets, supporting growth, carcass yield, and meat quality. Furthermore, the experimental lines exhibited superior muscular development and carcass traits, suggesting their higher suitability for meat production. The findings highlight the potential of insect-based diets to enhance sustainable poultry production without compromising animal health or product quality.

Key words: *black soldier fly, broiler chickens, carcass traits, Hermetia illucens, slaughter performance.*

INTRODUCTION

Global demand for poultry products is steadily increasing due to their high nutritional value, cost-effective production, and rapid growth rate (Neeteson et al., 2023; Burnside et al., 2025). Chicken meat is recognized as an important source of high-quality protein and essential amino acids, playing a significant role in human nutrition and health. In the European Union, poultry meat remains one of the most widely consumed animal protein sources, with a continuous upward trend in demand. According to the Global Agricultural Information Network (GAIN) of the USDA, chicken consumption in the EU is projected to increase by 1.6% in 2024, confirming the sustained growth observed in recent years, when chicken meat has become one of the most accessible and frequently consumed protein sources in the region (USDA, 2026).

Poultry consumption continues to rise regardless of a country's income level, as measured by Gross Domestic Product (GDP) (OECD/FAO, 2024). However, the sustainability of poultry production is challenged by the high cost and limited availability of conventional protein sources like soybean meal and fishmeal (Syed Makhdoom et al., 2024). As a result, researchers are investigating alternative, sustainable protein sources to lessen reliance on these ingredients while maintaining animal performance and product quality. In recent years, insects have attracted considerable interest as viable alternatives to conventional feed proteins due to their high nutritional value, efficient feed conversion, and reduced environmental impact (Huis, 2013; Caisin et al., 2025). Among these, the black soldier fly (*Hermetia illucens*) has emerged as one of the most suitable species for large-scale production. Its larvae are rich in crude protein (40-60%), essential amino acids, lipids, and bioactive compounds that support animal health (Barragan-Fonseca et al., 2017; Gasco et al., 2019). Furthermore, *Hermetia illucens* larvae can be reared on a wide range of organic by-products, thereby contributing to waste valorization and supporting circular economy principles (Wang & Shelomi, 2017).

Numerous studies have evaluated the inclusion of *Hermetia illucens* larvae meal (HILM) in poultry diets, reporting comparable growth rates, feed conversion ratios, and meat quality parameters to conventional protein sources (Cullere et al., 2016; Schiavone et al., 2017). However, the impact of HILM on slaughter performance and carcass composition remains variable and dependent on inclusion level, processing method, and the nutritional profile of the substrate used for rearing larvae (Bovera et al., 2018; Heuel et al., 2022). Understanding these effects is critical for optimizing insect-based feed formulations that meet both sustainability and production efficiency standards.

Therefore, this study aims to evaluate the slaughter performance and carcass traits of poultry fed diets containing *Hermetia illucens* larvae meal (HILM) as a replacement for conventional protein sources. The results will contribute to developing sustainable feeding strategies that maintain high carcass quality while mitigating the ecological footprint of poultry production.

MATERIALS AND METHODS

Experimental Design

The research was conducted in accordance with classical methods of experimental animal science, AOAC standards, and methodologies commonly applied in meat quality control laboratories.

The experiment was carried out at the Department of Animal Resources and Food Safety of the Technical University of Moldova. One-day-old unsexed broiler chicks the Ross-308 cross were selected as experimental material. They were randomly assigned to four groups: control group and three experimental groups, each consisting of 20 birds. The chicks were homogeneous in terms of age, body weight, and health status.

Broilers were kept under standardized environmental conditions in accordance with the Ross 308 guidelines (Aviagen, 2025). The chicks were housed in cages with wire mesh floors, equipped with adjustable feeders and nipple drinkers. Each cage was provided with an infrared lamp to maintain optimal temperature conditions.

At the beginning of the rearing period (days 1–2), the average temperature in the houses was 30-33°C. It was gradually decreased over the following days and, by the end of the experiment, it reached approximately 18-22°C (days 22-41).

The chickens were fed *ad libitum* with feed mixtures from a commercial manufacturer: starter (from day 1 to day 10 of the rearing period), grower I (from day 11 to day 24), finisher I (from day 25 to day 30), and finisher II (from day 31 until the end of the rearing period).

The control group received a basal diet, while the experimental groups were fed the same diet supplemented with different levels of *Hermetia illucens* larvae meal (HILM), as follows: 2.0%, 3.5%, and 5.0%. In the experimental diets, fish meal was replaced with the tested feed additive. Feed intake was monitored daily by weighing feed offered and refusals.

The blood was collected from birds in each group on day 41 of the study. All the hematological and serum biochemical determinations were done immediately on sample collection, following standard procedures.

Productive Performance Measurements

During the rearing period, based on the obtained production data, the following production indicators were determined: average body weight (BW, g - weekly and at the end of the production cycle); rearing period (days) and feed conversion ratio (FCR, g).

Growth performance was further assessed using the following indicators: absolute growth rate, relative growth rate, and growth intensity. Body weight gain (g/bird) was calculated as $W_2 - W_1$ where W_2 is the final body weight at the specified time point, and W_1 is the initial body weight.

Relative Growth Rate (RGR) of the animals was calculated using the following equation:

$RCR = 1nW2-1nW1/t2-t1$; where $W1$ is the initial body weight, $W2$ is the final body weight, and $t2-t1$ is the duration of the period in days.

Feed intake (g/bird) was determined as the difference between the amount of feed offered and the feed residues left per group/bird. The feed conversion ratio (FCR) was estimated using the formula: *FCR = Feed intake (g)/ Weight Gain (g/d)* (FAO, 2011).

Slaughter and Carcass Evaluation

Four randomly selected broilers from each group were weighed and slaughtered after fasting for 12 h at 41 d of age. Broilers were then scalded for 90 s, picked for 30 s and weighed (dressed weight). After removal of the crop, intestine, spleen, pancreas, bile, and reproductive organs, the rest of the body was weighed (semi-eviscerated weight), and the eviscerated weight was then determined by removing the liver, heart, gizzard, head, lung, and stomach.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel (Microsoft Corp., USA). Descriptive statistics were calculated for each experimental group, including mean (M), standard deviation (SD), standard error (SE), coefficient of variation (CV), and 95% confidence intervals (95% CI). Differences among treatments were evaluated by one-way analysis of variance (ANOVA). Statistical significance was determined at $p < 0.05$, and treatment means were compared using the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSIONS

Growth Performance

Initial body weights did not differ significantly among the treatment groups, confirming the homogeneity of the experimental groups at the start of the trial. This suggests that any subsequent differences observed can be attributed to the dietary treatments rather than to initial variability. The dynamics of live body weight in the experimental groups were studied at 7, 14, 21,28, 35, and 41 days of age.

Following group allocation, the mean body weights were similar across groups, indicating a high degree of baseline homogeneity and confirming that the experimental groups were comparable at the start of the study.

On day 1, no statistically significant differences were observed among treatments ($F = 0.03$, $p > 0.05$), demonstrating uniform initial conditions (Figure 1).

Throughout the experimental period, body weight increased progressively in all groups, reflecting normal growth dynamics under the applied rearing conditions. During the early phase of the trial (days 1-21), growth patterns remained comparable among treatments, and no statistically significant differences were detected ($p > 0.05$).

From day 28 onward, intergroup differences became statistically significant ($p < 0.05$), indicating that treatment composition began to influence growth performance. At this stage, birds in the EG2 group exhibited the highest mean body weight, followed by EG3, EG1, and CG.

By day 35, the EG2 group maintained the highest body weight, while EG3 showed comparable values but with greater variability. In contrast, CG and EG1 remained lower, although both groups demonstrated stable and consistent growth. The observed differences at this stage suggest that EG2 promoted more efficient weight gain compared with the other treatments.

At the final observation point (day 41), the differences among groups were highly significant ($F = 5.27$, $p < 0.01$). Birds receiving the EG2 treatment reached the highest final body weight, confirming the superior growth-promoting effect of this treatment under the conditions of the present experiment. EG3 ranked second, whereas EG1 and CG showed lower final values.

Overall, the results demonstrate that all groups exhibited steady and biologically consistent growth; however, the magnitude of weight gain differed significantly in the later stages of development. Among the tested treatments, EG2 produced the most favorable growth response, combining the highest final body weight with acceptable variability and strong statistical support.

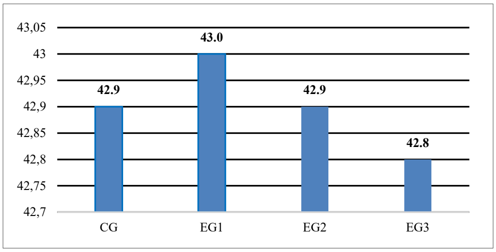

Figure 1. Broilers body weight at the start of trial, g

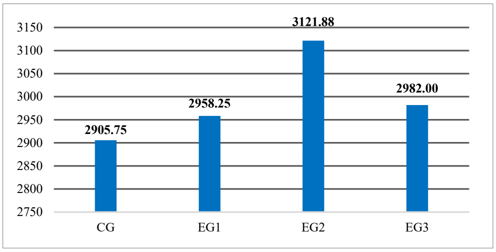

Figure 2. Broilers body weight at the end of trial, g

These findings indicate that EG2 was the most effective treatment for improving growth performance during the experimental period.

The obtained results are consistent with numerous studies investigating the use of insect-derived ingredients in poultry nutrition. In recent years, larval meal, particularly from the black soldier fly (*Hermetia illucens*), has attracted considerable attention as a sustainable and nutritionally valuable alternative protein source for livestock feed. Such ingredients are characterized by a high content of digestible protein, essential amino acids, lipids, and biologically active compounds, which can positively influence growth performance and metabolic processes in poultry (Barman & Saikia, 2024).

Experimental studies have demonstrated that the inclusion of *Hermetia illucens* larval meal in broiler diets can improve nutrient digestibility, energy utilization, and intestinal health, which ultimately contributes to improved growth performance (Dalmoro et al., 2025). In addition, insect-derived ingredients contain antimicrobial peptides and other bioactive substances that may enhance gut microbiota balance and support immune responses in poultry (Dörper et al., 2024).

The results obtained in the present experiment suggest that moderate inclusion levels of larval meal provide the most favorable effect on growth performance. In particular, the highest final body weight was observed in group EG2, which received the intermediate inclusion level (3.5% larval meal). Similar findings have been reported in other studies, where moderate dietary inclusion levels of insect meal produced optimal growth responses, while excessive inclusion did not lead to further improvements in productivity (Seyedalmoosavi et al., 2022).

Another important aspect is the relatively low coefficient of variation observed throughout the experiment, which indicates good uniformity of the birds and stable experimental conditions. This confirms that the observed differences in body weight were primarily associated with the dietary treatments rather than random variation among individuals.

Figure 3 shows the feed conversion ratio (FCR) of broilers in different experimental groups.

The control group (CG) consumed 4313.78 g of feed per bird, with an FCR of 1.48. All experimental groups exhibited reduced feed intake and improved FCR: EG1 – 4233.07 g, FCR 1.43 (−1.87% feed, +3.38% FCR); EG2 – 4186.06 g, FCR 1.34 (−2.96% feed, +9.46% FCR); EG3 – 4193.00 g, FCR 1.41 (−2.80% feed, +4.73% FCR). These results indicate that all treatments enhanced feed efficiency, with EG2 showing the greatest improvement.

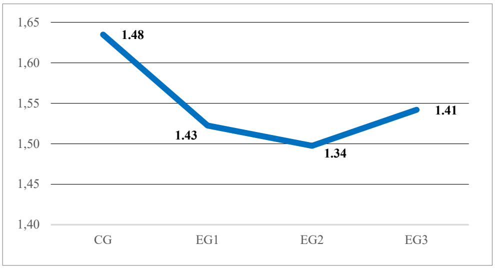

Figure 3. Feed conversion ratio of broilers, kg

Haematological and biochemical parameters

The morphological analysis of blood showed that most hematological parameters (HCT, HGB, RBC, MCH, MCV, PLT) did not differ significantly among the experimental groups.

The biochemical analysis also indicated that the majority of parameters remained within similar ranges across the studied groups.

However, statistically significant differences were observed only for alanine aminotransferase (ALT), whereas the remaining biochemical parameters did not differ significantly among groups ($p > 0.05$). According to the post hoc comparison, ALT activity was significantly higher in EG1 compared with CG, EG2, and EG3 ($p \leq 0.05$), while no significant differences were detected among CG, EG2, and EG3, which shared the same statistical grouping.

Aspartate aminotransferase (AST) activity showed only minor variation among groups, ranging from 367.50 ± 12.42 U/L in EG1 to 394.50 ± 36.38 U/L in EG3, and remained statistically comparable to CG (385.18 ± 16.62 U/L; $p > 0.05$). This indicates the absence of marked hepatocellular damage and confirms that liver function was not adversely affected by the tested treatments.

In contrast, alanine aminotransferase (ALT) demonstrated significant intergroup variation ($p < 0.05$). The highest ALT activity was recorded in EG1 (120.50 ± 2.07U/L), which differed significantly from CG (116.32 ± 1.28 U/L), EG2

(115.95 ± 0.19 U/L), and EG3 (114.15 ± 0.83 U/L). Meanwhile, EG2 and EG3 remained statistically similar to CG, indicating that only EG1 induced a modest but significant elevation in ALT activity. Despite this difference, ALT values remained within physiologically acceptable limits, suggesting only moderate modulation of hepatic metabolic activity rather than clinically relevant liver dysfunction.

Total protein (TP) and albumin (Alb) concentrations showed only minor, statistically insignificant fluctuations among groups ($p > 0.05$). Total protein values remained stable, ranging from 29.35 ± 5.62 g/L in EG3 to 30.93 ± 2.67 g/L in CG, indicating preserved protein metabolism across all treatments.

Albumin concentrations were slightly higher in EG1 (17.69 ± 2.07 g/L) and EG2 (17.78 ± 1.16 g/L) compared with CG (16.45 ± 0.66 g/L), although these differences were not statistically significant ($p > 0.05$). Nevertheless, this tendency may suggest mildly improved protein synthesis and nutritional status in these groups.

Glucose concentrations were higher in EG1 and EG2, suggesting more active carbohydrate metabolism and potentially improved energetic status. EG3 had the lowest α-amylase activity, which may indicate reduced pancreatic enzymatic activity compared with the other groups.

Uric acid concentrations were higher in EG1, EG2, and EG3 than in CG, which may reflect intensified protein turnover. However, creatinine and urea values remained stable, indicating preserved renal function.

Overall, the biochemical indicators remained within physiologically comparable limits, suggesting that all treatments were metabolically well tolerated and induced only moderate biochemical variation. Among the tested groups, EG2 maintained the most balanced biochemical profile, combining stable hepatic enzyme activity with preserved protein metabolism and no evidence of metabolic distress.

Slaughter Performance

Slaughter analysis at 41 days of age revealed no significant differences in pre-slaughter live weight among the experimental groups ($p > 0.05$), indicating that the dietary inclusion of *Hermetia illucens* larvae meal did not affect the attainment of market weight. Significant differences were observed in carcass length between the control group and EG2 ($p < 0.001$) and between the CG and EG3 ($p < 0.001$), as well as in semi-eviscerated carcass mass between EG1 and EG2 ($p < 0.05$). However, these differences were not associated with reductions in overall carcass weight or dressing percentage.

The dressing percentage ranged from 73.9% in the control group to 74.83% in the EG2 group receiving 3.5% HILM, remaining within the expected commercial range for broiler chickens (Figure 4).

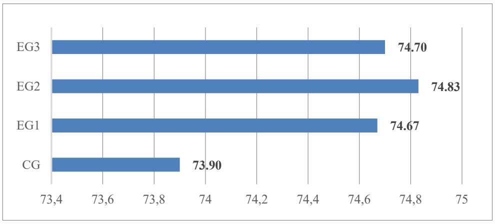

Figure 4. Dressing percentage of broilers, %
[Dressing percentage was calculated as: Dressing, % = (Fully eviscerated carcass weight/Live body weight) * 100]

Broilers in EG2 and EG3 tended to produce slightly heavier carcasses with a higher meat yield. From a production standpoint, maintaining dressing percentage above 74% is considered economically advantageous in modern broiler systems, as it reflects efficient carcass deposition relative to live mass (North & Bell, 1990; Leeson & Summers, 2005).

The absence of negative effects on carcass weight and yield indicates that skeletal development and carcass formation were not adversely influenced by the dietary treatments. Variations in carcass conformation are therefore more likely attributable to normal biological variability rather than dietary factors. The numerically higher dressing percentage observed in the group receiving 3.5% HILM may suggest an optimal inclusion level at which the nutritional advantages of insect-derived protein are effectively utilized. Black soldier fly larvae meal is characterized by a favorable amino acid profile, high digestibility, and the presence of bioactive compounds such as medium-chain fatty acids, which may enhance nutrient utilization and protein deposition.

These findings are consistent with previous studies showing that *Hermetia illucens* larvae meal can partially replace conventional protein sources without compromising growth performance or carcass traits (Huis, 2013; Gasco et al., 2019; Wang & Shelomi, 2017; Józefiak et al., 2020). From a sustainability perspective, insect-derived protein supports circular bioeconomy strategies by converting organic by-products into high-value feed ingredients, thereby reducing the environmental footprint of poultry production and dependence on imported soybean meal.

Organ Weights

The weights of carcass components, including larynx, trachea, esophagus, crop, proventriculus, gizzard, cuticle, and intestines, as well as spleen, pancreas, gallbladder, liver, heart, and lungs, were measured across different groups (CG, EG1–EG3). Minor variations were observed between CG and EG1 in most organ weights. The liver weight ranged from 58.10±3.63 g in EG1 to 63.13±1.25 g in EG2, showing minor variation compared to the control group (62.00±3.63 g).

Pancreas weight differed significantly among the experimental groups ($p < 0.05$). The control group (CG) exhibited the lowest value (4.93 g), while all experimental groups showed higher pancreas weights.

Specifically, EG1, EG2, and EG3 recorded values of 5.49 g, 5.57 g, and 5.74 g, respectively, all of which were significantly greater than the control. No significant differences were observed among the experimental groups themselves ($p > 0.05$).

The spleen showed a slight reduction in EG1 (2.78±0.20 g) and EG3 (2.87±0.31 g) compared to CG (3.63±0.38 g), whereas EG2 (3.10±0.13 g) remained closer to control values (Table 1).

Table 1. Selected internal organs

Parameter/Group	Liver (g)	Pancreas (g)	Spleen (g)
CG	62.00±3.63^{ab}	4.93 ± 0.15^{a}	3.63±0.38^{a}
EG1	58.10±3.48^{a}	5.49 ± 0.21^{b}	2.78±0.20^{b}
EG2	63.13±1.25^{b}	5.57 ± 0.38^{b}	3.10±0.12^{ab}
EG3	61.75±1.38^{ab}	5.74 ± 0.29^{b}	2.87±0.31^{b}

$^{a-c}$ - data within rows with different superscript letters are significantly different ($P < 0.05$)

These results indicate that the experimental treatments had minimal impact on liver and heart masses, while slight variations in spleen weight could reflect subtle immunological or hematopoietic responses.

The observed organ responses are consistent with recent literature reporting that insect-based diets can induce beneficial morphological adaptations without compromising health status (Gasco et al., 2019; Józefiak et al., 2020; Abd El-Hack et al., 2020; Carpentier et al., 2024).

Carcass Traits

The carcass and thigh measurements were recorded for the control group (CG) and three experimental groups (EG1–EG3) (Table 2).

Table 2. Carcass dissection parameters of broiler chickens, g

Parameter	Group			
	CG	**EG1**	**EG2**	**EG3**
Pre-slaughter body weight, g	3095.25 ± 158.4^{ab}	2918.00 ± 63.8^{a}	3122.75 ± 103.6^{b}	3042.50 ± 55.6^{ab}
Un eviscerated carcass weight, g	2659.00 ± 124.9^{a}	2708.00 ± 58.3^{a}	2938.75 ± 78.0^{b}	2863.00 ± 57.8^{ab}
Semi-eviscerated carcass weight, g	2488.75 ± 116.9^{ab}	2365.00 ± 64.9^{a}	2541.50 ± 44.9^{b}	2390.75 ± 48.8^{ab}
Carcass length, cm	24.25 ± 0.63^{b}	22.50 ± 1.54^{ab}	20.35 ± 0.09^{a}	20.50 ± 0.72^{a}
Eviscerated carcass weight, g	2278.25 ± 76.0^{a}	2179.00 ± 53.7^{a}	2336.75 ± 13.4^{b}	2272.75 ± 47.8^{ab}

$^{a-c}$ - data within rows with different superscript letters are significantly different ($P < 0.05$)

The analysis of slaughter traits revealed both significant and non-significant differences among the groups. Pre-slaughter body weight varied significantly ($p < 0.05$), with the highest value recorded in EG2 (3122.75 g), which differed from EG1 (2918.00 g), while CG and EG3 showed intermediate values without significant differences from either group.

A similar trend was observed for un eviscerated carcass weight, where EG2 exhibited the highest value (2938.75 g), significantly exceeding CG and EG1 ($p < 0.05$), while EG3 showed intermediate results. Semi-eviscerated carcass weight also differed significantly, with EG2 again presenting the highest value (2541.50 g), compared to the lower value in EG1 (2365.00 g), while CG and EG3 did not differ significantly from either.

Carcass length demonstrated significant variation among groups ($p < 0.05$), with the greatest length observed in the control group (24.25 cm), whereas EG2 and EG3 showed significantly shorter carcasses (20.35 cm and 20.50 cm, respectively). EG1 presented intermediate values.

Eviscerated carcass weight followed a similar pattern to other weight-related traits, with EG2 recording the highest value (2336.75 g), significantly higher than EG1, while CG and EG3 occupied intermediate positions.

EG2 consistently demonstrated the highest values for most weight-related parameters, whereas the control group showed the greatest carcass length.

CONCLUSIONS

The inclusion of Black Soldier Fly (*Hermetia illucens*) larvae meal in broiler diets demonstrated positive effects on growth performance, carcass traits, and muscular development.

Experimental groups receiving 2.0%, 3.5%, and 5.0% *Hermetia illucens* larvae meal exhibited improved carcass composition compared to the control, with significant increases in thigh and shank muscle mass, breast muscle weight, and sternal development. Internal organ weights (liver, heart, spleen) remained within normal physiological ranges, indicating that insect-based feed did not adversely affect health or metabolic status.

The enhanced muscular development observed in experimental groups confirms that BSF larvae can serve as an effective, sustainable protein source, supporting meat yield and quality without compromising broiler health.

These findings underline the potential of insect-based diets as a sustainable strategy in poultry production, particularly for lines selected for meat performance, offering both economic and environmental benefits while maintaining animal welfare and product quality.

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