

GROWTH PERFORMANCE OF STARTER BROILER FED BLACK SOLDIER FLY LARVAE MEAL-BASED DIETS

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ABSTRACT

Rearing black soldier fly is an efficient way to dispose of organic waste by converting them into protein-rich feed to substitute animal and plant-based sources in animal feeds. This study aimed to determine the optimal inclusion level of black soldier fly larvae meal (BSFLM) as a substitute for soybean meal (SBM) in broiler starter diets and evaluate their impact on growth performance. Five isonitrogenous diets (22% crude protein, CP) and isocaloric (3000 Kcal/kg) were formulated such that BSFLM substituted SBM at 0% (control, T1), 25% (T2), 50% (T3), 75% (T4), and 100% (T5) on a protein basis. A total of 120 broiler chicks were randomly assigned to the five treatments with eight birds per replicate using completely randomized design. The data collected were subjected to ANOVA, and the least significant difference test was used to separate the means. Significant differences were observed in the results of broilers fed BSFLM diets. Final weight (316.67 g) and body weight gain (266 g) of broilers fed T3 were significantly ($P < 0.05$) higher than broiler chickens fed the other treatments (T1, T2, T4 and T5). Feed conversion ratio (FCR) of birds fed T4 was significantly ($P < 0.05$) higher than birds fed the control, 25%, 50% and 100% inclusion levels. Results of Initial weight, feed intake (FI), average daily weight gain (ADWG) and average daily feed intake (ADFI) did not show any significant difference ($P > 0.05$) across all the treatments. This study has demonstrated that BSFLM can partially replace conventional SBM in the diet of broiler starter chicken.

Keywords: Black soldier fly, broiler chicken, growth performance, Soybean meal, protein source

INTRODUCTION

The use of non-conventional feed ingredients such as insects, microalgae, or even food waste in animal production has the potential to increase farming efficiency and sustainability (De SouzaVilela *et al.*, 2019). Some insects can be fed with organic waste using fewer natural resources including less water, energy and landmass, facilitating insect production even in conditions known for its limited productivity (Madau *et al.*, 2020). The Black Soldier Fly larvae (BSFL; *Hermetia illucens*) are known for their suitability for mass production and a nutrient composition allowing them to be used especially in monogastric animal feed (Alagappan *et al.*, 2022). Black soldier fly larvae also have the capacity to reduce the amount of organic waste sent to landfill, and are a potential alternative feed ingredient in different monogastric animal diets including poultry, pigs, fish, and dogs (Lei *et al.*, 2019). The BSF larvae can then be used to produce black soldier fly larvae meal (BSFLM). The meal can be used as an ingredient in livestock diets because of its high crude protein and lipid content. The BSFLM contains consistent essential amino acids and fatty acids when grown in diverse substrates (Gasco *et al.*, 2018).

In the poultry industry, feed represents 60–70% of production costs where energy and amino acids account for more than 90% of this cost (Van Huis *et al.*, 2013). The high cost of poultry feed is mainly due to the use of soybean meal (SBM). Soybean meal is a plant-based source of protein and fat in poultry feed, but it is scarce and expensive. In terms of nutrients, SBM is limited in sulfur amino acids (methionine and cystine) and contains trypsin inhibitor that hinders the activity of the proteolytic enzyme's trypsin and chymotrypsin in monogastric animals: this results in low protein digestibility (Liu, 1997). In contrast, BSF larvae are cheap, easy to rear and can provide high-value protein with a better amino acid profile compared with that of SBM (Tran *et al.*, 2015). Studies have indicated that BSFLM can replace SBM in broiler diets to some extent. Onsongo *et al.* (2018) fed 11.0, 37.2, and 55.5% of the crude protein in the finisher feed of diets to broilers and concluded that replacement of SBM with BSFLM did not affect daily body weight gain and feed conversion ratio (FCR). Similarly, Popova *et al.* (2020) fed diets containing 5% full fat and partially defatted BSFLM and found that there was increased body weight gain. Few studies have examined optimal inclusion levels of BSFLM when replacing SBM in broiler diets. This study, therefore, evaluated the growth performance of broiler starter chicks fed diets containing BSFLM as a substitute for Soybean meal at the starter phase.

MATERIALS AND METHODS

This study was conducted at the poultry unit of the teaching and research farm of the Faculty of Agriculture and Agricultural Technology, Benson Idahosa University, Benin City, Edo State.

Preparation of diets

All feed ingredients were obtained from local reputable animal feed dealers. However, black soldier fly larvae were reared at Benson Idahosa University using faecal matter as the feed substrate. The larvae were harvested and sundried for 14 days. The dried larvae were then ground into powder. The powder was then mixed with other raw materials to formulate five isonitrogenous diets (22% CP) and isocaloric (3000 Kcal/kg metabolizable energy) such that BSFLM substituted SBM at 0% (T1) – control; 25% (T2); 50% (T3); 75% (T4); and 100% (T5) on crude protein basis (Table 1). The feed was formulated to meet the nutrient requirements for broiler starters (National Research Council, 1994).

Table 1: Gross composition of experimental diets

INGREDIENTS	T1 0%(Control)	T2 (25%BSFL)	T3 (50%BSFL)	T4 (75%BSFL)	T5 (100%BSFL)
Maize	50.60	50.60	50.60	50.60	50.60
SBM	25.00	18.75	12.50	6.25	1.00
BSFL	0.00	6.25	12.50	18.75	25.00
Fishmeal	7.00	7.00	7.00	7.00	6.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Soya Oil	2.00	2.00	2.00	1.00	1.00
DCP	0.20	0.20	0.20	0.20	0.20
Bone Meal	4.00	4.00	4.00	5.00	5.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.20	0.20	0.20	0.20	0.20
TiO ₂	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Nutrients					
ME(Kcal/kg)	3000.59	3000.40	3042.22	3004.53	3010.14
CP (%)	22.09	22.28	22.47	22.36	22.26
CF	4.06	4.09	4.12	4.14	4.23
ASH	3.77	4.91	6.05	7.19	8.31
ETHER EXTRACT	4.06	4.06	6.66	7.96	9.22
Ca (%)	1.05	1.23	1.40	1.71	1.83
P (%)	0.74	0.76	0.77	0.83	0.82
Ca:P	1.42	1.63	1.83	2.06	2.23

¹Composition of vitamin premix per kg of diet: vitamin A, 12500 I.U; vitamin E, 40mg; vitamin K, 2mg; vitamin B1, 3mg; vitamin B2, 5.5mg; niacin, 5.5mg; calcium pantothenate, 11.5mg; vitamin B6, 5mg; vitamin B12, 0.025mg; choline chloride, 500mg, folic acid, 1mg; biotin, 0.08mg; manganese, 120mg; iron 100mg; zinc, 80mg; copper, 8.5mg; iodine, 1.5mg; cobalt, 0.3mg; selenium, 0.12mg; anti-oxidant, 120mg.

Growth performance trial

The chicks had one-week adaptation period before the start of the experimental diets. During this period, the birds were fed a formulated starter diet that met the nutrient requirement for starter chicks. Using a completely randomized design (CRD), the birds were transferred into 15 replicates each holding 8 chicks for the five dietary treatments. The initial weight of each bird per cage (replicate) was taken before the commencement of the experiment (day 7). Experimental diets were introduced from day 7 and continued to day 28. Birds had free access to feed and water throughout the experiment. Average daily feed intake (ADFI), FCR, average daily weight gain (ADWG), and total weight were calculated. The final weight and the number of dead birds during the entire experimental period were recorded.

Weekly Feed Intake =

$$\text{Feed intake/bird/day (g)} = \frac{\text{Weekly Feed Intake}}{\text{No. of birds} \times 21 \text{ days}}$$

$$\text{Daily weight gain/bird (g)} = \frac{\text{Final live weight} - \text{Initial weight}}{\text{No. of birds} \times 21 \text{ days}}$$

$$\text{Feed Conversion Ratio} = \frac{\text{Average weekly feed Intake}}{\text{Average weekly body weight gain}}$$

$$\text{Mortality (\%)} = \frac{\text{Number of dead birds} \times 100}{\text{Number of initial stock}} \quad 1$$

Data Analysis

All growth performance data were subjected to one-way analysis of variance (ANOVA). Statistical Analysis Software (SAS 2012) was used to determine whether there were significant differences. Where the differences occurred, mean separation was done by least significance difference (LSD) method.

RESULT AND DISCUSSION

Table 2 showed the growth performance of broiler chickens fed the black soldier fly meal based-diet. Significant differences were observed in the results of broilers fed BSFLM diets. Final weight (316.67 g) and body weight gain (266 g) of broilers fed T3 were significantly ($P < 0.05$) higher than broiler chickens fed the other treatments (T1, T2, T4 and T5). Feed conversion ratio (FCR) of birds fed T4 was significantly ($P < 0.05$) higher than birds fed the control, 25%, 50% and 100% inclusion levels. Results of Initial weight, feed intake (FI), average daily weight gain (ADWG) and average daily feed intake (ADFI) did not show any significant difference ($P > 0.05$) across all the treatments.

Table 2: Growth performance of broiler chickens fed black soldier fly larvae meal-based diets

Parameters	T1 0%(Control)	T2 (25%BSFL)	T3 (50%BSFL)	T4 (75%BSFL)	T5 (100%BSFL)	SEM
Initial weight (g/bird)	52.63	50.42	50.67	50.92	53.92	0.85
Final weight (g/bird)	245.83 ^b	254.17 ^b	316.67 ^a	210.42 ^b	241.67 ^b	16.54
BWG (g/bird)	193.20 ^b	203.75 ^b	266.00 ^a	159.50 ^b	187.75 ^b	16.81
FI (g/bird)	95.83	79.17	100.83	104.17	108.33	4.73
ADWG (g/bird)	33.81	35.66	46.55	27.91	32.86	2.94
ADFI (g/bird)	16.77	13.85	17.65	18.23	18.96	0.83
FCR	0.51 ^b	0.39 ^b	0.44 ^b	0.66 ^a	0.58 ^b	0.04

^a and ^b Means across rows with different superscripts differ significantly at $P < 0.05$; BWG: Body weight Gain
ADFI: Average Daily Feed Intake; ADWG: Average Daily Weight Gain; FCR: Feed conversion Ratio; TFI:
Total Feed Intake; SEM: Standard Error of Mean.

In relation to the broiler chicks' growth performance (Table 2), BSFLM-based diets provided better performance than those fed diets containing conventional SBM (T1). Black soldier flies larvae meal being an insect-based ingredient is rich in key nutrients such as a crude protein with a high biological value, fat, and minerals (Makkar *et al.*, 2014). Feed intake was similar across all the treatments. There was a numerical decrease (13.85 g) in the ADFI of birds fed BSFLM (25% inclusion level) in the diets. This may be attributed to high-fat content as a result of increased level of BSFLM with high fat (44.84%). This was translated to the diet, consequently increasing dietary energy density and thereby decreasing feed intake. There was significant increase of final weight and BWG as the level of BSFLM in the diets increased. This was due to an adequate supply of nutrients to the birds provided by the various diet types (Sumbule *et al.*, 2021). Reduced body weight gain in the control diet (SBM-based, 0% BSFLM) despite similar crude protein levels across the diets implies there was an adequate supply of nutrients to the birds on BSFLM diets. The nutrients were probably deficient in SBM which was the major protein ingredient being substituted by BSFLM. SBM is deficient in methionine and cystine (Kirimi *et al.*, 2020) and contains proteinase inhibitors which reduce the availability of amino acids. However, there was the addition of limiting amino acids (methionine and lysine) across the treatments. This source of nutrients may have provided an extra supply of limiting essential amino acids, though it could not compensate for the deficient nutrients in the SBM-based diet that led to low BWG. The quality of feed, therefore, is a function of the ingredients used and how well it meets the nutrient requirements of the birds.

CONCLUSION

The results of the study showed that broiler starter chickens fed on BSFLM-based diets at 50% inclusion level performed better in terms of growth performance than 100% SBM. Hence, BSFLM can partially replace SBM in broiler diets without negatively affecting the growth performance. However, more research is needed on the finisher phase and optimal inclusion levels.

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