UDS International Journal of Development [UDSIJD]
Volume 4 No. 1, August, 2017
http://www.udsijd.org

EFFECTS OF BLACK SOLDIER FLY (*hermetia illucens)* LARVAE MEAL ON THE GROWTH PERFORMANCE OF BROILER CHICKENS

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Abstract

An experiment was conducted using broiler finishers to determine the effects of black soldier fly larvae meal on their growth performance. Thirty-two (32) chicks (Cobb strain) were selected and randomly divided into 16 groups of 2 birds each. Kitchen waste was used as a bait to attract the flies. The larvae were self-harvested according to the design of the baiting apparatus. The larvae were toasted, sun-dried and milled into powder. The fly larvae meal replaced commercial fish meal at 0% and 33% in broiler finisher diets. Two treatments were tested using a Completely Randomized Design and each treatment replicated thrice. Birds were fed from 3 to 8 weeks of age. Feed and water were provided ad libitum. Data collected were subjected to a two-sample design using GenStat, and treatment effects compared by Studentized T-test. Birds fed the black soldier fly larvae meal had similar feed intake ($P>0.05$) to that of their counterparts fed the control diets. All birds obtained similar ($P>0.05$) live weight gains and feed efficiencies. Birds fed the larvae meal had higher ($P<0.05$) carcass dressing than their counterparts fed the control diet. There was a significant increase ($P<0.05$) in the levels of haemoglobin, packed cell volume and red blood cells of birds fed the larvae meal than their counterparts fed the control diet. Based on this study, it can be concluded that black soldier fly larvae meal had the potential to replace fish meal in broiler chicken diet and could replace fish meal up to 33.3% in their diet without adverse effect on growth performance.

Key words: Black soldier fly, Broiler chickens, Carcass yield, Growth, Haematology

Introduction

In recent years, increasing urbanization has played an important role in the change in dietary pattern, causing increasing pressure on the livestock sector to meet the growing demand for high value animal protein (FAO, 2014). Poultry becomes the animal of choice when a quick means of significantly improving animal protein in the human diet is the objective (Longe, 1986). However, escalating cost of feed is currently undermining the progress of poultry industry in Ghana and many other African countries. Apata & Ojo (2000), indicated that the high cost of compound feeds for poultry is driven largely by exorbitant prices of feed ingredients and scarcity of the conventional ingredients, especially fish meal which is highly priced among feed ingredients.

Therefore, to reduce feed cost, research efforts are being geared towards evaluating alternative feed ingredients for poultry (Ojewola *et al*., 2003) and such alternatives should have comparative nutritive value but cheaper than the conventional protein sources (Atteh & Ologbenla, 1993).

One such ingredient is black soldier fly (*Hermetia illucens)* larvae which has the potential to replace fish meal in the diet of poultry. Studies show that black soldier fly (*Hermetia illucens)* larvae meal can

replace at least 25% of the fish meal in a diet with no reduction in gain or feed conversion ratio (FCR) in channel catfish (Newton *et al.,* 2004). Makkar et al. (2014) stated that insects might have an essential amino acid profile that matches with the required amino acid profiles of growing pigs and broiler chickens. However, there is little information on how partial substitutions of fish meal with black soldier fly larvae meal would influence the growth performance of broiler chickens when fed diet containing 33.3% replacement of fish meal with black soldier fly larvae meal.
Hence a need to evaluate the effect of diet containing black soldier fly larvae meal on growth, carcass and haematological profile of broiler chickens.

Materials and methods

Experimental site

The experiment was conducted at the Poultry Unit of the Animal Science Department, University for Development Studies, Nyankpala Campus, Tamale. Nyankpala is located in the Guinea Savanna Zone on latitude 09˚ 25N and longitude 00˚ 58N at altitude 183m above sea level (SARI, 2001). The temperature fluctuates between 19˚C (minimum) and 42˚C (maximum) with a mean annual temperature of 28.3˚C. Rainfall is mono-modal which occurs from April to October with a mean annual rainfall of 1200mm and a mean annual day - time humidity of 54% (SARI, 2001).

Source of experimental material

The Black Soldier Fly (figure 1) is proving very useful in farm manure management systems and composting operations. They are harmless, lacking both stingers and functional mouthparts (Hawkinson, 2005). Adults live but a few days, dying after mating and egg-deposition (Hawkinson, 2005). Kitchen waste was used as a bait to attract the flies to settle and lay eggs. A harvesting tube was connected to the main container housing the bait (figure 2), where mature larvae travel through to the harvesting container where they were collected for processing (figure 3). They were collected and processed by heating, drying (figure 4) and then milled. Sample was used for proximate analyses for crude protein, ether extract and ash (table 1).

Fig. 1: Black soldier fly

Fig. 2: Baiting container

Fig. 3: Fresh laevea

Fig. 4: Dried larvea

Experimental birds

Fifty day-old Cobb broiler chicks were brooded for 21 days and fed commercial starter diet. At 21 days of age, thirty-two (32) Cobb broiler chicks of similar live weights (900g/bird) were selected randomly and divided into 16 groups with 2 chicks per group (1 male, 1 female) per replicate. The black soldier fly larvae meal was substituted (w/w) for fish meal at two dietary levels (0, 40 g/kg) in a grower diet (Table 1). Each treatment group was replicated eight times in a Completely Randomized Design. The birds were housed in pairs in a raised-floor pens (0.4 m x 0.3 m = (0.12m^2/bird). Feed and water was given *ad libitum* from 21 to 49days of age. Light was provided 24 hours.

Table 1: Composition of experimental diets

Ingredients	Control diet (%)	Experimental diet (%)
Maize	61.5	61.5
Fish meal	12	8
BSFLM[1]	0	4
Wheat bran	11	11
Soya bean meal	13.3	13.3
Vitamin/mineral premix[2]	0.25	0.25
Dicalcium phosphate	0.25	0.25
Oyster shell	1.5	1.5
Sodium chloride	0.2	0.2
Calculated nutrient analysis		
Crude protein (%)	21.0	20.0
Calcium (%)	1.43	1.43
Phosphorus (%)	0.78	0.72
Lysine (%)	1.11	1.01
Methionine (%)	0.44	0.40
Metabolisable energy (MJ/Kg)	12.2	12.0

[1]**BSFLM:** Black soldier fly larvae meal

[2] **composition of premix per kg**: Elemental magnesium 50,000mg, Elemental zinc 40,000mg, Elemental copper 4,500mg, Elemental cobalt 100mg, Elemental iodine 1000mg, Elemental selenium 100mg, Elemental Butylated Hydroxydoluene 10,000mg, vitamin A 8,000,000 UI, vitamin D_3 1,500,000 UI, vitamin E 2,500mg, vitamin k_3 1,000mg, vitamin B_2 2,000mg, vitamin B_{12} 5mg, Folic acid 500mg, Nicotinic acid 8,000mg, Calcium panthotuate 2,000mg, Choline cloruro 50,000mg.

Data collection

Proximate composition of BSFLM

Black soldier fly larvae meal sample was analyzed for its crude protein, ether extract and ash at the Spanish laboratory of the University for Development Studies, Nyankpala, Tamale, in accordance with the procedures described by AOAC, (1990).

Growth and carcass parameters

Feed intake was measured weekly by subtracting the left-over feed at the end of the week from the amount of feed provided. Live-weights of birds in each replicate was measured weekly by weighing them in batches of 2 birds using a digital electronic scale (Jadever, JPS-1050), and weekly live weight gains calculated. Feed conversion efficiency was defined as live weight gain per unit feed consumed. There was no mortality during the period of the experiment. At 49 days of age, they were starved for 8 h, slaughtered using recommended procedure at the Meat Processing Unit of the University for Development Studies at Nyankpala Campus, defeathered, eviscerated and carcass and organ characteristics measured. Carcass dressing was calculated as dress weight over the live-weight, multiplied by 100.

Haematological parameters

At 49 days of age, one bird from each replicate was sampled for haematological analysis. The selected birds were restrained and 1ml of blood was drawn from their wing veins with a syringe and needle. The collected blood from each bird was emptied into test tubes and labeled. The test tubes for the haematological analysis contained ethylene diaminetetra acetic acid (EDTA). The haematological analysis was done using the haemo-

analyzer (Sysmex Hematology Analyzer, XS-500i) at the Tamale teaching hospital. The parameters measured were WBC (Total), RBC, PCV, Hb, MCH and MCHC.

Statistical analysis

The dietary treatment effect for all the variables measured was analyzed for student T-test using GenStat 8th edition (Lawes Agricultural Trust, 2005).

Results

Table 2 shows some proximate composition of black soldier fly larvae meal (SFLM). The material was high in crude protein (42.6%), making it suitable to replace fish meal in the diets of poultry. The ether extract content was 36.9% and ash composition was 15.3% (Table 2).

Table 2: Some proximate composition of black soldier fly larvae meal

Proximate analysis	Amount (%)
Crude protein	42.6
Ether extract	36.9
Ash	15.3

Table 3 shows the growth performance of broiler chickens fed diet containing soldier fly larvae meal (SFLM). There was significant difference between birds fed diet containing SFLM and those birds fed control diet in terms of feed intake, weight gain and feed conversion efficiency.

Table 3: Effects of black soldier fly larvae meal on the growth performance of broiler chickens (21-49 days of age)

Parameter	Control (s.d)	SFLM (s.d)	P. value
Feed intake (g/bird/day)	156.6(1.29)	152.2(6.77)	0.932
Weight gain (g/bird/day)	55.10 (3.35)	53.83(4.16)	0.730
Gain/feed ratio	0.352 (0.02)	0.354 (0.01)	0.417
Final live-weight gain (Kg/bird)	2.193 (0.09)	2.157 (0.12)	0.730

In terms of carcass evaluation, birds fed diet containing SFLM had higher ($P<0.05$) carcass dressing than their counterparts fed the control diet (Table 4). All other carcass and organ parameters were similar ($P>0.05$).

Table 4: Effects of black soldier fly larvae meal on carcass and organ characteristics of broiler chickens (21-49 days of age)

Parameter	Control (s.d)	SFLM (s.d)	P. value
Dress weight (Kg)	1.703(0.246)	1.710(0.070)	0.483

Carcass dressing (%)	73.67(1.496)[a]	76.12(0.492)[b]	0.027
Liver (g)	50.67(6.429)	47.33(1.155)	0.787
Spleen(g)	2.67(1.155)	4.00(1.000)	0.103
Heart(g)	10.00(2.000)	10.67(1.155)	0.322
Empty crop(g)	11.33(1.155)	10.00(2.000)	0.813
Empty gizzard(g)	42.67(5.033)	44.00(2.000)	0.346
Whole intestines(g)	95.00(1.000)	91.33(5.033)	0.858

s.d= standard deviation, Means within a row with different superscripts are significantly different (P<0.05)

Haematological profile of the experimental population indicated that WBC, MCH, MCV and MCHC were similar (P>0.05). However, birds fed diet containing SFLM had higher (P<0.05) values in terms of PCV, Hb and RBC than their counterparts fed the control diet (Table 5).

Table 5: Effects of black soldier fly larvae meal on haematological profile of broiler chickens (21-49 days of age)

Parameter	Control (s.d)	SFLM (s.d)	P. value
PCV (%)	25.87(0.651)[a]	31.47(0.839)[b]	<0.001
Hb (g/dl)	6.23(0.231)[a]	8.00(0.458)[b]	0.002
RBC (10^6/uL)	1.96(0.144)[a]	2.37(0.098)[b]	0.008
WBC (10^3/uL)	130.6(21.39)	146.3(5.324)	0.142
MCV (fl)	132.6(12.70)	129.2(4.735)	0.657
MCH (pg)	31.90(1.778)	32.87(2.259)	0.296
MCHC (g/dl)	24.10(1.054)	25.43(0.851)	0.082

Means within a row with different superscripts are significantly different (P<0.05), PCV= Pack cell volume, Hb= Haemoglobin, RBC= Red blood cells, WBC= White blood cells, MCV= Mean corpuscular volume, MCH= Mean corpuscular haemoglobin and MCHC= Mean corpuscular haemoglobin concentration.

Discussion

Black soldier fly larvae meal contains high amount of crude protein and ether extract. The feed intake levels and growth of the birds indicate that the BSFLM contain reasonable amounts of essential amino acids that could guarantee the quality of protein in the BFLM (Table 1).

Generally, feed intake was high for all birds in both treatment groups for the period of the experiment (Table 3). However, mean feed intake for both groups were similar. This clearly suggests that the BSFLM was palatable as standard fish meal and had no adverse effect on feed consumption.

The similarities in feed intake and growth variables observed between the control group and the group fed black soldier fly larvae meal (BSFLM) based diet indicated that replacing 33.3% of fish meal with BSFLM did contribute significantly to the protein needs of the birds. This has contributed to the

similarity in both weight gain and feed conversion efficiency. Moreover, the levels of essential amino acids in BSFLM appeared to be sufficient to comply with requirements for pigs (NRC, 2012) and poultry (CVB, 2012). According to Newton *et al*. (1977), BSFLM contains lysine content of 3.4% and methionine content of 0.9%. Newton *et al*. (2004) show that black soldier fly larvae meal can replace at least 25% of the fish meal in channel catfish diet with no reduction in gain or feed conversion ratio (FCR). Carcass and organ characteristics of the experimental population did not differ significantly except for carcass dressing in which birds fed diet containing SFLM had a significantly higher carcass dressing than their counterparts fed the standard diet. This could probably be attributed to the quality of protein in the BSFLM.

Haematological analysis is significant in nutritional studies because the blood, the metabolites and their concentration provide information for their direct nutritional assessment due to the fact that feed components affect body constituents (Harper *et al.,* 1979). Haematological profile of the two experimental groups indicated superiority in the PCV, Hb and RBC of the birds fed BSFLM-based diet over their counterparts fed the standard diet. This suggests improved healthy condition of the birds fed BSFLM. The haematological values recorded in this experiment were similar to those reported by Sirois (1995), except for WBC, MCV, MCH and MCHC. These differences might be due to species difference. According to Egbunike & Akusu (1983), factors such as genotype, breed of animals, management or environment, age, diseases, medication and nutrition may have influence on the blood parameters of farm animals.

Conclusion

Based on the results of this study, it was concluded that larvae from black soldier fly contain high level of crude protein and ether extract and that it can replace 33% of fish meal in broiler grower diet without any adverse effect on their growth, carcass and health status.

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