Annals of Animal and Biological Research, 2024; 4(1)


Original Article

# Productive performance and economic viability of broiler chicks fed black soldier fly (*Hermetia illucens*) larva meal-based diets

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**Article Information**
***Keywords***
Chicken, feed, fish meal, insect, net profit

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***Article History***
Received: December 31, 2023
Accepted: January 9, 2024
Published: March 31, 2024

*Article can be accessed at www.aabrjournalaaua.org.ng*

**Abstract**

This study was conducted to investigate black soldier fly larva meal (BSFLM) as replacement for fish meal on general performance of broiler chick production. The live larvae were poured into heated water at about 70 - 80°C and stirred for about 5 minutes in order to make the larvae inactive. Filtered larvae were sun dried to minimum moisture content and then milled. Two hundred and fifty Cobb 500 breed day-old chicks were randomly allotted at 50 chicks per treatment of 5 replicates using performance and cost implication as response criteria in a Completely Randomized Design. The BSFLM was used to replace fish meal at graded levels of 0, 25, 50, 75 and 100% and designated Diets I, II, III, IV and V, respectively. The respective diets were fed to the chicks *ad libitum* from 1 – 21 days. Among all the growth parameters measured, only the total feed consumed was significantly ($P \leq 0.05$) influenced by the dietary treatments. Highest total feed consumed (620.79g) and lowest total feed consumed (562.34g) were recorded in chicks fed diets I and III, respectively. Highest final weight (643.67g) and highest weight gain (602.92g) were recorded in chicks fed diet I. The net profit/started chicks was highest in chicks fed diet V. Generally, the net profit/started chicks increased as the level of BSFLM increased in the diets. From this study, the replacement of fish meal with BSFLM in the diets of broiler chicks could help to reduce the over dependence of broiler producers on importation of fish meal.

## INTRODUCTION

Feed constitutes the major component cost of poultry production under intensive system and this varies between 65 – 75% total costs of production (Adegbenro *et al.,* 2012). Feed formulation is more than mere adding ingredients together but it involves combining ingredients in proportions necessary to provide the animal with proper amount of nutrients required at a particular time. The rising cost of fishmeal on daily basis is brought about by its unavailability. Currently, the cost of fish meal per kg is two thousand, eight hundred naira (₦2,800.00) per kilogram. This input could be substantially reduced or completely

**How to cite this article:**
M. Adegbenro, A. O. Ayeni, A. A. Akintomide, A. J. Atansuyi and J. O. Agbede (2024). Productive performance and economic viability of broiler chicks fed black soldier fly (*Hermetia illucens*) larva meal-based diets. *Annals of Anim. Bio. Res.,* 4(1): 1-8

substituted if black soldier fly (*Hermetia illucens*) larva meal is produced in large quantity from some plant-based organic wastes.

Black soldier fly is small, harmless insect that has the potential to provide promising solutions to the high cost of animal feed and environmental pollution (waste management). Recent research has shown that black soldier fly may be instrumental in closing the loop between animal waste and animal feed (Watson *et al.,* 2005). Black soldier fly larvae will eat nearly all kind of organic wastes ranging from animal waste to food scraps. The dry weight of Black Soldier Fly larva (BSFL) contain up to 50% crude protein (CP), up to 35% lipids and have an amino acid profile that is similar to that of fishmeal (Elwert *et al.,* 2010). Thus, this study was designed to evaluate the potential of Black Soldier Fly larva meal as animal protein source in broiler chick diets.

## MATERIALS AND METHODS

### Experimental site

The study was carried out at the Poultry Unit of the Teaching and Research Farms of The Federal University of Technology, Akure, Nigeria. The University is located on Latitude 7º18"N and Longitude 5º10"E (NIMET, 2014). The altitude is about 350.52m above sea level, the annual humidity is 75% and that of temperature is 27 ºC absolute (Ashaolu and Adebayo, 2014).

### Processing of Black Soldier Fly Larva Meal

Black soldier fly larvae were harvested from a location in Ilesha, Nigeria and were transported to Akure, Nigeria. The live larvae plus debris, were poured into buckets containing cold water and thoroughly washed before processing. During processing, the live larvae were poured into heated water at about 70 - 80°C and stirred for about 3 – 5 minutes in order to make the larvae inactive. Filtered dead larvae were spread on nylon for solar drying to minimum moisture content. Dried larvae were then milled to produce black soldier fly larva meal (BSFLM), and stored in an air-tight container prior to use.

### Experimental Diets Production

The fishmeal in the basal diet was replaced with black soldier fly larva meal at 0, 25, 50, 75 and 100% and designated Diets I, II, III, IV and V, respectively. The gross composition of the experimental diets is shown in Table 1.

### Experimental Layout and Feeding Trial

A total number of 300 day-old chicks of Cobbs 500 breed of broiler chicken were procured from Zartech Farms Limited, Ibadan, Nigeria out of which 250 were assigned to five dietary treatments of five replicates and 10 chicks per replicate on the day of arrival in a Completely Randomized Design. The right to conduct the research was granted by the Research Committee of the Department of Animal Production and Health, The Federal University of Technology, Akure, Nigeria.

### Growth performance

At the beginning of the experiment, the broiler chicks were weighed and the initial weight of each group replicate was balanced (±1g) thereafter each group was fed their respective diet *ad libitum* from 1 – 21 days during which weekly feed consumption and weight gained were measured, while the feed conversion ratio was calculated as the ratio of feed consumed to weight gain.

**Table 1. Gross composition of experimental black soldier larva meal-based diets (g/100g)**

| Ingredients | Diet I | Diet II | Diet III | Diet IV | Diet V |
|---|---|---|---|---|---|
| Maize | 53.45 | 53.45 | 53.45 | 53.45 | 53.45 |
| Soybean meal | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 |
| Groundnut cake | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Fishmeal | 5.00 | 3.75 | 2.50 | 1.25 | 0.00 |
| Black Soldier Larva Meal | 0.00 | 1.25 | 2.50 | 3.75 | 5.00 |
| Lysine | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Methionine | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Di-Calcium Phosphate | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Limestone | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Oil | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Salt | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |
| **Calculated Nutrients** | | | | | |
| Crude protein (%) | 23.74 | 23.55 | 23.37 | 23.18 | 22.99 |
| Metabolizable Energy (Kcal/kg) | 3023.18 | 3037.43 | 3051.68 | 3065.93 | 3080.18 |
| Calcium (%) | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| Available phosphorus (%) | 0.52 | 0.50 | 0.50 | 0.50 | 0.43 |
| Lysine (%) | 1.31 | 1.31 | 1.31 | 1.30 | 1.30 |
| Methionine (%) | 0.48 | 0.48 | 0.48 | 0.47 | 0.47 |

## Economic Viability

The cost of producing the experimental diets based on the current market prices for all the ingredients. The cost of feed consumed per chick was calculated by the cost of experimental diets multiplied by total feed consumed. The total cost of production was calculated by adding the cost of day-old chicks, cost of feed consumed and cost of drug/vaccines. The net profit/started chick was calculated by subtracting the total cost of production from sales price of started chicks. The other expenses such as day-old chicks, drugs and vaccines were common for all the five treatments.

## Data analysis

All data collected were subjected to Analysis of Variance (ANOVA) using SPSS version 25 package and Duncan Multiple Range Test of the same package were used to separate the mean difference among treatments. The Experimental model is a Completely Randomized Design.

# RESULTS

## Growth performance

This study revealed differences in growth performance of broiler chicks fed black soldier larva meal-based diets. The influence of BSFLM diets on the

**Table 2. Performance of broiler chicks fed black soldier larva meal-based diets**

| Parameters | Diet I | Diet II | Diet III | Diet IV | Diet V | SEM | P-Value |
|---|---|---|---|---|---|---|---|
| Initial weight (g/bird) | 40.75 | 40.75 | 40.83 | 40.83 | 40.75 | 0.04 | 0.94 |
| Final weight (g/bird) | 643.67 | 619.46 | 602.43 | 573.27 | 572.40 | 11.17 | 0.19 |
| Total weight gain (g/bird) | 602.92 | 578.72 | 561.60 | 532.40 | 531.65 | 11.17 | 0.19 |
| Total feed consumed (g/bird) | $620.79^{b}$ | $608.93^{ab}$ | $562.34^{a}$ | $576.60^{ab}$ | $564.51^{ab}$ | 8.99 | 0.05 |
| Feed conversion ratio | 1.03 | 1.05 | 1.00 | 1.08 | 1.06 | 0.02 | 0.73 |

performance of broiler chicks of age 1 – 21 days indicated that among all the growth parameters measured, only the total feed consumed was significantly ($P \leq 0.05$) influenced by the dietary treatments. Highest final weight (643.67g), highest weight gain (602.92g) and highest feed consumed (620.79g) were observed in chicks fed diet I, while lowest final weight (572.40g), lowest weight gain (531.65g) were observed in chicks fed diet V and lowest feed consumed (562.34g) was observed in chick fed diet III. Considering Figures 1 – 3, chicks fed diet I had the highest weekly weight gain at weeks 1, 2 and 3 with lowest weekly weight gain recorded in chicks fed diets IV and V for weeks 1, 2 and 3. Highest weekly feed intake was observed in chicks fed diet I in weeks 1, 2 and 3, while, lowest weekly feed intake was observed in chicks fed diet V in weeks 1, 2 and 3. Best feed conversion ratio was observed in chicks fed diet III at weeks 1, 2 and 3.

## Economic Viability

The economic viability of production of BSFLM diets as replacement for fish meal as protein source in broiler chick diets showed that there were differences

**Table 3. Economic viability of broiler chicks fed black soldier larva meal-based diets**

| Parameters | Diet I | Diet II | Diet III | Diet IV | Diet V |
|---|---|---|---|---|---|
| Cost of Day-old chicks | 520.00 | 520.00 | 520.00 | 520.00 | 520.00 |
| Cost of experimental diet (₦/kg) | 422.84 | 400.96 | 379.09 | 357.21 | 335.34 |
| Total feed consumed (Kg/bird) | 0.62 | 0.61 | 0.56 | 0.58 | 0.56 |
| Cost of feed consumed (₦/bird) | 262.16 | 244.59 | 212.29 | 207.18 | 187.79 |
| Weight gain (kg) | 0.60 | 0.59 | 0.56 | 0.53 | 0.53 |
| Cost of drugs and vaccines (₦) | 120.00 | 120.00 | 120.00 | 120.00 | 120.00 |
| Total cost of production (₦) | 902.16 | 884.59 | 852.29 | 847.18 | 827.79 |
| Sales price of started chick (₦/bird) | 1600.00 | 1600.00 | 1600.00 | 1600.00 | 1600.00 |
| Net profit/started chicks (₦) | 697.84 | 715.41 | 747.71 | 752.82 | 772.21 |

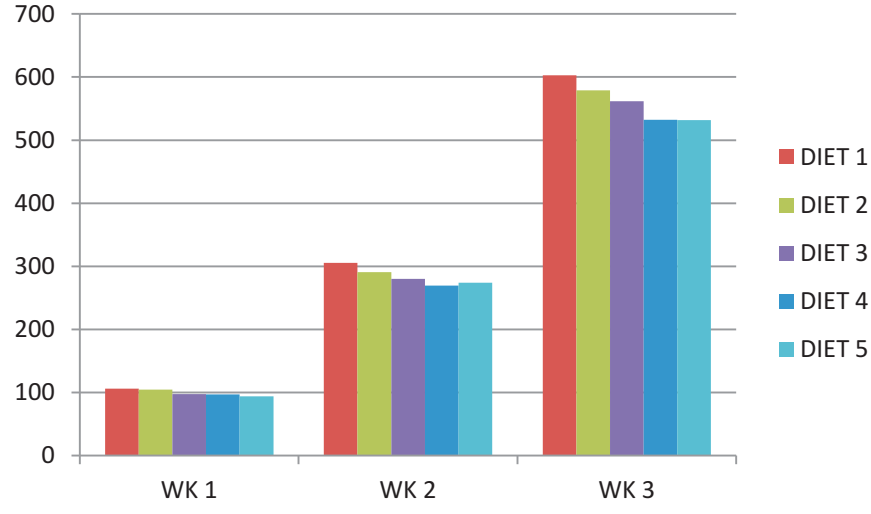


**Figure 1** Weekly weight gain (gm) of chicks fed black soldier larva meal-based diets

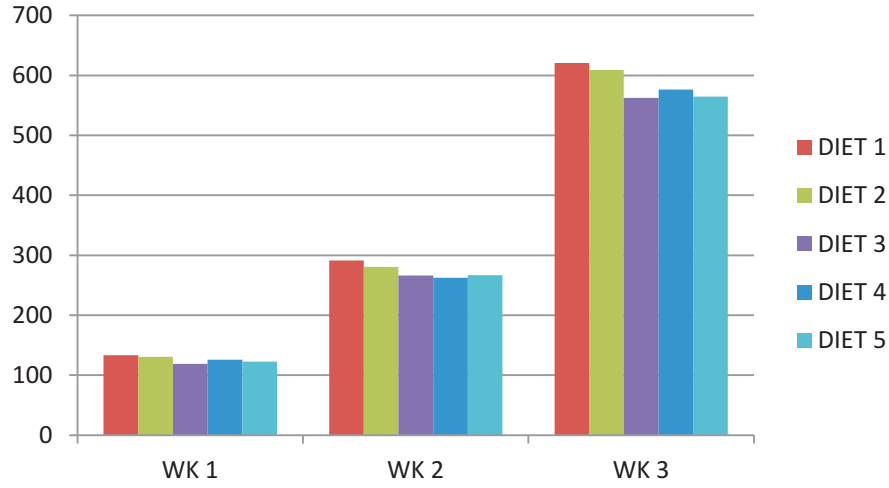


**Figure 2**. Weekly feed intake (g) of chicks fed black soldier larva meal-based diets

observed in cost of experimental diets, cost of feed consumed and total cost of production. Highest cost of experimental diet (N422.84), highest cost of feed consumed (N262.16) and highest total cost of production (N902.16) were recorded for diet I. Diet V (100% BSFLM diet) had the lowest cost of experimental diet (N357.21), lowest cost of feed consumed (N207.18) and lowest total cost of production (N 847.18). The highest net profit/started chick (N772.21) was recorded in chick fed diet V, while lowest net profit/started chick (N697.84) was recorded in chick fed diet I. Generally, the net profit/started chick increased as the level of the BSFLM increased.

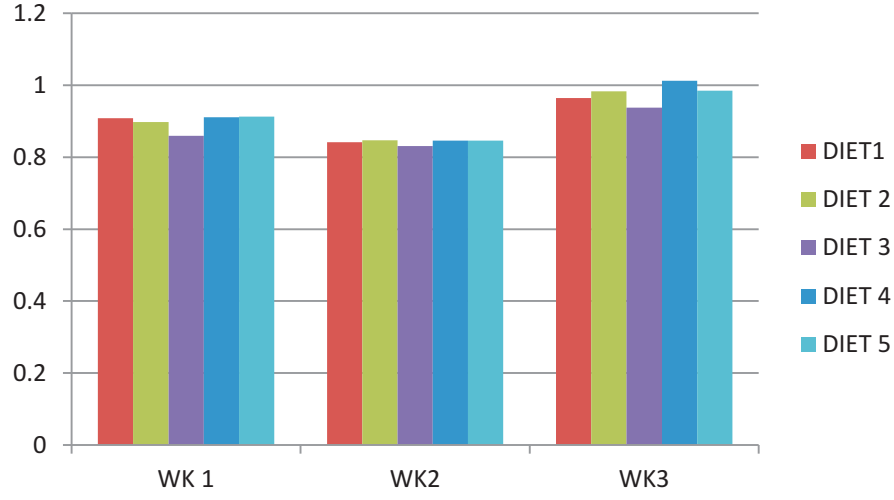


**Figure 3**. Feed conversion ratio of chicks fed black soldier larva meal-based diets

## DISCUSSION

From Table 2, all the parameters, with the exception of total feed consumed, were not influenced by the dietary treatments. An experiment to carry out the effect of replacing fish meal with maggot meal in the starter and grower-finisher diets on the production performances of broiler chickens had earlier been reported by Téguia *et al.* (2022). The feed conversion ratio was best with diet III (0.94) compare to chicks on other experimental diets. This result agreed with the report of Okah and Onwujiariri (2012) that chickens fed maggot meal diets has superior feed conversion ratio than those fed the control diet in their experiment. This finding suggested the nutritional adequacy of the BSLFM in replacing the conventional fish meal in broiler chick diets. The result of the present study is also in tandem with the findings of Téguia *et al.* (2022) where the authors observed no difference among the treatment groups for feed conversion ratio for both the starter and grower-finisher periods.

The increase in the weekly weight gain of chicks fed black soldier larvae meal-based diets from week one to three as the chicks' advanced in age (Figure 1) is expected because the feed consumption increased with increase in the age of the chicks. It was also observed in the Figure that for each week, chicks on diet 1 gained more weights than those placed on the other experimental diets. It could be observed in Figure 2 that the weekly feed intake of chicks fed black soldier larva meal-based diets increased as the chicks grew older in age from week one to three. This is expected because feed consumption has direct proportionality with age of chicks. It could be observed in the Figure that for each week, chicks fed diet without black soldier fly larva meal consumed more feed compared to those placed on diets containing black soldier fly larva meal during the experiment. The Feed conversion ratio (FCR) of chicks fed black soldier fly larva meal-based diets as shown in Figure 3 indicated that the weekly FCR of chicks was highest in chicks fed diet IV and least in those fed diet III. This showed that the chicks utilized diets containing black soldier fly larva meal better than the one without the meal. In overall, the chicks utilized diet III better than the other formulated diets during the period of the study which is an indication of the rate at which the feed was converted to muscle.

Although, no difference was recorded among treatment groups on the feed cost for the production of 1kg of live weight, there was a 5.18 – 20.69% reduction in cost of production of treated groups as compared to the control group of the birds during the experimental period. Meanwhile, Téguia *et al*. (2022) in a similar experiment obtained 4 - 16% reduction in cost of production of treated groups as compared to the control group of broiler chickens during starter and finisher periods of their experiment. In this study, the cost per unit of production of experimental diet (N/kg) decreased as the level of black soldier larva meal increases in the diets. Thus, cost of feed was highest for diet I (N422.84) and least for diet V (N335.34) translating to about 1 – 0.8 USD/kg, respectively. This report is in concordance with that of Okah and Onwujiariri (2012) that the cost of diets decreased with increased level of maggot meal addition in their study on performance of finisher broiler chickens fed maggot meal as a replacement for fish meal. As expected, the 620g of total feed consumed (kg/bird) and N262.16 of the cost of feed consumed

(N/bird) were highest for diet I and hence, the highest total cost of production (N902.16) which translated to about 2.3 USD.

Akpodiete and Inoni (2000) found out that replacing fish meal at 75% with maggot meal resulted in reduced cost of feed as well as cost /kilogramme weight gain of broiler chicken at starter, finisher and the overall production period. It could be deduced from this study that the odour, noticed during production of the larva meal and feeding trial of chicks, generated by the addition of black soldier fly larva meal affected the taste of the diets and thus repelled the birds from consuming more feed. This was observed in the study as the birds consumed less when more of black soldier fly larva meal was added to the feed. The net profit per started chicks' production (N) was directly proportional to the addition of black soldier fly larva meal. This means that, as the quantity of black soldier fly larva meal added to the diet increases, the net profit per started chick production (N) increases, ranging from N697.84 for diet I to N772.21 for diet V which translated to about 1.30 to 2.05 USD. The result obtained in this study agreed with the report of Akpodiete and Inoni (2000) that the net returns on broilers fed maggot meals were raised by 15.79, 12.28 and 13.63% respectively at the starter, finisher and during the overall production period.

## CONCLUSION

The replacement of commercial fish meal in broiler chick diets with black soldier fly larva meal under this study could help to reduce the over dependence of broiler farmers, especially those that are involved in started broiler production, on importation of fish meal thus leading to reduction in the price of finished feed leading to availability of poultry meat to the populace.

**Acknowledgements:** The authors sincerely appreciate the Tertiary Education Trust Fund (TETFund) Institution-Based Research Intervention for sponsoring this project.

**Conflict of Interest:** All authors indicated no conflict of interest.

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