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Utilization of Black Soldier Fly (*Hermetia illucens*) Maggot Meal as an Alternative Protein Source in Broiler Chicken Diets

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ABSTRACT
The escalating price and scarcity of conventional protein sources like soybean and fish meal are major constraints to profitable broiler production in Nigeria. This study was conducted to evaluate the potential of Black Soldier Fly (Hermetia illucens) maggot meal (MM) as a sustainable and cost-effective alternative protein source. Larvae were reared on household food waste and agricultural by-products, harvested at the late larval stage (14 days), heat-treated at 65ºC for 5 minutes, and sun-dried before milling. One hundred and twenty day-old broiler chicks were randomly assigned to four dietary treatments (0%, 5%, 10%, and 15% MM inclusion) in a completely randomized design with three replicates of 10 birds each for a period of six weeks. The maggot meal contained 48.72\% crude protein, 24.18% ether extract, 6.54% crude fibre, and 9.63% ash. Data were analyzed using one-way ANOVA ($P < 0.05$) with means separated by Duncan's Multiple Range Test. Results indicated that increasing maggot meal inclusion did not adversely affect performance. Final body weights ranged from 2170.6 g in the 15% group to 2210.3 g in the 10% group ($P > 0.05$), while body weight gains were comparable at 2128.4g and 2167.9 g respectively. Feed conversion ratios remained stable between 1.84 and 1.89 ($P > 0.05$), and mortality was low across all groups (0%–2.0%). Notably, feed cost per kilogram of diet decreased significantly ($P < 0.05$) from ₦420 in the control to ₦350 in the 15% inclusion group, representing a 16.7% cost reduction. It was concluded that Black Soldier Fly maggot meal can safely replace conventional proteins up to 15% in broiler diets, maintaining growth efficiency while significantly reducing production costs.
Keywords: Alternative protein, Black Soldier Fly, Broiler chickens, feed cost, Maggot meal

INTRODUCTION

In developing nations, the primary economic constraint in poultry farming is the high cost of feed, with protein ingredients like soybean and fish meal accounting for a substantial portion of production budgets. Specifically, in broiler enterprises, these costs can reach approximately 75% of total expenditures, making protein the most expensive dietary component. The combined challenges of price volatility, seasonal scarcity, and a dependence on imported inputs often compromise the viability of small-to-medium-scale poultry farms. Consequently, there is an urgent need to identify alternative, indigenous, and affordable protein sources that can sustain optimal bird performance.

Insect-based feeds have gained prominence as sustainable alternatives due to their impressive protein

levels, balanced amino acid profiles, and capacity to valorize organic waste. Among these, the Black Soldier Fly (*Hermetia illucens*) is particularly notable for its resilience in tropical environments and its rapid biomass accumulation. The larvae (BSFL) possess a broad nutritional range, with crude protein levels fluctuating between 32% and 63% depending on the substrate used for rearing. This species provides a dual benefit by acting as a biological waste management tool while simultaneously serving as a high-quality nutrient source for livestock.

Existing literature indicates that insect meals can partially or fully replace traditional proteins without harming the growth, efficiency, or health of the birds. Nevertheless, site-specific, replicated data within the Nigerian context remains limited, which hinders the widespread adoption of this technology. This study was therefore designed to investigate the impacts of graded levels of Black Soldier Fly maggot meal on the growth performance, survivability, and economic efficiency of broiler chickens.

MATERIALS AND METHODS

Study Location The experiment was carried out at the Teaching and Research Farm of the Federal College of Education (Technical), Ekiadolor, Benin City, Edo State, Nigeria. The area lies within the humid tropical rainforest zone and is characterized by relatively high temperature and humidity.

Production and Processing of Black Soldier Fly Maggot Meal

Black Soldier Fly larvae were produced using a mixture of household food wastes and agricultural by-products as substrates. Harvesting was done at the late larval stage (14 days). The larvae were separated from the substrate, thoroughly washed with clean water, and subjected to heat treatment at 65ºC for 5 minutes to reduce microbial contamination. The larvae were then sun-dried to constant weight and milled into fine maggot meal (MM), which was stored in airtight containers until diet formulation.

Proximate Composition Analysis

Analysis of the maggot meal followed the procedures of the Association of Official Analytical Chemists (AOAC, 2016). The analyzed values are presented in Table 1.

Experimental Design, Birds, and Management

A total of 120 day-old broiler chicks were randomly allocated to four dietary treatments in a completely randomized design (CRD): T1 (0% MM, Control), T2 (5% MM), T3 (10% MM), and T4 (15% MM). Each treatment consisted of three replicates with 10 birds each. Birds were housed under standard deep-litter management, provided with feed and clean drinking water *ad libitum*, and managed uniformly with routine vaccination and sanitation practices.

Diet Formulation

The composition and proximate analysis of the experimental diets are presented in Tables 2 and 3.

Data Collection

Body weight was measured weekly. Feed intake was recorded daily, and feed conversion ratio (FCR) was calculated as the ratio of feed consumed to body weight gain. Mortality was recorded as it occurred. Feed cost per kilogram of diet was computed based on prevailing market prices of ingredients.

Statistical Analysis

Data were subjected to one-way Analysis of Variance (ANOVA) using SPSS (Version 25). Significant differences among treatment means were determined at $P < 0.05$, and means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The inclusion of Black Soldier Fly (BSF) maggot meal at levels up to 15% did not adversely affect the growth parameters of the birds. Table 4 presents the effect of graded inclusion on growth performance and economic indices. There were no significant differences ($P > 0.05$) in final body weight, weight gain, or FCR among treatments, indicating that nutrient utilization from MM was comparable to conventional sources. The final body weights, ranging from 2170.6g to 2210.3g, demonstrate that MM can successfully substitute high-cost proteins like soybean meal.

The stability in FCR (1.84–1.89) suggests that the amino acid balance and digestibility of the maggot

meal were adequate to sustain rapid growth. These findings are consistent with reports by Biasato et al. (2018) and Al-Qazzaz et al. (2016). Mortality rates remained low across all treatments ($P > 0.05$), confirming the safety of the processed maggot meal. This safety is reinforced by inherent bioactive compounds in BSFL, such as lauric acid, which possesses antimicrobial properties against pathogens like *Enterobacteriaceae*.

Economic analysis revealed a significant ($P < 0.05$) reduction in feed cost as MM inclusion increased. The 16.7% reduction in feed cost per kilogram at the 15% inclusion level represents a substantial economic advantage for poultry producers in Nigeria, consistent with findings that insect-based diets provide superior profit margins compared to conventional regimes.

Tables

Table 1: Proximate Composition of Black Soldier Fly Maggot Meal (%)

Parameter	Value (%)
Dry Matter	92.36
Crude Protein	48.72
Ether Extract	24.18
Crude Fibre	6.54
Ash	9.63

Table 2: Composition of Experimental Diets (%)

Ingredient	0%	5%	10%	15%
Maize	55.00	55.00	55.00	55.00
Soybean meal	25.00	20.00	15.00	10.00
Maggot meal	0.00	5.00	10.00	15.00
Wheat offal	15.00	15.00	15.00	15.00
Premix	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
DCP	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**

Table 3: Proximate Composition of Experimental Diets

Parameter	0%	5%	10%	15%
Crude Protein (%)	22.5	22.4	22.6	22.7
Ether Extract (%)	4.5	5.2	6.0	6.8
Crude Fibre (%)	4.0	4.1	4.2	4.3
Ash (%)	6.0	6.1	6.3	6.5
ME (kcal/kg)	3000	3005	3010	3015

Table 4: Growth Performance and Economic Indices of Broilers (0–6 Weeks)

BSF Level (%)	Final BW (g)	Weight Gain (g)	FCR	Feed Cost (₦/kg)
0	2180.5	2138.2	1.89	420
5	2195.8	2153.7	1.87	395
10	2210.3	2167.9	1.84	370
15	2170.6	2128.4	1.86	350
SEM	32.4	31.9	0.04	18.6
P-value	0.68	0.71	0.63	0.04

CONCLUSION

Black Soldier Fly maggot meal can be safely included up to 15% in broiler chicken diets without adverse effects on growth performance, feed efficiency, or survivability, while significantly reducing feed cost. Its inclusion offers a sustainable and economically viable alternative protein source for broiler production.

RECOMMENDATIONS

It is recommended that poultry farmers adopt Black Soldier Fly maggot meal as a partial replacement for conventional protein sources to reduce production costs. Further studies should evaluate higher inclusion levels and the impact on meat quality.

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CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interests regarding the publication of this article.

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