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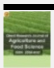

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Effect of full-fat black soldier fly larvae (*Hermetia illucens*) meal in the diet of broiler chickens

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ABSTRACT

One hundred and fifty Ross 308 Breed broiler chickens were used to investigate the effect of full-fat black soldier fly larvae (Hermetia illucens) meal in the diets of broiler chickens. The birds were randomly assigned to five treatments/diets in a Completely Randomized Design (CRD). Each treatment was made up of three replicates with 10 birds per replicate. With the exception of treatment one (T1) which is the control, the other treatments T2, T3, T4 and T5 contained incorporated full-fat Black Soldier Fly Larvae Meal (BSFLM), as replacement of fishmeal in the diets of broiler chickens at 25%, 50%, 75% and 100% respectively. The result showed that there were no significant (P>0.05) differences in values obtained for growth parameters except FCR. The FCR of diet 3 (50%) showed significantly (P<0.05) lower value than other diets (T1, T2, T4 and T5). Diet 3 (50%) showed significantly (P<0.05) higher values for cut-parts, especially in the prime parts (drumstick and thigh). Diet 3 (50%) also compared favourably with other treatment diets for organ weights. Conclusively, 50% replacement of fishmeal gave the best performance when full-fat BSFLM was fed to broiler chickens and is therefore recommended.

Keywords: *Full-fat Black soldier fly larvae meal, broiler chickens, growth performance, cut-parts, organ weight*

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INTRODUCTION

Poultry production, particularly the rearing of broiler chickens, represents a pivotal strategy for achieving sustainable and accelerated production of high-quality protein to address the growing nutritional demands of Nigeria's rapidly expanding population (Ogunbode et al., 2016; Okosun and Eguaoje, 2017; Ahmed et al., 2022). This is largely attributable to the short generation interval characteristic of broiler chickens, which facilitates efficient and rapid turnover in meat production (Akinmutimi and Iboro, 2012).

Feed constitutes a significant portion of the total production cost in poultry farming, making the reduction of feed expenses a critical objective for poultry farmers and animal nutritionists. The high cost and limited availability of conventional feed ingredients, such as maize and soybean meal, are exacerbated by competition with human food consumption, further driving up prices and creating supply challenges (Idahor, 2013).

Among the feed ingredients, protein and energy sources are the most expensive due to the fact that demand for them outweighs the supply (Okorie, 2006). Therefore, it is argued that the protein sources that are used directly by humans, should not be shared as ingredients in animal production systems. The search for alternative sources of animal feed resources with minimal or zero competition with man has been a subject of numerous cost-oriented studies (Emenalom *et al.,* 2009; Biasato *et al.,* 2018; Petkov *et al.,* 2022).

A search for cheaper, environmentally friendly animal protein is therefore essential. Insect protein is becoming of great interest in this regard. At present, there is a growing global interest on the use of insect as alternative animal protein source (Belluco *et al.,* 2013; Looy *et al.,* 2014; Kieronczyk *et al.,* 2022). Wageningen UR Livestock Research WUR (2012) advised that black soldier fly (BSF) prepupae as animal feed should be given serious consideration, noting their role in waste utilization and nutrient recycling. Dried BSF prepupae, according to Newton *et al.* (1997) contain 42% protein and 35% fat (on dry matter basis) while the live prepupae consist of 44% dry matter and can easily be stored for long periods. As a component of complete diet, the inclusion of larvae and pre-pupae of the *Hermetia illucens* has been researched in swine diets , aquaculture diets (St-Hilaire *et al.,* 2007; Sealey *et al.,* 2011) and poultry diets (De Marco *et al.,* 2015; Uuoshona, 2015), but most of these studies are in temperate countries. Hence, it is necessary to study the effects of black soldier fly larvae meal as an alternative protein source in broiler chicken diets in tropical countries like Nigeria. The present study is aimed at determining the effect of effect of full-fat black soldier fly larvae (*Hermetia illucens*) meal in the diet of broiler chickens in tropical countries like Nigeria.

MATERIALS AND METHODS

Source and processing of black soldier fly larvae (BSFL)

Meal

The Black soldier fly larvae was reared and supplied by a commercial company (The Fly Colony, Ilishan Remo, Ogun State) in 2 batches. The 2 batches of BSFL used for these experiments were produced under the same conditions: fed the same poultry manure as a substrate. Larvae was harvested after 14 days (enough time for larvae to have reached mature stage). Harvested larvae was dried in an oven at 90^{O}C (Peters *et al.,* 2017) and milled afterwards using JTC OmniBlend V Heavy duty professional blender TM-800 Model.

Experimental birds and their management

A total of one hundred and fifty (150) day old Ross 308 broiler chicks were purchased from a reputable hatchery or distributor in the study area. The chicks were brooded together with a 60W bulb in a brooding pen for the first 7 days, thereafter, they were randomly divided into 5 groups of 30 birds each. Each group was further subdivided (replicated) into 3 groups of 10 birds. The experimental phase lasted for 49 days. The birds were managed in deep litter pens during the brooding and rearing phases. Wood shavings served as the litter material. Experimental feeds and clean water were given *ad-libitum*, kerosene stove and lantern served as heat source. Birds were vaccinated against Gumboro disease at 7th and 18th day of life while Newcastle disease vaccine were administered at 12th day. Coccidiostats were also administered to the birds during the experiment.

Experimental diets

Five (5) experimental straight diets were formulated such that control diet 1 (T1) did not contain full-fat Black Soldier Fly larvae meal, while substituting the dietary fish meal composition at 25%, 50%, 75% and 100% for diets 2, 3, 4 and 5 (T_2, T_3, T_4 and T_5) respectively. The composition of the diets and calculated analysis are as shown in (Table 1).

Table 1: Percentage composition of Full-Fat Black Soldier Fly meal based Broiler Diets.

INGREDIENTS (kg)	T1	T2	T3	T4	T5
Maize	50	50	50	50	50
Soybean meal	16	16	16	16	16
Groundnut cake	14	14	14	14	14
Palm Kernel Cake	8	8	8	8	8
Wheat offal	6.2	6.2	6.2	6.2	6.2
Fish meal	2	1.5	1	0.5	-
Full fat black soldier fly meal	_	0.5	1	1.5	2
Bone meal	3	3	3	3	3
Lysine	0.2	0.2	0.2	0.2	0.2
Methionine	0.1	0.1	0.1	0.1	0.1
Vitamin Mineral Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total (kg)	**100**	**100**	**100**	**100**	**100**
Calculated composition					
Crude protein (%)	22.05	21.96	21.86	21.77	21.67
Energy (Kcal/kg ME)	2882.40	2894.60	2906.80	2919.00	2931.20
Crude fibre (%)	3.90	3.93	3.96	3.99	4.02
Lysine	1.18	1.17	1.16	1.15	1.14
Methionine	0.45	0.44	0.44	0.44	0.44

Analytical procedure

The full-fat Black Soldier fly larvae meal and their respective feeds were analyzed chemically for proximate composition and gross energy according to the official methods of analysis described by the Association of Official Analytical Chemist (AOAC, 2005). The experiment lasted for 49 days and data for weight gain and feed intake were collected weekly. Growth performance were carried out according to Scott *et al.* (1969). Carcass evaluation was carried out at the end of the experiment; this was as described by Scott *et al*. (1969) and reported by Ubak (2012).

Experimental design and statistical model

The design was completely randomized design. The statistical model for this design was:

$Y_{ij} = \mu + Ti + e_{ij}$

Y_{ij} = Single observation

μ = Overall mean

Ti = Effects of treatment

E_{ij} = Error term,

which is independently identically normally distributed with a zero mean and constant variance.

Table 2: Growth performance of broiler chickens fed full-fat BSFLM.

Parameters	T1 (Control) (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM
Initial weight (g)	198.33	198.33	200.00	198.67	198.33	0.53
Final weight (g)	2105.37	2074.23	2064.60	1816.27	2024.07	48.72
Weight gained (g)	1907.03	1875.90	1864.60	1617.60	1825.73	48.84
Average daily weight gained (g)	38.92	38.29	38.05	33.01	37.26	1.00
Total feed intake (g)	5142.44	5053.35	4984.91	5387.70	5106.66	137.86
Average daily feed intake (g)	104.95	103.13	101.74	109.95	104.22	2.81
FCR	2.71^{ab}	2.71^{ab}	2.68^{b}	3.31^{a}	2.81^{ab}	0.09

$^{a-b}$ Means treatment in a row with different superscripts are significantly different (P<0.0.5).
SEM = Standard error of mean
FCR = Feed conversion ratio

Table 3: Cut-parts (as expressed as % dressed weight) of broiler chickens fed full-fatBSFLM.

Parameters	T1 (Control) (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM
Live weight/bird (g)	1900.00	1900.00	1873.33	1866.67	2016.67	42.59
Dressed weight/bird (g)	1250.00	1316.67	1300.00	1333.33	1400.00	33.38
Dressing (%)	65.58	69.29	69.75	71.42	69.43	1.09
Breast-cut/bird (%)	34.39	36.16	35.49	34.60	35.48	0.48
Wing-cut/bird (%)	9.38b	12.18a	12.75a	11.84a	11.68a	0.40
Thigh/bird (%)	15.02	13.62	16.70	15.10	16.51	0.66
Drumstick/bird (%)	16.92^{a}	15.57^{ab}	17.08^{a}	14.79^{b}	15.60^{ab}	0.31
Back-cut/bird (%)	18.73	18.74	17.50	18.89	18.19	0.37
Abdominal fat/bird (%)	0.18^{ab}	0.30^{a}	0.31^{a}	0.17^{ab}	0.13^{b}	0.03

$^{a-b}$ Means treatment in a row with different superscripts are significantly different (P<0.0.5).
SEM = Standard error of mean.

All data analyses were done using IBM® SPSS version 20.0. The data were then subjected to descriptive analysis where the separation of means and standard deviation was computed. The data collected was subjected to analysis of variance (ANOVA) according to Steel and Torie (1980). The significant means were separated using the Duncan's Multiple Range Test as described by Duncan (1955).

RESULTS AND DISCUSSION

The growth performance of broiler chickens fed FFBSFLM is as shown in (Table 2). From the result, there was no significant (P>0.05) differences observed among treatment means such as initial weight, final weight, weight gained, average daily weight gained, total feed intake and average daily feed intake except for feed conversion ratio. From the result above, the non-significant differences across most parameters could be as a result of the high fat content of the larvae meal which resulted in the reduced feed intake and weight gain as the inclusion level increased; high fat in diets reduces palatability which may be related more to their oxidation at high temperature (Belluco *et al.,* 2013; Shantibala *et al.,* 2014), consequently increasing dietary energy density thereby decreasing feed intake, and a substantial increase in body weight gain.

Another potential contributing factor is the presence of chitin in Black Soldier Fly Larvae Meal (BSFLM). Chitin, being indigestible, has the capacity to bind proteins, thereby reducing their overall digestibility (Borelli et al., 2017; Longvah et al., 2011). Additionally, the relatively low bulk density of BSFLM, which ranges between 381.54 and 494.58 g/l, may also influence its utility as an animal feed. Bulk density is a critical parameter affecting feed intake, as a lower bulk density occupies less gut space and could consequently limit the feed intake of animals (McDonald et al., 2001; Ndou et al., 2013).

The feed conversion ratio showed that Diets T1, T2, T4 and T5 were statistically similar, but significantly (P> 0.05) lower than Diet T3. Among the diets, the value of Diet T3 with the least FCR (2.68) proved to be more superior, since the lower the FCR, the more superior the diet (Akinmutimi, 2004).

This result agrees with reports from Onsongo *et al.* (2018), who did not find any effect of insect diets on performance parameters like feed intake and body weight gain, but disagrees with his findings on non-effect of feed conversion ratio in broilers when being fed with BSFL at different inclusion levels up to 15%. It also agrees with reports by Attia *et al.* (2023) who reported that a 5% inclusion level of FFBSFLM in Abor Acres chickens did not significantly alter feed intake and body weight gain. Conversely, Heita *et al.* (2023) observed significant changes in Ross 308 chickens at the same 5% inclusion level, with a notable decrease in feed intake.

Table 3 shows the cut parts values of broiler chickens fed full-fat black soldier fly larvae meal. The result shows

Table 4: Organ weights (as expressed as % live weight) of broiler chickens fed full-fat BSFLM.

Parameters	T1 (Control) (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM
Liver/bird	1.87	1.65	1.96	1.76	1.58	0.06
Gizzard/bird	2.19	2.03	2.15	2.20	2.16	0.07
Kidney/bird	0.58	0.55	0.57	0.66	0.66	0.04
Heart/bird	0.45	0.42	0.44	0.40	0.37	0.02
Proventiculus/bird	0.47	0.44	0.43	0.45	0.41	0.02
Lungs/bird	0.57	0.65	0.72	0.64	0.74	0.04
Crop/bird	0.49^{b}	0.51^{b}	0.80^{a}	0.49^{b}	0.43^{b}	0.04
Spleen/bird	0.14	0.11	0.14	0.11	0.11	0.01
Pancreas/bird	0.38^{a}	0.33^{ab}	0.27^{ab}	0.37^{a}	0.23^{b}	0.02
Bile/bird	0.12	0.12	0.13	0.13	0.13	0.01
Small intestine/bird	3.95	3.19	4.08	3.30	3.25	0.19
Large intestine/bird	0.48	0.43	0.61	0.53	0.58	0.03

$^{a-b}$ Means treatment in a row with different superscripts are significantly different (P<0.0.5).
SEM = Standard error of mean

that wings, drumsticks and abdominal where significantly (P < 0.05) affected by the dietary treatments, but for dressed weight, dressing percentage, breast cut, thigh and back cut, there were no significant (P > 0.05) difference among the treatments. This result showed that the treatment diets support tissue development (Ayodele and Funmilayo, 2013). Studies by others have produced similar results, Schiavone *et al.* (2018) reported that supplementation of 10% BSFL had no effect on live weight, chilled carcass, breast and high, Onsongo *et al.* (2018) reported that supplementation at 5, 10 and 15% had no effect on breast meat weight.

For abdominal fat, values for diets T_1 and T_2 were statistically similar (P < 0.05) to diets T_2 and T_3 but significantly lower (P > 0.05) than diet T_5. The trend showed that the higher the inclusion level of full-fat BSFLM, the higher the abdominal fat deposit but inclusion levels higher than 50% (T_3) led to a decrease in abdominal fat this could be due to the prebiotic properties in the chitin which is responsible for low cholesterol levels. This is in contrast to reports by Schiavone *et al.* (2018) and Onsongo *et al*. (2018) who both reported no significant difference in abdominal fat in broilers fed FFBSFLM but agrees with Adegbenro *et al.* (2024) who recorded a linear response of abdominal fat increasing BSFLM levels.

Table 4 shows the mean weight of organs expressed as percentage dressed weight. There were significant (P < 0.05) differences for the value obtained for crop and pancreas but for gizzard, proventiculus, heart, spleen, liver, bile, kidney, lungs and intestines, there were no significant (P > 0.05) differences across the treatment groups. The increase in crop may be due to the bulkiness of the diets containing full-fat BSFLM, hence, the bigger volume of the crop, this is line with findings of Oluokun, 2000, Fathalla *et al.* (2015) and Esonu *et al.* (2006) who reported that increase in organs like gizzard and heart may be due to the bulkiness of the diets containing BSFLM.

For the weight of the pancreas, birds placed on control diet (T1) was statistically similar to birds placed on diet 4 (15%) but differed significantly (P < 0.05) from birds placed on diet 2, 3, and 5; the increase in weight of pancreas was probably due to increased metabolism of high energy in BSFLM based diets (Oluokun, 2000).

Conclusion

The study demonstrates that a 50% replacement of 65% fishmeal with full-fat black soldier fly larvae meal (BSFLM) in poultry diets (Diet 3) yields superior outcomes in terms of growth performance, specifically feed conversion ratio, compared to other experimental diets. Additionally, Diet 3 exhibited higher values for key cut-parts, including wings, thighs, and drumsticks, as well as the highest recorded liver weight among organ measurements. On average, the performance of Diet 3 was comparable to the control diet (Diet 1) across the evaluated parameters. Therefore, the inclusion of full-fat BSFLM at a 50% replacement level is recommended as a viable alternative to conventional fishmeal in poultry nutrition.

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