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UPGRADING THE NUTRITIVE VALUE OF FULL-FAT SOYABEAN MEAL FOR BROILER PRODUCTION WITH EITHER FISHMEAL OR BLACK SOLDIER FLY LARVAE MEAL (*HERMETIA ILLUCENS*)

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Target Audience: Poultry Scientists, animal nutritionists, feed millers and farmers.

ABSTRACT

An experiment was conducted using Anak Red broiler chicks to evaluate the effect of upgrading the nutritive value of full fat soyabean meal diet based with either fishmeal or Black soldier fly larvae meal for broiler production. The average live weight gains of broilers fed an all vegetable protein, fishmeal and larvae meal diets at 10 weeks of age were 1465g, 2045g and 2015g respectively. The corresponding feed consumption values for same period were 4140g, 4878g and 5075g respectively. While the figures for the feed/gain ratio were 2.8 2.4 and 2.6 respectively. Significant (P<0.05) treatment effects in favour of diet upgraded with the larvae meal were obtained in the carcass yield, internal organ measurements (kidney, gizzard and liver) and the abdominal fat. The amino acid profile of the larvae meal compared favourably with that of fishmeal and also found to be superior to that of soybean meal. The study suggests that inclusion of protein of animal or insect origin to an all-vegetable diet was very desirable for better nutrient utilization. The results also revealed that under the conditions of the experiment, larvae meal could replace fish meal to upgrade the nutritive value of soyabean meal in the broiler starter and finisher rations without any adverse effect on the rate of gain, feed consumption and feed: gain ratio.

Key words: Black soldier fly, larvae meal, soybean meal, fish meal, broiler.

DESCRIPTION OF PROBLEM

Full-fat soyabean is a valuable plant protein source that can be used to replace groundnut cake or reduce the conventional requirement of fish meal in monogastric feeds (1). However one of the limiting factors affecting its utilization is its relatively low contents of methionine and cystine which can be upgraded through supplementation with synthetic protein source or protein of animal origin. Some antinutritional factors in soyabean such as trypsin inhibitor, hemaglutins, saponins and estrogen, which limit the utilization by chicks have been identified (2). For on-farm mixing programme, raw soyabean seeds can be roasted or parboiled before feeding to remove or reduce the effect of anti-nutritional factors. Fishmeal is the conventional protein source for poultry but is very expensive for poor-resource farmers. Alternative non-conventional animal protein source although not widely

used is the larvae of Black Soldier Fly *(Hermetia Illucens)* which can be cultivated on-farm-in poultry litters (3.4). The larvae are relatively large measuring 1.9cm inch when fully developed with more or less flattened body and equipped with short projecting bristles (5). These larvae can be roasted, ground before being incorporated in poultry feeds (6). The suitability of Black Soldier fly meal from the stand point of amino acid profile in the diets of rabbits, chicks and pigs respectively has been reported (3,7,8). Maggot meal utilisation in poultry feed as replacement for soyabean meal (9) and fishmeal in laying hens (6,10) broilers (11) has been shown to be beneficial.

The present experiment was designed to evaluate the effect of upgrading full-fat soyabean based diet with either fishmeal or Black Soldier fly larvae on the performance and carcass quality of broiler birds.

MATERIALS AND METHODS

Processing of Samples.

Full-fat Soyabean: Raw soyabean seeds were roasted in hot pot. The roasted seeds were then ground, bagged and kept in a cool dry place for use.

Fishmeal:- The fishmeal purchased from commercial feed ingredient seller was kept in a cool dry place. Portions were weighed out for experimental feeds.

Larvae Meal Preparation: Large quantity of Black Soldier fly larvae were collected from a wild population growing in poultry litter at lower Ogun-Oshun River Basin Authority, Abeokuta. The larvae were washed clean under tap water in basket which allowed dirts to sieve through. The washing process was followed by roasting of the larvae to a 15% moisture content in a forced draft oven with a minimum temperature setting of 80 -100° C. The dried larvae were ground with a hammer mill and then mixed with 40 ppm of butylated hydroxy toluene (BHT) to stabilise the lipids before storage. Chemical analysis of the three major protein sources: roasted soyabean meal, larvae meal and fishmeal assessed in the nutritional studies were determined using AOAC (12) method.

Diet Preparation: Three isocaloric and is nitrogenous diets in accordance with recommendations of Olomu (13) were prepared for both starter and finisher phases of broiler production (Table 1). Diet A contained soyabean meal only, diet B contained soyabean meal plus fishmeal while Diet C contained Black Soldier Fly Larvae meal plus soyabean meal as sole protein sources. Larvae meal replaced fishmeal on equiprotein basis in diet C.

Experimental Design and Management

One hundred and eighty day-old Anak Red breed broiler chicks purchased from a local hatchery with a mean body weight of 35.1g were randomly allotted in groups of 20 birds per replicate. Three of such replicates were assigned randomly to one of the three diets in a randomized complete block design arrangement such that group average weights at day old were similar. The chicks were fed the starter ration for 5 weeks and finisher for another 5 weeks totalling 10 weeks. Feeds and water were made available *ad-libitum* through out the trial period. The chicks were raised in brooder pens (3.05m x 2m per pen), which were

Table 1: Composition of the Experimental Diets (%)

Ingredients	Diets[a]					
	Starter			Finisher		
	A	B	C	A	B	C
Maize	52.2	52.5	52.5	58.0	63.0	61.6
Soyabean meal (full-fat)	33.0	28.0	26.8	26.5	19.0	18.8
Black Soldier Larvae Meal	-	-	5.6	-	-	5.6
Fishmeal	-	4.5	-	-	4.5	-
Wheat offal	7.8	7.1	7.1	6.5	4.5	5.0
Brewers Spent Grains	3.5	3.5	3.5	4.5	4.5	4.5
Oyster Shell	1.0	1.0	1.0	1.0	1.0	1.0
Bone Meal	2.5	2.5	2.5	2.5	2.5	2.5
Vit. Min. Premix	.5	.5	.5	.5	.5	.5
Salt	.5	.5	.5	.5	.5	.5
Calculated analysis:						
Crude protein (%)	20.3	20.4	20.5	18.2	18.0	18.0
M.E. KCal/Kg ration	2820	2805	2845	3032	3025	3035

heated during the first 5 weeks of life of the chicks before being transferred to another spacious rearing pens. Continuous light was provided.

At the end of the finisher phase, two birds from each replicate making a total of six birds per treatment were randomly selected for carcass evaluation. The birds were weighed individually, slaughtered and had their feathers plucked. The heads and feet were removed, followed by dissection of the bird and removal of internal organs which were weighed

individually. Each carcass was weighed and carcass yield was calculated from the weight of the carcass expressed as a proportion of live weight. All data collected were subjected to the analyses of variance according to Steel and Torrie (14).

RESULTS AND DISCUSSION

The results of proximate analyses of Black Soldier larvae meal, fishmeal and roasted soyabean meal are given in Table 2. As a protein source, the larvae meal was of better quality than soyabean meal and slightly lower than the fishmeal. The amino acid profile (Table 3) indicated that protein quality of larvae meal was comparable to that of fishmeal and superior to the roasted soyabean meal. The larvae are a good source of limiting amino acids with particular reference to arginine, lysine and methionine. On the basis of proximate composition, the Black Soldier larvae meal tends to be a good source of protein, fat and minerals for chicks as reflected by the proximate values.

The performance characteristics of the chicks at both starter and finisher phases are given in Tables 4 and 5. Data obtained in the starter phase indicate that the inclusion of protein of animal origin (fishmeal and larvae meal) in diets B and C improved weight gain, feed intake and efficiency of feed conversion over diet A which contained protein of plant origin (Soyabean meal) only.

Table 2: Proximate composition of Test Ingredients

	Protein Sources [a]		
Component	**FFSB**	**FM**	**BSLM**
Dry matter(%)	90.9	91.3	88.6
Crude Fibre(%)	6.0	1.1	8.3
Ether Extract (%)	18.5	7.3	24.8
Ash (%)	4.8	10.4	13.8
Gross Energy (KCal/Kg)	4350	2850	4750

[a] FFSB; full fat soyabean; FM; Fish Meal BSLM: Black Soldier Fly Larvae Meal

Table 3: Amino Acid Composition of the Test Ingredients (% of dry matter)

	Test ingredients		
	Fish Meal	**Larvae Meal**	**Roasted Soyabean**
Arginine	4.1	3.7	2.5
Histidine	1.3	2.1	1.4
Lysine	4.8	3.8	2.6
Phenylalanine	1.3	3.4	2.5
Tyrosine	2.0	3.8	1.6
Leucine	4.7	3.5	3.7
Isoleucine	2.7	2.4	2.3
Methionine	1.9	1.7	0.6
Valine	4.8	2.7	2.1
Cystine	0.6	0.7	0.5
Alanine	6.9	3.5	2.0
Glycine	4.8	2.6	1.9
Glutamic Acid	13.0	11.2	8.8
Serine	2.4	2.3	2.4
Threonine	2.9	2.4	1.7
Aspartic Acid	11.0	7.6	5.5

Average weight gain during starter phase (weeks 1 -5) were 385. 555. 535g for treatment A.B. and C respectively. The corresponding feed intakes were 1415.5. 1408. 1505g. The calculated feed conversion ratio for treatment A. B. and C respectively were 3.7. 2.5 and 2.8. Differences in weight gain. feed intake and efficiency of feed conversion between rations enriched with fishmeal and larvae meal were not significantly different although chicks fed fishmeal diet grew at slightly faster rate than chicks fed larvae meal fortified diet. At the finisher phase. the results obtained indicate similar trend for all the parameters considered although values for both rate of gain and feed consumption were greater than values obtained at the starter phase. Average weight gain and feed intake at the finisher phase were 1180. 1490. 1480g: 2625. 3470. 3570g for treatments A. B and C respectively. The corresponding feed conversion ratio were 2.2. 2.3 and 2.4 for treatment A. B. and C respectively.

Table 4. Biological Evaluation of Upgraded Full Fat Soyabean Meal Based Diet During the Starter Phase.

Parameters	[a]FFSBM	FM	BSLM	SEM	[b] Significant Main Effect
Av. Initial weight (g).	35.3	35.3	35.3	0.0	NS
Av. Weight gain (g) 0 -5 weeks	385	555	535	14.6	*
Av. Feed Intake 0-5 weeks (g).	1415.5	1408	1505	8.5	NS
Feed: gain ratio 0-5 weeks	3.7	2.5	2.8	0.3	*

[a] FFSBM = Full Fat soyabean Meal
FM = Fish Meal
BSLM = Black Soldier Fly Larvae Meal
[b] NS = Non Significant;
* = $P < 0.05$

When the data for both starter and finisher phases were pooled for the respective parameters (table 6), there were no significant differences ($P \geq 0.05$) between birds fed fishmeal and larvae meal fortified diets. However significant difference ($P \leq 0.05$) existed between birds fed on diets containing protein of animal origin (fishmeal and larvae meal) and chicks fed roasted soyabean meal enriched diet for total weight gain and feed intake. There were no significant differences among treatments for feed: gain ratio.

The treatment means of the carcass yield and relative organ weights expressed as a proportion of live weight of randomly selected birds from each dietary treatment are given in Table 7.

There was a slight added advantage from including protein of animal origin on the carcass yield. The mean percent carcass yield were 64.8, 68.2 and 71.0% for broilers offered diets fortified with soyabean meal alone, or soyabean meal with larvae meal and fishmeal respectively. The results also show a significant increase in the size of the liver, kidney and gizzard of birds fed larvae meal fortified diet when compared to those fed either fishmeal or soyabean meal alone. Abdominal fat deposition followed similar trend as the organs.
The larvae meal was much higher in ash, fat and fibre content than either fishmeal or roasted soyabean. It has been reported that hypodermis of Black Soldier fly larvae secretes a deposit of high calcium carbonate which may then account for the high ash content (15).

Table 5: Biological Evaluation of Upgraded Full fat Soyabean Meal Based Diet During the Finisher Phase.

Parameters	[a]FFSBM	FM	BSLM	SEM	[b] Significant Main Effect
Av. Initial weight (g).	385	555	535	14.6	*
Av. Weight gain (g).. 5 -10 weeks (g).	1180	1490	1480	19.3	*
Av. Feed Intake (g). 5-10 weeks (g).	2625	3470	3570	20.2	*
Feed: gain ratio 5 - 10 weeks	2.2	2.3	2.4	0.1	NS

[a] FFSBM= Full Fat soyabean Meal FM= Fish Meal
BSLM = Black Soldier Fly Larvae Meal[b] NS =Non Significant; *= P < 0.05

Table 6: Biological Evaluation of Upgraded Full fat Soyabean Meal Based Diet During the Combined Starter and Finisher Phases.

Parameters	[a]FFSBM	FM	BSLM	SEM	[b] Significant Main Effect
Av. Initial weight (g).	35.3	35.3	35.3	0.0	NS
Av. Weight gain (g). 0-10 weeks	1465	2045	2015	21.4	*
Av. Feed Intake (g) 0-10 weeks	4140.5	4878	5075	20.6	*
Feed: gain ratio 0-10 weeks	2.8	2.4	2.6	0.1	*

[a] FFSBM=Full Fat soyabean Meal FM=Fish Meal BSLM=Black Soldier Fly Larvae Meal [b] NS=Non Significant; *=P < 0.05

Black Soldier fly larvae apparently store large quantities of fat as an energy source to carry them through pupation and this may be responsible for the high fat content of the larvae. It has been reported that the major food reserves of insects are triglycerides (16). As a source of protein, the Black soldier fly larvae are quantitatively better than the roasted soyabean and slightly poorer than fishmeal The amino acid profile indicated that Black Soldier fly larvae was fairly comparable to that of fishmeal and superior to that of roasted soyabean meal. Amino acid contents of the larvae meal compare favourably well with other reported results (8). The larvae are a better source of methionine than soyabean meal. The relatively low value of methionine for the roasted soyabean meal agrees with earlier reports that soyabean is deficient in methionine 1.17. (18). It is interesting to note from the data presented here that the performance of birds on diet containing larvae meal is identical with those on fishmeal diet. Higher
growth rate of broilers fed either fishmeal or larvae meal fortified diet when compared to an all vegetable protein diet confirms the earlier report of another study (19) that inclusion of protein of animal source into rations based on soyabean meal is desirable for proper utilization of plant protein source. This might probably be due to complimentarity of the amino acids from the two sources.

Table 7. Effect of Upgraded Full Fat Soyabean Based Diet on Carcass Yield and Organ Measurements

	Diet [a]				
Parameters	FFSBM	FM	BSLM	±SE	[b] Significant Main Effect
Carcass yield %	64.8	68.2	71.0	1.5	*
Heart g/100g live weight	0.4	0.5	0.8	0.1	NS
Kidneys g/100g live weight	0.6	0.6	2.6	0.1	*
Lungs g/100g live weight	0.6	0.5	0.5	0.3	NS
Gizzard g/100g live weight	2.9	2.4	3.3	0.0	*
Liver g/100g live weight	1.7	1.9	2.3	0.1	*
Abdominal fat g/100g live weight	2.3	1.5	3.0	0.3	*

[a] FFSBM=Full Fat Soyabean Meal FM=Fish Meal
BSLM=Black Soldier Larvae Meal [b] NS =Non Significant *=P 0.05

The aspect of organ weights have not been covered by previous workers. The trends here showed significant increases in the weights of the kidney, gizzard, liver and abdominal fat deposit of birds fed larvae meal fortified diet. The bulkiness of the diet containing larvae meal probably contributed to a greater volume of the gizzard than for the other two diets. This means that birds on this larvae meal fortified diet would have to handle a greater volume of feed for each unit of weight when compared to birds fed either fishmeal or soyabean meal alone fortified diet.

Since gizzard is an organ involved in digestion, it may be that there was some enlargement of the gizzard to cope with increased volume of feed. This is in consonance with the findings from another study (20) in which diets with varied levels of protein and energy were offered. The significant increase in the weight of kidney and liver could probably be due to the significance of these organs in the metabolism of excess energy presented to them. It was reported that the fat content of the carcass was a direct reflection of the energy value of the diet (20,21).

CONCLUSION AND APPLICATIONS

In conclusion, the results of the present experiment clearly show that Black Soldier fly larvae meal can replace fishmeal to upgrade full fat soyabean in broiler diet. This will help to reduce the cost of production.

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