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COMPARATIVE EFFECTS OF THREE DIFFERENT PROTEIN SOURCES (FISHMEAL MAGGOT MEAL AND GRASSHOPPER MEAL) ON THE GROWTH PERFORMANCE AND NUTRIENT RETENTION OF PULLET CHICKS

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A B S T R A C T

This experiment was conducted to evaluate the comparative effects of three different animal protein sources (fish meal, maggot meal and grasshopper meal) on the growth performance and nutrient digestibility of pullet chicks. Two hundred and seventy-day-old pullets were assigned to 9 dietary treatments in a factorial design with thirty birds consisting of 10 chicks per replicate. Feed and clean water were provided ad libitum throughout the experimental period which lasted for 8 weeks. Diets were formulated to contain 1%, 2% and 3% fish meal, maggot meal and grasshopper meal respectively. Data collected was used to determine the average daily weight gain, total feed intake, feed conversion ratio and nutrient retention. Result showed that there was no significant ($p>0.05$) difference in total feed intake (g) and feed conversion ratio, Weight gain (g) and nutrient retention of dry matter, crude protein, crude fibre and ether extract were significantly influenced ($p<0.05$) among the treatments. It was concluded that inclusion of 1%, 2% and 3% replacement of fish meal with maggot meal and grasshopper meal respectively has no adverse effect on general performance of pullets.
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K E Y W O R D S

Fish meal, Maggot meal, Grasshopper meal, Pullets, Performance

Introduction

The use of conventional feeds is becoming popular in Nigeria and many other developing nations, before now livestock were fed on soya beans, fishmeal and groundnut cake as main protein source and maize as main source of energy. This practice has put the livestock industry into direct competition with man for these feed ingredients. Consequently, the prices of conventional feed stuff increased to the level that their inclusion level completely eroded the expected profit of the farmers (Njidda and Isidahomen, 2010; Alagbe, 2018). Due to the aforementioned situation, many researchers (Awoniyi *et al.*, 2003, Adeniji, 2007, Njidda and Isidahomen, 2010) have replaced fishmeal with other animal protein sources in order to stop the threat and competition with human being and poultry birds in food security.

Replacement of fishmeal with maggot has been used in Nigeria (Adeniji, 2007). The bulk of expenses in poultry production go to the procurement of feed alone representing about 60% of the cost incurred on poultry production (Awoniyi, 2003). Fish is a nutritious protein been consumed by Man and animals. Maggot is cheaper, with more nutritional value. It is easy and not expensive to produce when compared with other protein sources such as fish meal. Normally, maggots are sources of environmental pollution at numerous farms, however, its production and conversion to alternative protein source for livestock make it good option for environmental nuisance management (Makinde, 2015).

Maggot is a worm shaped larva of housefly origin it is found in decaying matter, especially at poultry farm where layer birds are reared in cages, abattoirs and dumpsites. Poultry droppings provides excellent environment to coprophagous insects like housefly for breeding/laying its eggs which develops to larva or maggots. Generally, Maggot Meal has been reported to be a cheaper and efficient replacement for fishmeal and Groundnut cake in poultry diet (Awoniyi *et al.*, 2003 and Adeniji, 2007). The willingness and acceptance of insect-based animal feed is currently favorable around the globe, farmers are ever willing to use insect-based feed as this serves as an in-expensive avenue for meeting the high demand of animal feed to improve the availability of protein source in animal diet and meet the global demand for livestock products. However, the acceptance of food products obtained from animals fed with insect-based feed by final consumer is low. Consumers believe that; the microbiological safety is questionable (Wim *et al.*, 2015).

Technically, the replacement of fishmeal with maggot meal is highly accepted by researchers. Quality and quantity of maggot meal have been evaluated and the results suggested that it is economical for farmers and palatable to poultry birds. The use of fishmeal in poultry feed has a negative environmental impact assessment, amount of fish that supposed to be eaten by human being is increasingly been converted into poultry feed, this invariable cause a kind of competition for this scarce resource (fish), (Maria-Jose *et al.*, 2014). The importance of maggot meal in poultry feed is enormous, at the moment it is the cheapest alternative protein source use by some farmers in preparation of poultry ration.

Many attempts have been made to find alternative to fish meal which is an expensive feed ingredient to non-expensive and relatively abundant nutrient substrate to partially or totally replace fishmeal which is high in cost because is a conventional feed stuff. Non edible insect to human being like maggot, earth worm have been researched on to check for their nutrient contents, relative in abundance and were processed into meal which are incorporated to formulate diet and subsequent development of technique(s) for commercial farm production and maggot has been find to be among the best alternative because it has high nutritional value and is cheaper and not tedious to produce than other animal protein source, It is produce from waste that can cause nuisance to the environment (Makinde, 2014).

Studies have been carried out that maggot meal can completely replace fish meal on equal protein basis in broiler chicken diet without significant effect on weight gain, feed consumed and feed efficiency. In the study the carcass and muscle revealed that there is no variation in the carcass and muscle development. Therefore, including non-costly feed ingredients like maggot meal with the costly and competitive feed ingredients like fishmeal would be replaceable by locally available maggot meal which similar in amino acid profile (Awoniyi *et al.*, 2003). In the process of using animal protein Black soldier fly larvae has been used as a component of total diet in poultry which has been found to support adequate growth in chicks, it has been used to replace soya bean meal and the weight gain of the birds fed with the black soldier larvae and the soy bean meal has no significant difference and they consumed more feed which means there is high feed conversion ratio of the diet containing the black soldier larvae meal. A 7-month layer feeding trial was also conducted by replacing fish meal with maggot meal and the results shows increased in egg yield and hatchability without any negative effects on egg production and shell strength but 100% replacement can be dangerous to hen-egg production. (Makkar *et al*., 2014).

Scientifically grasshopper falls under the order orthoptera family (four-winged insect). There are numerous grasshopper, among it are; American, Long-horned, short-horned and pygmy grasshopper. Grasshoppers are known to have high capacity for destroying farm crops and causing great damage to farm crops which leads to financial loss, could be turned to feed ingredients which will be of great advantage because this will reduce cost of feed and also serve as pest control. Protein content of grasshopper meal ranges from 43.9-77%. Grasshopper can contribute positively because of its amino acid content composition for poultry due to the contents of lysine, methionine and cysteine and might constitute a new source of dietary nitrogen for poultry. (Brah *et al.*, 2018)

In Western part of Africa, Grasshoppers and Locusts have been used to feed animals and they have great positive impact as is a more affordable source of protein in poultry diets. Grasshoppers has been used to replace fish meal in broiler chicken and it was observed that 50% grasshopper meal (*Schistocerca gregaria*) replacement do not affect broiler weight gain and its use did not cause physiological disorders in broilers, No significant effect on broiler weight gain, feed intake and feed conversion ratio. (Brah *et al.,* 2018). Grasshoppers are major pests that destroy several food crops like maize, vegetables, beans and the likes. They result in poor farm produce growth which leads to poor yield. They are mainly found in Sahara deserts, especially in Maiduguri. It will be a good measure, if these pests become a replacement for animal protein source in formulating feed for our growing animal industries. Unlike fishmeal, that has more demand by man and animals alike, only few percentage of the human population consumes grasshopper in some cultures around the globe.

Therefore, the aim of this study was to evaluate comparative effects of three different protein sources (fishmeal maggot meal and grasshopper meal) in the diets of pullet chicks.

Experimental Site

The experiment was carried out at the University of Abuja Teaching and Research Farm, Animal Science Section, Main Campus, along Airport Road, Gwagwalada, Abuja, Nigeria. Gwagwalada is the headquarters of the Gwagwalada Area Council and is located between latitude 8°57′ and 8°5′N and longitude 7° 05′ and 7° 06′E. The temperature of Gwagwalada ranges from 28-33 °**C** in the day time and 22-25 °**C** in the night. The area is dominated by two main seasons: wet seasons, which starts from the month of April to October, and dry season, which is between the month of November and March (Balogun, 2001).

Sources and processing of test materials

Fresh live maggots were collected at the poultry deep litter system in the poultry unit at the teaching and research farm using a 3mm sieve, washed and oven dried at 35 °C for 2 hours. The sample was removed from the oven and air dried. It was later blended into meal using laboratory blender and stored in an air tight labeled container for further analysis. Grasshoppers were purchased from an open market in Maiduguri, Borno State, Nigeria. It was grinded into powder using an electric grinder and stored in an air tight container.

Proximate analysis

Proximate components of Maggot and Grasshopper meals were determined according to AOAC (2000). Procedure for proximate analysis is to determine the dry matter content of the feedstuff. The dry matter procedure removes the free water from the sample. To perform the procedure the original sample is weighed, the weighed sample is placed in a 105 degree Celsius oven for 12-16 hours and the sample is re-weighed, The dry matter and moisture content of the feedstuff is calculated, The crude protein, crude fibre, estimate the quantity of protein and non-protein nitrogen compounds in the feedstuff

Metabolic trial

The metabolic trial was carried out at the end of 8th week of the experiments, 6 experimental birds per treatment (2 broiler birds per replicate) were randomly selected and kept separately in appropriate metabolic cages equipped with individual feeders, water troughs and facility for separate excreta collection for each experiment. A 3-day acclimatization period was allowed prior to the commencement of 3-day metabolic trial. The weight of feed given to each was recorded. The total droppings voided from the birds were collected in a labeled aluminum foil daily, weighed wet and dry in the oven at 65^0C to constant weight. The dried droppings from the sample replicate were pooled and ground. The dried, pooled and ground samples were analyzed for crude protein, crude fibre, ether extract and ash according to standard procedures of AOAC, (2000).

The Apparent Digestibility was calculated using the formula:

$$\text{Dry Matter Digestibility}= \frac{weight\ of\ feed\ intaake\ (DM) - wt.of\ dropping\ (DM}{Weight\ of\ Feed\ Intake\ (DM)} \times \frac{100}{1}$$

Also, the Digestibility Crude Protein (DCP) was calculated from the result of proximate composition of both the feed and faecal samples as follows:

$$\text{DCP}= \frac{feed\ intake\ (DM) \times \%CP\ in\ diet - Droppings\ (DM) \times \%CP\ in\ droppings}{Feed\ Intake\ (DM) \times \%CP\ in\ diet} \times \frac{100}{1}$$

Chemical analysis

The Proximate composition (CP, CF, EE and Ash) of the test ingredients were determined according to the standard procedures of (AOAC 2000). Calcium and phosphorus of the test ingredients were determined by the methods of Grueling (1966). Gross energy of the ground samples was determined using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd., Cambridge, UK).

Experimental birds, design and their management

Two hundred and seventy, day-old pullet chicks (Isa brown) were purchased from a commercial hatchery in Ibadan CHI farm and transported to University of Abuja Teaching and Research Farm, Gwagwalada Abuja. Prior to the commencement of the experiment, the pens were properly clean and disinfected; Drinkers and feeders were thoroughly washed and disinfected as well. On the arrival of the chicks to the farm, The chicks were weighed and feed too was weighed before being fed to the chicks and the leftover of the feeds too were weighed subsequently throughout the period of the experiment and this were done to determine the weight gain, feed intake and feed conversion ratio of the pullet chicks, For proper identification the pullets chicks were wing–banded, distributed randomly into 9 treatments of 3 replicates each consisting of 10 birds in a 3x3 factorial experimental arrangement. Electric bulbs and charcoal pots were used as source of heat. Light was also provided approximately 24 hours in a form of natural light during the day and artificial light during the night. Birds were kept under similar conditions of management throughout the experimental period. Vaccination was done according to the prevailing disease condition in the environment. Water soluble multi-vitamins (Biovite super® at 1 ml to 5 litres of water) was given to the chicks before 3 days of vaccination and 3 days after vaccinations in order to guard stress. Feed and clean cool drinking water was provided to the experimental bird's *ad-libitum* throughout the experimental period of 56 days

Experimental diets

Basal diet was formulated according to the nutritional requirements of birds (NRC, 1994). Nine (9) dietary treatments were used during the course of the research containing diets 1-9 as shown on figure 1 below. Diets (1, 2, 3), (4, 5, 6,) and (7, 8, 9) were formulated to contain 1%, 2% and 3% inclusion level of fish, maggot and grasshopper meal respectively.

Data collection

The initial weights of the birds were recorded at the commencement of the study and subsequently weighed on a weekly basis to determine the weight gain. Daily weight gain per bird per day was calculated by dividing the weight of chicks in each replicate by the number of chicks in the replicate and also by the duration of the experimental period. Feed intake was calculated by subtracting the weight of leftover feeds from the original weight of the feed supplied.

Feed conversion ratio was calculated by dividing total feed intake by the total weight gain in each replicate

$$\text{Feed conversion ratio} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

The birds were weighed at the end of the experiment to determine the final live weight while mortality was recorded as it occurred.

Statistical Analysis

All data obtained, from growth performance and nutrient digestibility were subjected to statistical analysis using the general linear model procedure of SAS (2001) for the analysis of variance (ANOVA). Significant difference among treatment means were separated using the Duncan's Multiple Range Test (Duncan, 1955). Means were considered different at $P < 0.05$.

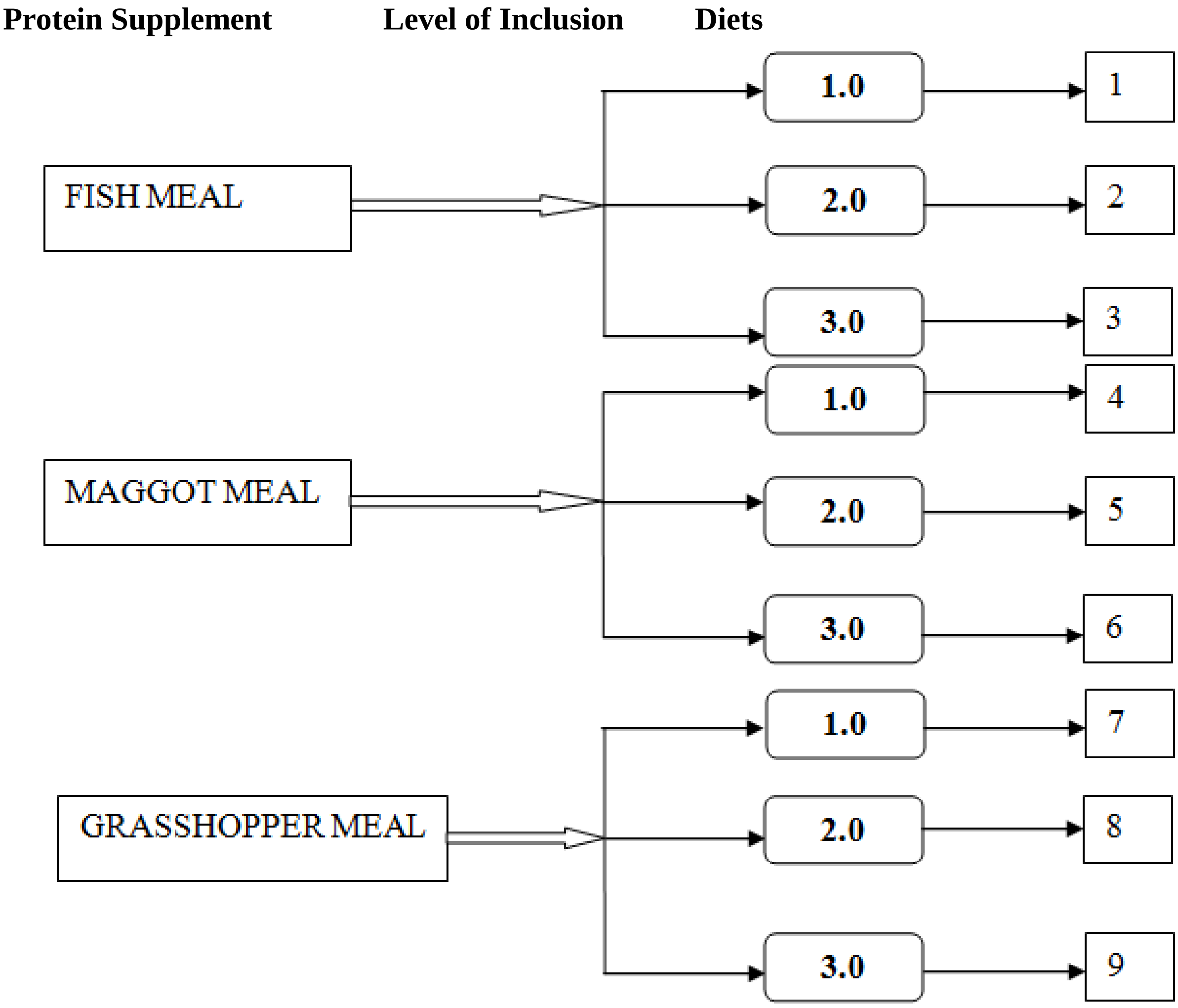

Figure 1. Experimental Layout

Table 1: Compositions of experimental diets

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7	Diet 8	Diet 9
Fish meal	1.00	2.00	3.00						
Maggot Meal				1.00	2.00	3.00			
Grasshopper Meal							1.00	2.00	3.00
Maize	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Groundnut Cake	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Wheat Offal	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50	15.50
Palm Kernel Cake	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Lime Stone	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Bone Meal	5.00	4.00	3.00	5.00	4.00	3.00	5.00	4.00	3.00
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
*Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Calculated Analysis									
Crude Protein	20.46	21.17	21.43	20.34	20.91	21.43	20.41	21.07	21.44
Crude Fibre	4.16	4.17	4.19	4.23	4.24	4.29	4.19	4.25	4.33
Ether Extract	4.47	4.51	4.57	4.68	4.93	5.18	4.56	4.71	4.81
Dry Matter	88.68	89.86	90.64	88.72	89.69	90.67	88.68	89.66	90.64
Metabolizable Energy	2928.53	2959.71	3022.04	2919.53	2942.28	2967.28	2967.28	2972.29	2979.75

*Premix – quantity per Kg of product: vitamin A, 2500 IU; vitamin D3, 50000 IU; biotin 50 mg; choline 50 mg; niacin 3000 mg; vitamin B12, 7 mg; vitamin B2, 1800 mg; vitamin E, 7500 mg; vitamin K3 1000 mg; Fe, 4000 mg; Mn, 2000 mg; Zn, 4000 mg; Co, 360 mg; Mg, 840 mg; Se, 120 mg.

RESULTS

Proximate Composition of Maggot and Grasshopper meal

The results of the Proximate composition of the maggots and grasshopper meal are presented in the Table 4.1 below which shows the Average dry matter content of 89.67%, Crude protein of 59.34 %, Crude fibre of 4.34 %, Ash of 9.44 %, Ether extract of 23.46 %, Nitrogen free extract 3.43 % and Metabolizable energy of 2500 kcal/kg for Maggot and Grasshopper Dry matter of 90%, Crude protein 61.45%, Crude Fibre 5.44%, Ash of 1.98%, Ether extract 13.11% and metabolizable energy of 2520 kcal/kg as indicated in the table 2.

Table 2: Proximate and Energy composition of Maggot meal and Grasshopper meal

Parameters	DM %	CP%	C F%	Ash %	E E%	MEkcal/kg
Maggot	89.67	59.34	4.34	9.44	23.46	2500
Grasshopper	90.00	61.45	5.44	1.98	13.11	2520

DM: Dry Matter, CP: Crude Protein, CF: Crude Fiber, EE: Ether Extract; ME: Metabolizable Energy

Averages of growth performance of pullet chicks fed diet of different animal protein sources at 1, 2 and 3 % inclusion level

Table 3 below shows the averages of growth performance of pullet chicks fed diet of different animal protein sources that there were no significant ($p>0.05$) in the Initial weight, Average daily weight gain and Average feed intake and feed conversion ratio, however there were significant ($p<0.05$) difference in final weight and weight gain and mortality rate.

Table 3: Growth performance of pullet chicks fed diet of different animal protein sources at 1, 2 and 3 % inclusion level

Diets	Initial weight(g)	Final weight(g)	Weight gain(g)	ADWG(g)	Feed Intake(g)	ADFI(g)	FCR (%)	Mortality (%)
Fishmeal	59.83	630.10^{b}	570.27^{b}	11.19	2190.55	39.12	3.84	0.00^{c}
Maggot meal	59.98	632.36^{a}	572.38^{a}	11.24	2190.55	39.15	3.83	3.67^{b}
Grasshopper meal	59.92	628.01^{c}	568.09^{c}	11.19	2191.71	39.13	3.86	14.11^{a}
SEM	0.53	0.50	0.65	0.01	0.51	0.01	0.01	1.05
LOS	NS	**	**	NS	NS	NS	NS	**

[a,b,c] Means with different superscripts within the column differ significantly (p<0,05)
LOS-Level of significant, SEM-Standard error of mean, ADWG-Average daily weight gain, ADFI-Average daily feed intake; FCR-Feed conversion ratio.

Growth performance of pullet chicks fed diets containing different animal protein sources at 1 % inclusion level

Table 4 shows the growth performance of pullet chicks fed diets containing different animal protein sources at 1 % inclusion level, there was significant ($p<0.05$) difference in the Final weight, weight gain and average daily weight gain similarly there is significant ($p<0.05$) difference in the mortality rate of pullet chicks fed 1 % replacement of fishmeal with maggot and grasshopper meal. However, there were no significant ($p>0.05$) difference in Initial weight, Feed conversion ratio and Feed intake of pullet chicks fed the experimental diets.

Table 4: Growth performances of pullet chicks fed diets containing different animal protein sources at 1% inclusion level

1 % Diets Inclusion Level	Initial weight(g)	Final weight(g)	Weight gain(g)	ADWG(g)	Feed Intake(g)	ADFI(g)	FCR	Mortality%
Fishmeal	59.75	630.00 ^{a}	570.25^{a}	11.25	2190.38	39.11	3.84	0.00 ^{a}
Maggot meal	57.50	6625.25 ^{c}	567.75^{b}	11.17	2190.67	39.12	3.86	0.00 ^{a}
Grasshopper Meal	60.00	627.50 ^{b}	567.50^{b}	11.21	2191.83	39.12	3.86	10.33 ^{b}
SEM	0.58	0.63	0.93	0.01	0.55	0.01	0.01	1.24
LOS	NS	**	**	NS	NS	NS	NS	**

[a,b,c] Means with different superscripts within the column differ significantly (p<0.05)
LOS-Level of significant, SEM-Standard error of mean, ADWG-Average daily weight gain, ADFI-Average daily feed intake, FCR-Feed conversion ratio.

Growth performance of pullet chicks fed diets containing different animal protein sources at 2% inclusion level

Table 5 shows the effects of replacement of fishmeal with maggot and grasshopper meal in the diets of pullet chicks. There is no significant ($p>0.05$) difference in the Initial weight, Feed intake, Average daily feed intake and Feed conversion ratio. However, result shows significant ($p<0.05$) difference in the mortality rate, final weight and weight gain

Growth performance of pullet chicks fed diets containing different animal protein sources at 3% inclusion level

Table 6 below shows the results of growth performance of pullet chicks fed diets containing different animal protein sources at 3% inclusion level, there were no significant ($p>0.05$) difference in the Initial weight, Average daily weight gain, Feed intake and Feed conversion ratio. However, result showed significant ($p<0.05$) difference in Final weight and mortality rate.

Table 5: Growth performance of pullet chicks fed diets containing different animal protein sources at 2% inclusion level

2% Diets Inclusion Level	Initial weight(g)	Final weight(g)	Weight gain(g)	ADWG(g)	Feed Intake(g)	ADFI(g)	FCR	Mortality%
Fishmeal	55.70	625.67^{b}	569.97^{a}	11.17	2191.00	39.12	3.84	0.00^{a}
Maggot meal	57.85	630.00^{a}	572.15^{b}	11.25	2190.77	39.12	3.83	3.33^{b}
Grasshopper Meal	60.00	626.27^{c}	566.27^{c}	11.18	2191.63	39.14	3.87	14.67^{c}
SEM	0.59	0.61	0.94	0.22	0.51	0.02	0.02	1.22
LOS	NS	**	**	NS	NS	NS	NS	**

a, b, c means with different superscripts within the column differ significantly ($p<0,05$)
LOS-Level of significant, SEM-Standard error of mean, ADWG-Average daily weight gain, ADFI-Average daily feed intake, FCR-Feed conversion ratio.

Table 6: Growth performance of pullet chicks fed diets containing different animal protein sources at 3% inclusion level

3% Diets Inclusion Level	Initial weight(g)	Final weight(g)	Weight gain(g)	ADWG(g)	Feed Intake(g)	ADFI(g)	FCR	Mortality%
Fishmeal	54.42	625.00^{b}	570.58	11.16	2190.33	39.12	3.84	0.00^{a}
Maggot meal	55.27	632.50^{a}	577.23	11.29	2190.13	39.11	3.79	7.67^{b}
Grasshopper Meal	57.75	626.27^{b}	568.52	11.18	2191.67	39.14	3.85	17.33^{c}
SEM	0.53	0.50	0.93	0.01	0.51	0.01	0.01	1.20
LOS	NS	**	NS	NS	NS	NS	NS	**

[a,b,c] Means with different superscripts within the column differ significantly ($p<0,05$)
LOS-Level of significant, SEM-Standard error of mean, ADWG-Average daily weight gain, ADFI-Average daily feed intake, FCR-Feed conversion ratio.

Growth performance of pullet chicks fed diets containing different animal protein sources at 1 %, 2 % and 3 % inclusion level

There was no significant difference (p>0.05) in the initial bodyweight of the chicks, the mean initial weight of the chicks was 59.91 ± 0.59g as presented in Table 7. There were significant (p>0.05) difference in the final body weight of the chicks; the final bodyweight was 627.61 ± 0.65 g at the end of the trial. The body weight gain of the chicks for the experimental period was not significantly different (p>0.05) among the groups of the dietary treatment, the mean bodyweight gain was 570.02 ± 0.96 g as shown in the Table 7. Meanwhile, there was no significant difference (P>0.05) in the average daily weight gain of the chicks which was 11.21 ± 0.01 g, the details are presented in Table 7 below.
The total feed intake for the period was also not significantly difference (P>0.05) for the groups which was 2190.82 ± 0.58 g as presented in Table 4. 6 Similarly, there was no significant difference (p>0.05) in the daily feed intake of the experimental birds which was 30.12 ± 0.01 g and the feed conversion ratio and the mean value is 3.84 ± 0.01respectively as shown on Table 7. The final bodyweight of the bird was higher in the groups T1, T3, T5 and T6 compared with other groups; the minimum and maximum bodyweight gain were 625.00 g and 632.50 g respectively. Similarly, the groups T1, T3, T5 and T6 had higher average daily body weight gain compared with other experimental groups while the mortality rate was significantly different (p<0.05), the mean mortality was 6.00 ± 1.00 %. While the lowest mortality was found in the T1, the highest mortality was found in the T9; the mortality range between 0.00 and 18.00 % respectively as shown on Table. 7.

Table 7: Growth performance of pullet chicks fed diets containing different animal protein sources at 1 %, 2 % and 3 % inclusion level.

Diet	Initial weight(g)	Final weight(g)	Weight gain(g)	ADWG (g)	Feed intake(g)	ADFI(g)	FCR	Mortality %
T1	59.75	630.00	570.25	11.25	2190.33	39.11	3.84	0.00
T2	55.70	625.67	569.97	11.17	2191.00	39.12	3.84	0.00
T3	54.42	625.00	570.58	11.16	2190.33	39.11	3.84	0.00
T4	57.50	625.25	567.75	11.17	2190.67	39.12	3.86	0.00
T5	57.85	630.00	572.15	11.25	2190.77	39.12	3.83	3.33
T6	55.27	632.50	577.23	11.29	2190.13	39.11	3.79	7.67
T7	60.00	627.50	567.50	11.21	2190.83	39.12	3.86	10.33
T8	60.00	626.27	566.27	11.18	2191.63	39.14	3.87	14.67
T9	57.75	626.27	568.52	11.18	2191.67	39.14	3.85	17.33
SEM	0.59	0.65	0.96	0.01	0.58	0.01	0.01	1.28
LOS	NS	**	**	NS	NS	NS	NS	**

LOS-level of significance, SEM-Standard error of mean, ADWG-Average daily weight gain, ADFI-Average daily feed intake, FCR-Feed conversion ratio, T1-1 % inclusion of fishmeal, T2-2 % inclusion of fishmeal, T3-3 % inclusion of fishmeal, T4-1 % inclusion of maggot meal, T5-2 % inclusion of maggot meal, T6-3 % inclusion of maggot meal, T7-1% inclusion of grasshopper meal, T8-2 % inclusion of grasshopper meal, T9-3 % inclusion of grasshopper meal.

Nutrient digestibility of pullet chicks fed diets containing different animal protein sources

Table 8 shows the nutrient retention of pullet chicks fed diets containing different animal protein sources. There was no significant difference (p>0.05) in Dry matter and Crude protein, the minimum and the maximum values of dry matter are 57.30 and 57.90 % while the minimum and maximum values of crude protein are 64.17 and 72.22% respectively. However, there were significant difference in (p<0.05) in Crude fibre and Fat of the pullet chicks, also minimum and maximum values of crude fibre is 34.80 and 46.02 and the minimum and maximum values of fat are 74.13 and 89.50 respectively.

Table 8: Nutrient digestibility of pullet chicks fed diets containing 3 different animal protein sources (fish, maggot and grasshopper meals)

Diet Inclusion	% DM	% CP	% CF	Ether Extract
T1	57.70	64.17	37.09	82.74
T2	57.30	64.83	34.81	89.50
T3	57.70	72.22	46.02	85.61
T4	57.80	68.39	39.15	74.14
T5	57.06	72.22	45.52	74.63
T6	57.40	65.79	46.02	74.13
T7	57.90	68.66	37.09	75.13
T8	57.30	64.17	36.67	85.61
T9	57.30	64.83	36.87	85.11
SEM	0.30	0.34	0.25	0.36
LOS	NS	NS	**	**

a, b, c means with different superscripts within the column differ significantly (p<0,05)

LOS-Level of significance, SEM-Standard error of mean, DM-Dry matter, CP-Crude protein, CF-Crude fibre

DISCUSSION

Proximate composition of maggot and grasshopper meal

The results on proximate composition of maggot and grasshopper meals shows some similarities and differences, The crude protein of grasshopper and maggot meals obtained in this study are 61.45% and 58.86% respectively .the crude protein value of maggot meal obtained in this study is similar to the value (55.1 % CP) reported by (Awoniyi *et al.*, 2003) which is higher than the crude protein of maggot which is 53.86 % and the value of the crude protein of maggot is similar to that report by (Awoniyi *et al*., 2003) which is 55.1%. This crude protein of maggot which is 53.86 % is in line with initial crude protein which varied from as high as 64 % (Hwangho *et al*., 2009) to as low as 39.16 % (Atteh and Ologbenla,1993). (Makkar *et al*., 2014) also reported a similar crude protein for grasshopper which ranges from 57.90 - 65.90 %, The crude fibre of grasshopper is 5.44 % which is closer to cruder fibre of maggot which is 4.34 %, Dry matter of grasshopper is 90.00 % and is similar to dry matter of maggot which is 89.67 %, The ash content of maggot is 9.44 % while the ash content of grasshopper is lower which is 1.98 %. On the other hand, the level of ether extract of maggot is 23.46 % which is relatively higher than that of grasshopper which is 13.11 %. However, (Makkar *et al.*, 2014) reported an ether extract that are within similar range which is 14.10 %.

Growth performance of pullet chicks fed different animal protein sources

The similarity in performance observed in the final live weight of pullet chicks fed diet containing different protein sources agreement with the report of (Teguia *et al.*, 2002) who opined that maggot meal supplementation has no significant effect on the body weight of pullets chicks The parameters measured in the growth performance of the pullets chicks fed diet of different animal protein sources which are initial weight, Average daily weight gain, feed intake, average daily feed intake and feed conversion ratio, However there was significant difference in final weight gain and mortality rate at the end of the experiment, The initial body weight of pullets chicks fed maggot meal and grasshopper meal were similar at the beginning of the experiment which shows that the pullets had equal opportunity to perform, This was to avoid variation in the experiment. The values of average daily weight gain, feed intake and feed conversion ratio of the experimental bird fed maggot meal and fish meal were all similar and not differ to fishmeal which is the control. Similarly, the final weight gain and entire body weight gain of the pullet chick fed diet of maggot meal and fish meal were significantly difference and similarity of performance observed in the final weight and body weight gain shows the two dietary treatment contain high crude protein in the diet and may be as a result of high feed intake of the diets because it was observed that the pullet chicks has similar feed intake in all the groups. These findings agree with that of (Hassan *et al*., 2009; Alagbe, 2017) who reported that grasshopper meal constitute high protein rich concentrate that can be used as protein supplement for broilers and that weight gain is as a result of feed digestibility and palatability. (Teguia *et al*., 2002, Agubosi *et al*., 2022) also found no significant effect of maggot meal supplementation on weight gain and feed conversion ratio were not significantly difference among the groups. Hence maggot meal can be used broadly as source of animal protein. There are no previous work with 1%, 2 % and 3% inclusion level of maggot meal and Grasshopper but work on maggot meal and grasshopper meal are review in the work, There were no significance difference at 1 %, 2 % and 3 % inclusion level of maggot meal and grasshopper meal in the initial weight, final weight ,weight gain, average daily weight gain, feed intake and feed conversion ratio, All the parameters were similar throughout the groups, The similarity of performance observed in the final body weight of the pullets chicks fed 1 % inclusion of fish meal, 2 % inclusion of maggot meal and 3 % inclusion of maggot meal that was seen to be higher compare with other groups shows improve quality of dietary treatment of maggot meal at 2 % and 3 % respectively and these can replace fishmeal at 1% which is in line with the report of (Egbewande *et al.*, 2019) who notice similar effect when fed broiler chicken different animal protein sources including Lizard, Grasshopper and maggot in replacing fish meal where the birds fed with maggot meal perform better than others in their absolute weight gain. Similarly, (Liu and Lian 2003) replace fish meal with grasshopper meal at 20 % and 40 % in broiler diets without any significant difference. However, (Ojewole *et al.*, 2003) reported depressed body weight gain and feed efficiency except protein content when added grasshopper meal at levels of 2.5-7.5 % in broiler diets. Variations in results of different studies of grasshopper meal could be attributed to differences in locust species, stage of their development and season of the year during which the samples were collected.

There was significance difference in the mortality rate of the pullet chicks fed different animal protein sources, pullet chicks with dietary treatment 1 % has no mortality rate at 2 % the mortality is low while there is slight increment at 3 % which occur at the same level of 1 % inclusion of maggot meal diet. The mortality rate is minimal at the initial stage of the research and increase a bit towards the termination of the experiment and the dietary treatment that has more mortality rate than the rest are the birds fed with diet with the inclusion of grasshopper but all the mortality rate fall on normal range of poultry production of 18% throughout the production cycle.

Effects of replacing fishmeal with maggot meal and grasshopper meal on nutrient digestibility of pullet chicks

Nutrient digestibility is a measure of degree of net absorption of nutrient in the digestive tract. The result of nutrient digestibility on the table 4.5.1 above shown that the pullets chicks fed with maggot meal and grasshopper meal have uniform protein retention value, the protein values of maggot meal and grasshopper meal are closely related to fishmeal which is related to the amount of unsaturated lipids in the diets supported by Kussaibati *et al*.(1983); Oluwafemi *et al*. (2019) that stated that apparent digestibility of protein is always higher when diets are reach in unsaturated lipids. Hence, the protein and the fat retention values obtained in all the treatment may be attributed to the fact that pullet chicks being monogastric could not effectively make use of fibrous materials in the diets.

The uniformly weight gain exhibit by the pullet chicks implies that maggot meal diet and grasshopper meal diets at 1 %, 2 % and 3 % diets may be attributed to high protein retention values recorded for the experimental birds (pullets chicks) as stated by Ichhponani and Malik (1971) that protein retention per unit of feed is in correlation with growth rate as well feed to gain ratio obtained for this dietary treatment followed this trend. At 1 % the crude fibre values are similar throughout while at 2% the crude fibre value of maggot meal is a little bit higher than that of grasshopper meal but they are all in the same range including fish meal which is the control. The uniformity in feed intake combined with similar protein content and retention when maggot meal and grasshopper meal replaced fishmeal caused observed similar weight gain in the pullet chicks. It can be concluded from this study that at 1 %, 2 % and 3 % maggot meal and grasshopper meal could replace fish meal without detrimental effects on performance nutrient digestibility of pullet chicks.

Conclusion

The data analyzed at the end of this research has revealed that maggot meal and grasshopper at 1 %, 2 % and 3 % inclusion level can replace fish meal at 1 %, 2 % and 3 % inclusion level because it has good performance without significant effect on their entire body weight gain, feed intake and feed conversion ratio.

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