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Original article

Identification of the economics, composition, and supplementation of maggot meal in broiler production

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ABSTRACT

The primary goal of this study was to conduct a preliminary assessment of maggot meal protein supplements in broiler production. Maggot meal comprises 55 percent crude protein (CP), 27.65% ether extract, 8.33% Ash, 3.37 crude fiber (CF), 2.14 NFE, 94.7 percent Dry Matter, 5702 kcal/kg gross energy, and 3955 kcal/kg metabolizing energy, according to proximate analysis. Maggot meal supplementation affected broiler meat feed intake, body weight gain, FCR, dressing %, mortality, antibody titer against ND, and organoleptic features. The cost-effectiveness of maggot supplementation was also evaluated. Birds were put into four experimental groups after a week of adaptation:Control group (M0), the first experimental group (M1), the second experimental group (M2), and the third experimental group (M3), which received supplements of 0, 2, 3, and 4 g/kg, respectively. A plane ratio was given to the control group as well. The overall feed intake findings were inversely proportional to the supplementation rate. Thus, the highly supplemented group (M3) showed the lowest feed intake than the control group (M0). Bodyweight gain was directly proportional to the supplementation rate, as evident by a considerable increase in the highly supplemented group (M3) compared to the control group.

1. Introduction

Poultry farming in Pakistan is becoming more and more popular. However, disease outbreaks, a lack of good nutrition, and the high cost of chicken feed ingredients, especially protein sources, continue to plague this industry. All of these difficulties impact the birds' overall productivity. Most vegetable protein sources utilized in poultry rations lack essential amino acids, particularly lysine. As a result, diets based only on plant-based protein are impossible to create. Because lysine is required for breast muscle development, it is essential for maximal body weight increase and feed efficiency in broiler chicks (Saima et al., 2010).

Traditional protein sources, which are in high demand for animal and human populations, are relatively expensive. The continual rise in the cost of poultry feed ingredients has prompted a search for less expensive alternatives to these protein sources with good nutritional value. Any endeavor to find low-cost protein sources will significantly reduce animal expenditures, especially poultry production (Okah and Onwujiariri, 2012). The high expense of traditional protein ingredients in poultry rations is one of the main reasons for looking for alternative protein sources. In wastes with high nutritional content, many easily digested byproducts, such as maggots, are raised. Maggots have a rich nutritional profile, including high crude protein levels (30–60%) and essential amino acids. It's also been said that the quality of this protein is superior to that of soybeans and that it may compete

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with fish meals. Maggots can be raised in organic materials such as poultry manure. It can be easily transformed into dinner at no expense (Adeniji, 2007; Harinder et al., 2014).

To boost the growth performance of broiler chicks, they require high-quality protein. Protein is found in maggots, earthworms, and termites. It's common knowledge that maggot protein is used in poultry feed. The nutritional content of maggot revealed that it includes 60% crude protein and 20% crude fat, indicating that it might be employed as a protein source in poultry feed. Various authors, on the other hand, have reported different nutritional values for maggot diets. These values are linked to differences in house fly species, pupae age, and maggot meal conversion, i.e., rearing and drying processes (Fasakin et al., 2003; Idowu et al., 2003).

Because of the ongoing expansion of the poultry business in emerging countries, protein sources in poultry feed are becoming more expensive, pushing small breeders from the industry. To remain alive in this industry, small poultry breeders exclusively depend on the cheapest source of protein, and the use of maggots as a source of protein is the most suitable option for them. This breakthrough in poultry feed can help eliminate environmental problems caused by flies, create jobs, alleviate poverty, and lower the cost of poultry production, particularly in developing nations. Maggots can contribute vital elements to poultry feed, including crude protein, amino acids, and energy. Other traditional protein sources can substitute this meal without compromising the performance or quality of the meat (Okubanjo et al., 2014). Maggots can swiftly thrive on chicken manure, poultry offal, and other organic wastes if the temperature is not changed (2 to 4 days). The biological value of maggot protein is similar to that of the fish meal while being much superior to groundnut cake and soybean meal, according to the amino acid composition of maggots. Maggots can be fed to birds while still fresh and moist, although they prefer to keep them dry for storage and movement. Maggot meal may be used instead of fish meal in broiler chicks due to its high nutritional profile (Teotia and Teguia et al., 2002; Hwangbo et al., 2009).

Maggots are a low-cost animal protein that is no longer used in the human diet. Therefore they have a significant impact on the cost of poultry feed. Maggots in poultry feed are a public health concern. Maggots in poultry feed may decrease fly reproduction, lowering their involvement in disease transmission to humans. Furthermore, maggot meal can be substituted for fish meal in poultry rations without causing harm to the birds' blood indices (Awoniyi et al., 2004).

The use of maggot protein for poultry production has been widely reported (Sheppard et al 2002). However, different authors have reported different nutritional values for maggot meal some of which were attributed to variations in species, age, method of processing and source of maggot (Teguia et al 2002). Another concern is the lack of protein-rich ingredients for animal feeding, especially to organic poultry due to exclusion of synthetic amino acids (AAs) and oil cakes extracted with solvents. Current legislation allows 5.0% non-organic substrates in organic diets. It is a general concern that a 100% organic diet is unable to meet the requirements of poultry, particular sulfur-containing AAs (Sundrum and Richter 2005). Furthermore, extensive use of dietary protein, for reaching the required amount of EAAs, is a common practise in organic poultry production (Elwinger et al. 2008).

Since there are complaints about the lack of protein in commercial poultry feed thus, maggot meal supplementation may fulfill this deficiency in the commercial broiler ration. It might also be able to cover the protein needs of rural poultry. A good knowledge of the nutrient composition of specific maggot, especially one from a commercial model, with regards to its chemical composition parameters will equip diet formulators with more definite data for correct placement and replacement of feed ingredients in ration formulation. The purpose of this study is to evaluate the early evaluation of maggot meal protein supplements in broiler production as a less expensive alternative to standard protein sources.

2. Material and methods

2.1. Maggot meal production

Poultry offal was collected from the University Poultry Farm and stored in a specially built tank with a top entry for flies. The tank was put in an open area where house flies, Musca vicina, could fly around freely (Diptera: Muscidae). The top of the tank was left open to allow flies to enter. A net was placed at the bottom of the tank to capture maggots properly. For the storage and collection of live maggots, the tray was placed beneath the net. Maggots form when common house flies deposit eggs in the aquarium. From 1 kg of poultry offal, approximately 300 g of maggot larvae were produced. On the third day of their creation (pupae stage), maggots were collected and held in airtight containers overnight to kill them. The maggots were then spread out on aluminum trays, cleaned with tap water, and dried at 55°Celsius in a hot air oven. The maggots were taken out of the oven and placed in plastic bags after 36 h. Chemical makeup, bacterial growth, and mycotoxin load were all examined. Following relevant laboratory results, this meal was incorporated into the poultry ration at the planned rates.

All procedures used in the study entitled "Economics, composition, and supplementation of maggot meal in broiler production "were approved by the Research Ethical Committee of the Faculty of Animal Husbandry & Veterinary Sciences, The University of Agriculture, Peshawar, 25130, Khyber Pakhtunkhwa, Pakistan. #: AUP-7185–2021.

2.2. Proximate analysis, amino acid and mineral profile of maggot meal

On the third day of larvae formation, mature maggots were extracted using the stimulated sedimentation technique (SST) from a pool of maggots cultured on poultry offal and chicken waste (Aniebo, 2007). Harvested samples were dried in an oven at 55 °C until they reached 94 percent dry matter. Proximate analysis was used to determine the amount of crude protein, fat, crude fiber, and ash in dried samples (AOAC, 1990). In a truly randomized design, all samples were reproduced three times. The Kjeldahl process was used to assess nitrogen, while the petroleum ether (bp 40–60 °C) extraction in a Soxhlet device was used to determine fat. The starch and protein content of the sample had to be dissolved by boiling with acid and then with sodium hydroxide; the residue was fiber. Burning the sample at 550°Fahrenheit to burn off organic components yielded the ash. Finally, the algorithm was applied to determine carbohydrate content (CHO).

[100 – (moisture + fat + fiber + protein + ash)] = CHO.

2.3. Metabolizable energy (ME)

The equation presented by Lodhi et al. (1976) to determine metabolic energy was as follows:

$$ME\ (Kcal/kg) = 32.95\ (\%\ CP + \%\ EE \times 2.25 + \%\ NFE) - 29.20$$

2.4. Determination of amino acid

At the Pakistan Council of Scientific and Industrial Research (PCSIR) lab in Peshawar, the amino acid content of maggot samples was determined using High-Performance Liquid Chromatography (HPLC) and the Cserhati and Forgacs (1999) and Kerese (1999) techniques (1984). 4.83 g barium hydroxide and 5 ml boiling water

hydrolyze 500 mg of finely crushed materials. After that, the mixture was evacuated and heated at 120 °C for 8 h. After hydrolysis, the pH was adjusted to 3 using HCl, and the solution was diluted to 25 ml with HPLC grade distilled water. After vacuum drying a one-milliliter sample, it was dissolved in citrate buffer (0.1 m; pH 2.2). In evacuated and sealed tubes, acid hydrolysis with 6 N HCl was carried out at 110oC for 18–22 h. The hydrolysate was filtered and diluted to 250 ml, after which 1 ml of the sample was vacuum evaporated at 40oC till dry. In a citrate buffer, the contents were dissolved (0.1 M; pH2.2). This derivative was injected straight into the HPLC at a volume of 20 L. Shimadzu HPLC detector LC-10A with variable wavelength monitor set at 350–450 nm was used for detection. A binary gradient technique was used to resolve amino acid derivatives regularly. (A) 58.8 g sodium citrate containing 0.2 N sodium (pH 3.2), 210 ml 99.5 percent ethanol, and 50 ml (60 percent) perchloric acid, and (B) 58.5 g sodium citrate containing 0.6 N sodium (pH 10), 12.4 g Boric acid, and 30 ml 4 N NaOH solution The solvent was pumped into the column at a rate of 4 ml/min for 7 to 10 min.

2.5. Mineral analysis

An atomic mass spectrometry approach was used to determine the minerals calcium, phosphorus, potassium, magnesium, sulfur, copper, manganese, zinc, and iron in maggot meal, according to Malavolta et al. (1997).

2.6. Analysis for mycotoxin and bacterial growth

The mycotoxin content of a 25-gram sample of maggot feed was determined (aflatoxin B1). AOAC., 2000 Ch. 33, employed the TLC technique to assess aflatoxin B1 burden. The aflatoxin B1 level was<5 ppb after the examination. Standard microbiological protocols described by Carter et al. (1991) were employed for bacterial analysis. In the maggot meal sample, the focus was on the count range of Salmonella and *E. Coli*. There were no microorganisms with an unfavorable count range found.

2.7. Experimental diets and management of experimental birds

A total of 200 one-day-old chicks were purchased from the commercial market for this study. One hundred and twenty mixed-sex chicks of almost comparable weight were randomly divided into four groups after a week of the pre-experimental period; each group was replicated three times. Each group consisted of thirty females (ten per replicate). Each replicate's chicks were housed in their own 1010 foot 2 cage. A regular commercial ratio was fed to the control group (M0). The first experimental group (M1) was fed a commercial ration with 2 g/kg commercial ration maggot meal supplemented. The second experimental group (M2) was fed commercial rations containing 3 g of maggot meal per kilogram of commercial diet. The third experimental group (M3) was fed commercial rations containing 4 g of maggot meal per kilogram of commercial diet. Feed and water were freely available. All of the chicks in each group were kept in the same conditions. The research was extended for another five weeks. To avoid a disease breakout, proper hygiene was maintained.

2.8. Feed intake

Each replicate's feed consumption was tracked on a daily and weekly basis. Every twenty-four hours, the leftover feed was subtracted from the feed's amount to calculate daily feed consumption. The weekly feed intake was then converted from the daily feed intake. This activity was carried out for a total of five weeks.

Daily Feed Intake = Offered feed – Leftover Feed

2.9. Body weight gain

At the time of chick distribution among the experimental groups, the first body weight was recorded. Weight increase was then reported for each replicate at the end of each week. This procedure was followed until the experimental trials were completed. A proforma was created to keep track of body weight growth. The bird's final weight was subtracted from its previous week's body weight to calculate weight gain. Every week, data was collected.

Feed conversion ratio (FCR) was calculated weekly for each experimental unit. Using the equation.

Total Feed Consumed FCR = Body Weight Gain

2.10. Dressing percentage

Three birds were chosen randomly from each replication to calculate the dressing percentage. After determining the bird's live weight, the birds were eviscerated and weighed again after evisceration. The following formula then calculated the dressing percentage.

Eviscerated Weight Dressing percentage =× 100 Live Body Weight

2.11. Mortality

Each replication was observed for mortality, and data were recorded daily. Total mortality was calculated at the end of the trial.

2.12. Antibody titer against Newcastle disease

After the trial, two birds were chosen at random from each replicate for blood collection. Each bird's blood was collected aseptically and coagulated with two milliliters. After coagulation, serum was taken. Antibody titer was determined using the established standard methods of haemagglutination inhibition (O.I.E. Terrestrial Manual, 2012) after the experiment chicks were sold.

2.13. Organoleptic study

Organoleptic research was undertaken after the trial to assess the eating quality of broiler meat. Two panels were created for this purpose. The panelists were mostly from the department's staff and university students. For cooking, two chickens from each group were chosen at random. After preparing it, panels evaluated the taste, tenderness, juiciness, color, and flavor of cooked broiler meat. A sharp knife was used to sacrifice the chicks. The panelists were given a proforma that included all meat quality characteristics. Each characteristic was scored from 1 to 4, with 1 indicating poor quality and 4 indicating good quality. After tasting each sample, the panelists were instructed to consume a small amount of water. A proforma was used to record the information (Anita et al., 2012).

2.14. Economics of maggot meal preparation and supplementation

All costs, including feed, maggot meal, operating costs, total expenses, gross return, and net profit, were factored into maggot meal preparation and supplementation economics.

2.15. Data collection and analysis

Ten samples were evaluated three times each for proximate, amino acid, and mineral analyses for proximate composition. Steel and Torie's mean and standard errors were determined (1980). Each parameter was recorded daily and weekly for the supplemen-

tation experiment starting at the beginning of the trial. Using the SPSS application, all of the recorded data was subjected to analysis of variance.

3. Results

3.1. Proximate analysis, amino acid and mineral profile of maggot meal

Its value for poultry feed is demonstrated by a relatively high crude protein content (55 %). Maggot meal protein is not only comparable to that of fish (50 %) and soya bean meal (45 %), but it substantially outperforms both. Similarly, the energy level of poultry rations is quite encouraging (Table 1). Almost all necessary amino acids were found in maggot meals (Table 2). The tryptophan, on the other hand, could not have recovered or was limited. Mineral content (Table 3) is lower than that of fish meal (5.44 %) and soya bean meal (Table 3). (8.3 %). These might, however, be simply supplemented with a low-cost mineral premix.

3.2. Analysis for mycotoxin and bacterial growth

Maggot meal samples were subjected to analysis for mycotoxin (aflatoxin B1), and the results showed that the level of which was below 5 ppb. Standard microbiological procedures also analyzed other samples for detecting *E. Coli* and *Salmonella* and displayed no bacterial growth.

3.3. Feed intake

Mean feed consumption per bird was found in all four groups during the 2nd, 3rd, 4th, and 5th weeks of life (Table 4). During the second week, there were no significant differences in feed intake between the experimental groups. However, in the third week, feed consumption in groups M1, M2, and M3 was considerably lower than in the control group. The supplementation effect grew more specific in M3, although feed intake in the M1, M2, and control groups was not substantially different. Overall, the feed intake of the substantially supplemented group M3 was much lower than that of the M2 and M1 groups.

3.4. Body weight gain

Table 5 shows the average body weight gain per bird in all four groups during the second, third, fourth, and fifth weeks of life. The experimental groups did not differ significantly in their bodyweight growth during the second week. The M3 group, on the other hand, gained much more weight in week three than the control group. Similarly, during the fourth and fifth weeks of the study, M3 gained significantly more weight than M2 and M1, indicating that supplemented groups gained more weight. According to the total data, the birds in M3 gained the most weight, followed by M2 and M1.

3.5. Fcr

Table 6 shows the mean FCR observed in all four groups at the 2nd, 3rd, 4th, and 5th weeks of life. During the second and third weeks, the FCR of the experimental groups M3 and M2 dramatically improved. However, the FCR of group M1 and the control group did not differ substantially in the second week. FCR improved dramatically in group M3 throughout the fourth and fifth weeks, followed by M2 and M1. In terms of FCR, the overall results

Table 1
Proximate analysis and Metabolizable energy of maggot meal obtained from chicken offal and poultry waste.

S.No.	Meal Components	Percent Composition	Unit (Mg/kg)
1	Dry Matter	94.7	%
2	Crude Protein	55	%
3	Ether extract	27.65	%
4	Ash Content	8.33	%
5	Crude Fiber	3.73	%
6	NFE	2.14	%
7	GE	5702 kcal/Kg	
8	ME	3955 kcal/ kg	

Table 3
Mineral composition of maggot meal produced from chicken offal and poultry waste.

S. No.	Minerals	Quantity
1	Calcium	4.9 ± 1.2 g/kg DM
2	Phosphorus	16 ± 2.3 g/kg
3	Potassium	5.6 ± 3.2 g/kg
4	Magnesium	3.4 ± 3.3 g/kg
5	Iron	0.33 g/kg
6	Manganese	91.0 ± 110 mg/ kg
7	Cupper	27.0 ± 5.00 mg/kg
8	Zinc	117.0 ± 112 mg/kg

Table 2
Amino acid profile (g/100 g protien) of maggot meal obtained from chicken offal and poultry waste and its comparison with soya bean and fish meal.

S. No.	Amino acid	Unit (Mg/kg)	Maggot meal	Fish meal	Soya bean meal
1	Alanine	%	2.80	0.4	–
2	Arginine	%	5.86	3.99	2.90
3	Aspartic acid	%	8.33	0.53	–
4	Cystine	%	0.60	0.82	0.74
5	Glutamic acid	%	14.8	0.56	–
6	Gycine	%	4.61	0.41	–
7	Histidine	%	3.01	1.36	1.02
8	Isoleucine	%	3.14	2.97	2.07
9	Luecine	%	6.75	4.45	3.29
10	Lysine	%	6.01	4.55	2.62
11	Methionine	%	2.30	1.68	0.52
12	Proline	%	3.30	0.94	–
13	Phenylalanine	%	3.74	2.35	2.12
14	Serine	%	3.45	0.6	–
15	Threonine	%	2.02	2.60	1.66
16	Tyrosine	%	2.93	1.98	1.27
17	Tryptophan	%	–	0.69	0.65
18	Valine	%	3.60	0.64	2.6

Table 4
Mean feed intake (g) in broiler chicks fed with different levels of M.M.

Group	Mean feed intake (g) ± SE				
	Week 2nd	Week 3rd	Week 4th	Week 5th	Overall
M1	441.86 ± 9.04	730.80^{a} ± 4.55	1094.03^{a} ± 2.98	1185.50^{a} ± 5.92	3452.19^{a} ± 8.90
M2	451.3 ± 3.99	728.13^{a} ± 4.86	1080.77^{a} ± 7.82	1190.07^{a} ± 4.69	3450.19^{a} ± 11.39
M3	448.63 ± 3.58	720.66^{a} ± 3.53	995.70^{b} ± 8.63	1070.30^{b} ± 3.32	3235.29^{b} ± 21.91
Control	442.36 ± 7.42	745.86^{b} ± 5.40	1099.70^{a} ± 4.44	1198.57^{a} ± 8.35	3486.49^{a} ± 11.08

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

Table 5
Body weight gain (g) in broiler fed with different levels of Maggot Meal.

Group	Mean body weight (g) ± SE				
	Week 2nd	Week 3rd	Week 4th	Week 5th	Overall
M1	421.66 ± 10.13	431.66^{b} ± 8.33	557.33^{b} ± 10.10	598.33^{b} ± 4.40	2009.00^{b} ± 13.20
M2	420.00 ± 5.77	440.00^{b} ± 5.77	596.66^{a} ± 8.81	581.00^{b} ± 5.85	2037.67^{b} ± 12.33
M3	415.00 ± 8.66	488.33^{a} ± 11.66	630.00^{a} ± 11.54	673.33^{a} ± 12.01	2206.67^{a} ± 23.15
Control	398.33 ± 6.00	435.00^{b} ± 5.00	440.00^{c} ± 17.32	500.00^{c} ± 5.77	1778.33^{c} ± 11.66

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

Table 6
Mean F.C.R. of broiler chicks fed with different levels of Maggot Meal.

Group	Mean F.C.R. ± SE				
	Week 2nd	Week 3rd	Week 4th	Week 5th	Overall
M1	1.05^{a} ± 0.01	1.69^{b} ± 0.02	1.96^{b} ± 0.07	1.98^{b} ± 0.05	1.72^{b} ± 0.01
M2	1.07^{b} ± 0.01	1.65^{b} ± 0.05	1.81^{ab} ± 0.08	2.05^{ab} ± 0.05	1.69^{b} ± 0.04
M3	1.08^{c} ± 0.01	1.48^{c} ± 0.04	1.58^{c} ± 0.02	1.59^{c} ± 0.08	1.47^{c} ± 0.02
Control	1.2^{a} ± 0.00	1.71^{a} ± 0.02	2.50^{a} ± 0.04	2.40^{a} ± 0.04	2.07^{a} ± 0.01

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

showed that maggot meal supplementation considerably improved FCR in groups M3, M2, and M1.

3.6. Dressing percentage

The effect of maggot meal supplementation on dressing percentage was significant ($P < 0.05$) in all groups. As the number of supplements increased, the proportion of dressing was raised. Group M3, followed by group M2, saw substantial improvements (Table 7).

3.7. Mortality

Maggot meal supplementation does not influence chick mortality since mortality was lower in groups M3 and M2 than in the control group.

3.8. Antibody titer against Newcastle disease (ND) Vaccine

Group M3 had the highest antibody titer, followed by groups M2 and M1 (Table 8).

Table 7
Mean Dressing Percentage in broiler chicks fed with different levels of Maggot Meal.

Group	Mean Dressing Percentage ± SE
M1	71.33^{c} ± 0.69
M2	74.88^{b} ± 0.44
M3	77.11^{a} ± 0.77
Control	70.11^{c} ± 0.16

Means with different superscript in columns are significantly different at $\alpha = 0.05$.

3.9. Organoleptic study

There were no significant differences in taste, softness, or juiciness between the treatment and control groups. Maggot meal supplementation did not affect the color or flavor of broiler meat (Table 9).

3.10. Economics of maggot meal supplementation

Feed cost, maggot meal cost, operating cost, total expenses, gross return, and net profit were all considered while calculating the economics. Table 10 illustrates the economics. Maggot meal addition increased gross return and net profit significantly (**$P < 0.05$**). Group M3, heavily supplemented, had the highest gross return and net profit, followed by M2 and M1.

4. Discussion

According to the current study, the maggot meal extracted from chicken offal and poultry waste included 55 percent crude protein.

Table 8
Mean antibody titer against N.D. Vaccine in broiler chicks.

Group	Mean ND titer ± SE
M1	2.66^{ab} ± 0.33
M2	3.33^{a} ± 0.33
M3	3.33^{a} ± 0.33
Control	2.66^{ab} ± 0.33

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

Table 9
Organoleptic Study of broiler meat fed with maggot meal.

Group	Mean ± SE				
	Taste	Tenderness	Juiciness	Color	Flavor
M1	2.36 ± 0.06	2.30^{b} ± 0.00	2.43^{b} ± 0.06	2.36^{b} ± 0.06	2.40^{ab} ± 0.10
M2	2.40 ± 0.37	2.40^{b} ± 0.30	2.63^{a} ± 0.20	2.50^{a} ± 0.41	2.60^{a} ± 0.25
M3	2.33 ± 0.26	3.10^{a} ± 0.15	2.50^{b} ± 0.20	2.56^{a} ± 0.12	2.60^{a} ± 0.20
Control	2.40 ± 0.20	2.16^{b} ± 0.17	2.46^{b} ± 0.27	2.56^{a} ± 0.21	2.30^{ab} ± 0.17

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

Table 10
Economics of maggot meal supplementation.

Group	Mean (P.K.R.) ± SE					
	Feed Cost	M.M Cost	Op: Cost	Total Exp	G. Return	Net Profit Net profit
M1	136 ± 3.3	3.45^{c} ± 6.21	100.00 ± 4.56	239.45^{b} ± 3.6	301.5^{ab} ± 4.2	61.00^{ab} ± 5.7
M2	136 ± 3.62	5.19^{b} ± 4.23	100.00 ± 3.95	241.19^{a} ± 4.56	315.00^{b} ± 3.1	73.81^{b} ± 2.61
M3	136 ± 9.62	6.85^{a} ± 8.63	100.00 ± 9.56	242.85^{a} ± 8.34	322.00^{a} ± 9.43	79.15^{a} ± 11.45
Control	136 ± 8.35	0.00 ± 0.00	100.00 ± 6.35	236.00^{c} ± 4.52	258.00^{c} ± 6.37	22.00^{c} ± 7.93

Means with the same superscript in columns are not significantly different at $\alpha = 0.05$.

The composition of maggot meal varies depending on the substrate utilized, the species of fly, meteorological conditions, and the manner of production (Atteh and Adedoyin, 1993; Aniebo et al., 2008). The current crude protein value was higher than the 45 percent crude protein in the maggot meal reported by Gado et al. (1982), Atteh and ologbenda (1993), and Fasakin (2003). Aniebo et al. (2008) found 47.1 percent crude protein in maggots obtained from poultry and cattle manure mixed with fruit wastes. The fat content of 27% identified in this study was higher than the range of 20.7–25.3 percent reported by Atteh and Ologbenla (1993) and higher than Awoniyi et al. (2003). This study found that maggot meal contains 7.0 percent crude fiber, greater than the 6.3 percent reported by Awoniyi et al. (2003). When the results were compared to those of other researchers who grew their maggots on various substrate media, it was discovered that the maggot's proximal constitution might have influenced the substrate medium. In the current investigation, almost all necessary amino acids were found in maggot meals. The tryptophan, on the other hand, could not have recovered or was limited. Tryptophan was similarly shown to be limiting in maggot meal derived from poultry and cattle dung, according to Aniebo et al. (2008). The amino acid profiles of maggot meal, fish, and soya bean meal are compared in Table 5. The most limiting amino acids, lysine, and methionine were higher than fish and soya bean meals, as seen in the table.

Similarly, the ratios of leucine and isoleucine (6.35:3.06) were greater than the ratios of soya bean meal (2.97:4.45) and fish meal (4.45:2.97). This ratio of Leucine to Isoleucine is frequently linked to amino acid antagonism and should be taken into account when formulating chicken feed. According to fish meal, broilers performed poorly on maggot meal-containing rations compared to Fasakin et al. (2003). Tryptophan levels in maggot meals are either nonexistent or extremely low, explaining the problem. On the other hand, synthetic amino acids have solved this problem and can now be supplemented without incurring high costs. These findings support using maggot meal instead of soya bean meal in chicken feed. Harinder et al. (2014) found that maggot meal may completely replace fish meal and soya bean meal in poultry rations without compromising growth and performance.

A sample of maggot meal was tested for mycotoxin (aflatoxin B1), which was found to be<5 ppb. The mycotoxin load was determined using the thin layer chromatographic (TLC) technique. The bacterial growth examination was carried by using standard microbiological methods. E. Coli and Salmonella were also found in the sample. There was no evidence of bacterial growth.

At the end of the study, the total amount of feed consumed was calculated. Maggot meal supplementation reduced feed intake in all supplemented groups, according to the findings of this study. However, in group M3, supplemented with the highest level of maggot meal, it was dramatically reduced. The high fat and energy content of maggot meals may be causing the reduction in feed intake. Atteh and Ologbenla agreed with our findings (1993). They looked at maggot meal as a protein source for broiler chicks and found that it reduced feed consumption. They speculated that the decline in feed intake could be attributable to the birds' palatability issues. Teguia et al. (2002) also found that when maggot meal levels were raised, feed intake in broiler chicks was dramatically lowered due to the high energy and protein ratio. Earlier research by Moran (1982) and Akpodiete (1997) found that birds fed a maggot meal-based feed had lower feed consumption due to the high-fat content.

According to Ewing (1963) and Moran (1982), the black color of the maggot meal-supplemented diet may cause feed consumption to be reduced. Because the maggots turned dark brown after processing, they learned that birds are color-sensitive. Broilers fed earthworm meal showed a considerable reduction in feed intake, according to Barcelo (1988). He claimed that the high nutritional values of earthworm meal compared to a fish meal lowered feed intake. Broiler chicks given silkworm meal had decreased feed intake, according to Ijaiya and Eko (2009). They claimed that the high fiber content of silkworm meals was to blame for the decrease in feed intake. They went on to say that feed intake was lowered because broiler chicks couldn't digest the fiber content. In a study using maggot meal instead of fish meal, Awoniyi et al. (2003) found comparable findings. They stated that there was no significant difference in feed intake at the start of the experiment but a decrease in feed intake towards the end.

In the current study, higher supplemented group M3, moderate supplemented group M2, and lowest supplemented group M1 gained considerably more weight during the fourth and fifth weeks than control group M0, indicating that supplemented groups gained more weight. The considerable body weight gain compared to the control group may be explained by maggot meal's improved nutritional composition in terms of high crude protein and essential amino acid availability, as well as its digestibility. Our findings

were backed up by the findings of other researchers (Awoniyi et al., 2000), who found that birds fed maggot meal gained more weight than birds on a control diet. Hwangbo et al. (2008), who fed broiler chicks with dried maggots, found comparable results. The majority of authors (Atteh 1993, 1994; Inaoka, 1999; Teguia, 2002; Awoniyi et al. 2003, 2004) concluded that greater body weight gain could be attributable to maggot meal's superior nutritional profile and that supplementing commercial feed with it had good impacts on body-weight gain. According to Ichhponani and Malik (1971), the high protein retention value in maggot meals may increase body weight in broiler chicks. Ijaiya and Eko (2009) discovered that body weight gain rose when the fish meal was replaced with silkworm meal. They explained that silkworms' higher nutritional values impacted body weight gain. Awoniyi et al. (2003) found a similar increase in body weight in birds fed maggot food rather than fish meal. They speculated that maggot food's effect on broiler chick body weight gain could be due to the high protein and amino acid profile of maggot meal.

Adeniji (2007) found no significant differences in body weight gain across the experimental groups, contradicting our findings. Perhaps the variance in the nutritional composition of maggot diets has led to this finding. Maggots were cultured from the offal of chickens in this investigation. Adeniji (2007) produced low-protein, low-amino-acid maggots from poultry manure. Reduced feed intake was linked to lower body weight increase by Ewing (1963).

The most supplemented group M3, the moderately supplemented group M2, and the least supplemented group M1, had significantly higher FCR than the control group M0. Of supplemented groups, low feed consumption is associated with a significant rise in body weight, resulting in a greater FCR. Our findings were similar to Okah and Onwujiariri (2012), who discovered that maggot meal enhanced FCR more than the control group. According to Teguia et al. (2002), meal feed intake was lowered due to the greater nutritional profile of maggots, resulting in a higher FCR. When insects were used as a source of protein in broiler rations, Moreki et al. (2012) saw a higher feed conversion ratio. They claimed that a higher feed conversion ratio was connected to insects' better nutritional profile. According to Dordevic et al. (2008), incorporating maggot meal into commercial ration may explain higher FCR. For feed conversion ratio, Hwangbo et al. (2008) found the same results. They reported that feed intake was reduced because of the high protein digestibility, but body weight gain was high, resulting in a superior feed conversion ratio. Ijaiya and Eko (2009) found that feeding silkworm meals to broiler chicks improved feed conversion ratio. They claimed that silkworms had superior protein and quality amino acid profiles, resulting in a higher feed conversion ratio. Our findings matched those of Barcelo (1988), who found that feeding earthworm meal improved feed conversion ratio. He claimed that increasing the amount of earthworm meal in the broiler feed boosted FCR.

Jabiret al. (2012) reported similar proximate composition for maggot larvae with slight variations. These variations in the composition of maggot meal may be due to differences in the substrate used for its production, the fly type, weather conditions and method of production. The ratio of leucine and isoleucine is often implicated in amino acid antagonism and needs to be considered in poultry feed formulation (Aniebo et al., 2008). Hwangbo et al. (2008) that replaced soya bean meal with maggot meal and found that increasing the quantity of maggot meal in poultry feed had significantly lowered the feed intake, increased weight gains and better feed conversion ratio. The reason for best FCR in feed containing high level of maggot meal maybe due to differences between the treatment and control groups probably by an increased rate of protein accumulation, optimal essential amino acid profile (particularly lysine) and high nutrient digestibility. Teguia et al. (2002) also reported significantly decreased feed intake in broilers while feeding mag-got-based poultry diet which may be due to high energy and protein ratio in the maggot larvae. Moran(1982) stated that feed consumption might be reduceddue to the dull colour of the diet supplemented withmaggot meal and because birds are sensitive to colouras maggots become dark brown after processing. Teguia et al. (2002) sta-ted that due to better nutritional profile of maggotmeal feed intake was reduced which resulted in betterFCR. Moreki et al. (2012) recorded better feed con-version ratio when they used insects as a source ofprotein in broiler ration. Increase indressing percentage may be because of increased body weight gain which is associated with high crude pro-tein and essential amino acids in maggot meal.

After the trial, the dressing % of the birds was assessed, and the results revealed that maggot meal supplementation had a significant influence (P0.05) on the dressing percentage of the birds. With higher levels of supplementation, the percentage of birds dressed increased. Compared to the control group M0, the highly supplemented group M3 had a higher dressing %, followed by the moderately supplemented group M2 and the least supplemented group M1. Increased body weight gain, linked to high crude protein and important amino acids in maggot meals, could explain the rise in dressing %. Our findings were consistent with those of Teguia et al. (2002). In the commercial ratio, the group supplemented with maggot meal had a higher dressing %. The control group had a dressing percentage of 63.92 percent, whereas the supplemented group had a dressing percentage of 68 percent. Birds supplemented with maggot meal had a considerably higher (P 0.05) dressing % than the control group, according to Acar et al. (1991). They claimed that maggot meal's high amino acid profile contributed to the high dressing %. In birds fed maggot diets, Okah and Onwujiariri (2012) found a high dressing percentage. They speculated that this could be linked to a high-nutrient diet. Bilgili et al. (1992) further suggested that a high dressing % could be caused by the pace of protein accumulation and essential amino acid profile, particularly lysine in maggot meal.

Our research demonstrated that maggot meal supplementation has no negative impact on chick mortality. Because of maggot protein's protective effects on birds' immune systems, this could be the case. Dordevic et al. agreed with our findings (2008). They found that the group fed maggot meal had a lower death rate (2%) than the control group (4 percent). Similarly, Adeniji (2007) and Okah and Onwujiariri (2012) found the same results, concluding that maggot supplementation had no negative effect on chick mortality. Other researchers reported no pathogenic abnormalities in chicks fed a maggot meal mixed diet (Calvert et al., 1969; Polvotova et al., 1980; Bayadina et al., 1980). All of the previous researchers agreed that effective treatment and processing of maggots into maggots meal reduces or eliminates the unbearable level of all microorganisms.

The current study found no negative effects of maggot meal supplementation on Newcastle Disease antibody titers. According to the study's findings, maggot protein did not affect the immune systems of birds.

Although there was no relevant literature on the topic under investigation, additional protein sources were investigated for their influence on antibody titer against ND, which revealed that protein strengthens birds' immune systems. Tehari et al. (2005) reported a significantly greater ($P < 0.05$) antibody titer against ND in broiler chicks fed varying quantities of oil-derived propolis as a source of protein in their diet. Earlier research by Koo et al. (1980) found that properly treating maggots before employing them strengthens the flock's immune system rather than putting it at risk of disease transmission.

The taste, softness, juiciness, color, and flavor of broiler meat were not changed by maggot meal, according to overall observa-

tions of organoleptic properties of broiler meat. Our findings were comparable to those of Awoniyi et al. (2004) and Hwangbo et al. (2009), who found that maggot meal supplementation did not affect the organoleptic qualities of broiler meat. The same findings were reported by Eyo (2006), who noted that adding maggot meal to a fish's diet did not affect the flavor, juiciness, or texture of the fish products. Aniebo et al. (2011) reported no significant difference in flavor, juiciness, or texture between the treatment and control groups in an organoleptic analysis of fish fed with maggot meal. The organoleptic investigation of broiler chicks given maggot diet revealed no undesired and unpleasant changes in taste, tenderness, juiciness, color, or flavor of the meat, according to Okubanjo et al. (2014).

The current study demonstrated that maggot meal supplementation substantially impacted gross return and net profit. Because of the significant bodyweight rise, higher supplemented group M3 had the highest gross return and net profit, followed by moderate supplemented group M2 and lowest supplemented group M1 compared to control group M0. Although no relevant literature on the subject of net profit from maggot meal supplementation was found, Okah and Onwujiariri (2012) reported that the cost of 1 kg live weight of broiler chickens at 50% dietary replacement of fish meal with maggot meal was 34.22 percent less than the same weight in the control diet. Teguia et al. (2002) also claimed that the cheap cost of a maggot meal compared to a fish meal lowered the cost of feeding. They claimed that mass-producing maggot meals at a large scale lowered the cost of production greatly. When birds were fed silkworm meal, the cost per kg was lower, according to Ijaiya and Eko (2009). They noted that the total cost was steadily reduced by increasing the amount of silkworm meal in the broiler ration.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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