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Performance Characteristics and Economics Analysis of Earthworm Meal in Fish meal Based Diets of Broiler Chicken

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Abstract : The study was carried out to evaluate the effect of feeding Earthworm meal (EWM) based diets on the performance characteristics and economic analysis of broiler chicken. One hundred day old chicks of mixed sex were assigned to four dietary treatments (0.0, 0.50, 1.00 and 1.50% EWM) for a 56 day period. Diets were iso-caloric and iso-nitrogenous in nature. The data collected was subjected to (ANOVA) analysis of variance for a (CRD) completely randomized design, using IBM SPSS statistics version 20. The results revealed that body weight (BW) was increased as the EWM was increasing in the diets. Feed Conversion Ratio (FCR) increased when EWM was added to the diets with diets 2 recording the best FCR. Interestingly, feeding EWM based diets did not reduce growth performance. The highest weight gain was recorded for the EWM based diets (Diets 2 -4). The rate of return of capital were highest for EWM based diets with Diet 2 recording the best. Generally, the percentage cost reduction increased as the levels of EWM inclusion increased. Furthermore, EWM can be considered as an ingredient of choice to partially replace Fish meal for broilers with up to 1.5%. Conclusively, within the limit of this experiment, the partial replacement of Fish meal with EWM could help to stem over- dependence of Broiler farmers on importation of Fish meal hence, the novel feedstuff (EWM) opens a window for better bio- available protein source and it could possible reduce the supplementation cost in future.

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Key words: Broiler chicken, earthworm meal, economic analysis, performance characteristics

Introduction

Poultry which is the world major source of food (Dilger *et al.*, 2016) are produced globally with about 50 billion poultry birds and 66 billion poultry in 2011 and 2016 respectively. The country poultry production stands at about 180 million birds and most of which are found in the Southern part of Nigeria as semi-intensive or intensive management system (FAO, 2018).

It was reported that the demand for poultry products across African continent will increase by 60% mostly in Nigeria (World Economic Forum, 2019) and about,

192.69MT of poultry meat and egg products are consumed annually in Nigeria (Ritehies and Rose, 2020). However, the industry is faced with numerous challenges of high price of feed ingredients, pests and diseases, poor marketing and market channels, poor technical know-how, moribund extension services, poor infrastructure, poor land availability, unsupported insurance policy by appropriate authority and finally high feed ingredients.

One of the major sources of protein in broiler chicken production is Fish meal (FM). This ingredient is very expensive in Nigeria hence, it is pertinent to source for other alternative source to fish meal without compromising quality. Earthworm which is of such alternative candidates available for use in Animal feed.

Earthworm meal contains protein content of between 65 and 77% and has similar amino acid profiles to fish meal (Dedeke *et al*.,

2010) and have been used as protein supplements in the diets of chicken (Startford and Tacon, 2005; Monebi and Ugwumba, 2013) and many scientists have reported the possibility of using this meal (Sogbesan and Ugwumba, 2008). Earthworm meal is not only comparable but also superior to fish meal in terms of protein quality therefore, earthworm meal is considered rich to supplement or replace fish meal in livestock diet. Earthworm meal has 65.6% raw protein content (Damayanti *et al.*, 2008) which is richer than the percentage of fish protein (45%) and meat protein (51 percent). It also contains proline amino acid in about 15% of total 62 amino acids (Cho *et al.*, 1998) and 58.6% of essential amino acids (Istiqomah et al., 2009). Similarly, other studies showed that earthworm is rich in essential amino acids, especially lysine. The amount of lysine in earthworm meets the lysine required by growing poultry (Guerrero, 1981; Stafford and Tacon, 1984; Edwards and Niederer, 1988; Vielma *et al.*, 2003). In this context, Kucukersan *et al*., (2005) showed that humic acid found in earthworm meal improved feed intake and feed efficiency in poultry. Due to the fact that fish meal is now costly and scarce, it is essential to substitute earthworm meal with fish meal to minimize the cost of production in Broiler . Hence, the current study aimed at investigating the effect of (EWM) inclusion at various levels on the growth performance, digestibility and partial budget analysis of Broiler chicken fed EWM based diets.

Materials and methods

Experimental Site

The experiment was carried out at the University of Ilorin Teaching and Research Farm, llorin, Kwara state, Nigeria. The experimental area is located on latitude 8.35°E and longitude 4.35°N (Belewu et al. 2013). It has a humid tropical Savannah climate characterized by both wet and dry seasons with mean annual temperature between 25°C to 28.9. 1nclined mean annual rainfall is about 1150mm ((Belewu *et al.*, 2013).

Preparation of Earthworm Meal

Earthworms cultured using a process known as Vemiculture was employed. This involves the artificial rearing or cultivation of worms. The earthworms were harvested and washed using water to separate manure from outside skin and faecal mud and then sun-dried. The earthworms were milled and oven-dried at 40°C for 12 hours and sieved to obtain earthworm meal powder in homogenized form.

Experimental Birds and Management

All experimental protocol were in accordance with the University of Ilorin Research Policy on Animal welfare. The study was undertaken on one hundred (100) day old, mixed sex broiler chicks of same hatch purchased from a reputable commercial hatchery in Nigeria, and prior to the arrival of the birds, the cages to be used for the experiment were washed and disinfected to prevent infectious diseases / agents. On arrival, chicks were weighed individually, wing tagged and distributed randomly into four treatment groups, consisting 25 birds per treatment and 5 birds per replicate. Standard farm management practices such as vaccination, routine medication etc. were followed throughout the experimental period. Feeding and watering were supplied *ad libitum.* The experiment was conducted for a period of eight week. The daily feed consumption, weight gain and feed conversion ratio were properly recorded and the partial economic analysis was calculated.

Experimental Design

Treatment 1: Birds fed with fish meal (control)
Treatment 2: Birds fed with earthworm meal (0.5%) supplemented with fish meal
Treatment 3: Birds fed with earthworm (1%) supplemented with fish meal
Treatment 4: Birds fed with earthworm (1.5%) as total replacement

Chemical analysis

The proximate analysis of the earthworm meal and the experimental diets were done in accordance with AOAC (2010)

Data Analysis

Data collected in this study were analyzed with one-way analysis of variance (ANOVA) of a completely randomized design using statistical package for social sciences (SPSS) and means were separated using Duncan test.

Experimental Diets

Table 1: Composition of the experimental diets (Starter phase)

Ingredients (%)	Treatment 1 (Control 1)	Treatment 2	Treatment 3	Treatment 4
Maize	50.60	50.60	50.60	50.60
Fish meal	1.50	1.00	0.50	0.00
Earthworm meal	0.00	0.50	1.00	1.50
Soya bean Meal	28.48	28.48	28.48	28.48
Wheat offal	9.00	9.00	9.00	9.00
Bone meal	4.80	4.80	4.80	4.80
Oyster Shell	5.26	5.26	5.26	5.26
Salt	0.27	0.27	0.27	0.27
Methionine	0.20	0.20	0.20	0.20
Lysine	0.09	0.09	0.09	0.09
Vitamin Premix	0.24	0.24	0.24	0.24
Toxin binder	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00

Nutritive value					**EWM**
Crude Protein	21.53	21.33	21.13	20.93	60.54
ME (Kcal/Kg)	288.75	2987.05	2990.00	2995.20	3015.30
Calcium(%)	1.34	1.31	1.30	1.36	58.78
Phosphorus(%)	0.85	0.83	0.81	0.80	13.67

Table 2: Composition of the experimental diets (Finisher phase)

INGRIDENTS (%)	Treatment 1 (Control)	Treatment 2	Treatment 3	Treatment 4
Maize	63.08	63.08	63.08	63.08
Fish meal	1.50	1,00	0.50	0.00
Earthworm meal	0.00	0.50	1.00	1.50
Soya bean Meal	23.69	23.69	23.69	23.69
Bone meal	5.50	5.50	5.50	5.50
Oyster Shell	5.60	5.60	5.60	5.60
Salt	0.28	0.28	0.28	0.28
Methionine	0.15	0.15	0.15	0.15
Lysine	0.08	0.08	0.08	0.08
Vitamin premix	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00

Nutritive value				
Crude Protein	18.98	19.30	19.50	19.87
ME (Kcal/Kg)	3.25	3.28	3.40	3.55
Calcium (%)	0.99	1.05	1.10	1.20
Phosphorus (%)	0.60	0.67	0.68	0.69

Results and discussion

Table 3: Effect of earthworm meal on Productive Performance of Broilers

Parameters	Treatment 1 (Control)	Treatment 2	Treatment 3	Treatment 4	SEM	P-value
Initial weight (g)	47.45±1.94	45.37±1.35	43.89±1.19	44.43±0.14	0.62	2.97
Final Weight (g)	834.29±71.52^{d}	1274.18±78.94^{b}	1389.96±324.86^{a}	1136.22±246.38^{c}	96.61	2.59
Weight gain (g)	786.85±69.57^{d}	1228±80.29^{b}	1346.07±323.67^{a}	1091.79±246.24^{c}	93.80	0.18
Average Daily Weight Gain (g/d/bird)	16.06±1.42^{d}	25.08±1.64^{b}	27.47±6.60^{a}	22.28±5.02^{c}	1.98	2.64
Average Daily Feed Intake (g/d/bird)	44.70±11.35^{b}	33.58±6.24^{c}	52.53±10.40^{a}	45.73±6.83^{b}	3.51	1.53
Feed Conversion Rate	2.68±0.92^{b}	1.34±0.16^{a}	2.02±0.86^{a}	2.07±0.16^{a}	0.27	1.90

Values= means ±SD. Means bearing different superscript in a row differ significantly.

Effect of earthworm meal on productive performance of broiler

The Crude protein content of earthworm meal reported herein contained 60.54 which fell within the value reported by Reinecke et al. (1991) and Nalunga et al. (2021) but higher than the value obtained by Gunya *et al.*(2018) ; Jankovic *et al.* (2020) and Musyoka *et al.* (2020). The variation could be attributed to the variation in the species of earthworm, management method and substrate used for culturing the earthworm.

The effects of EWM dietary Treatment on the productive performance of broilers were summarized in Table 3. Adding of EWM to the diet resulted in significant increasing weight gain with EWM based diets recording higher weight gain compared to the Control Treatment 1. There was significant effect of the diet on feed intake during the study period. However, inclusion of EWM up to 1.5% had a positive effects of weight gain and feed conversion ratio with Treatment 2 noted for the best FCR followed by Treatments 3 and 4 respectively and the poorest was Treatment 1 (Control). Conversely, the result of the weight gain disagreed with the result of Janovic *et al*. (2015) and Jankovic *et al.* (2020) who reported decreased body weight gain in broiler fed earthworm meal based diets. The difference might be due probably to the feeding of fresh earthworm in the diet of the chicken compared to the dried earthworm meal used in this study. It is interesting to know that fresh earthworm crawl away from the feed also it rotten quickly after death which makes it unpalatable (Jankovic *et al*. 2020).

Overall, increasing levels of EWM in the diet enhanced Feed intake of the chicken. The broiler chicken with 1.0% EWM ate the largest amount of feed while the lease was noted for Treatment 1 (Control). This finding

is contrast to the reports of Dairo *et al.* (2010) Gunya et al. (2019) and Nalunga *et al.* (2021) who found decreasing Feed intake with increasing levels of EWM in the diets of chicken. The better Feed intake reported herein could be attributed to optimum and low inclusion of EWM which could have resulted in low level of arginine and cysteine which were implicated as lowering the appetite of chicken (Prayogi, 2011).

Feed conversion ratio :

The best FCR was noted for diets 2 >3 > 4 and the least was diet 1. The FCR values noted showed that EWM based diet are better than the Control Treatnment 1. This aligned with the reports of numerous researchers (Gunya *et al.*, 2019, Nalunga *et al.*, 2021). The FCR value noted showed that EWM did not only affect the weight of the broilers but also enhanced the feed intake and weight gain. The trend observed herein was in harmony with the previously published data (Hassan *et al.*, 2020).

Effects of earthworm meal on nutrient digestibility

There was numerical variations in the digestibility coefficient of the dietary Treatments however, no significant difference ($p>0.05$) was noted in the nutrient digestibility of the experimental broilers fed EWM based diet (Table 4). This showed that the chicken utilized the diets efficiently and effectively without any health hazard (Table 4). Experimental group fed 1.5% earthworm meal had higher mean values of crude protein and crude fibre (70.68±5.80, 86.96±2.70) digestibility as compared to other groups. This suggested better quality diet as compared to other experimental diets and this was in agreement with the report of Mulyono, (2008) who stated that poor quality feed will decrease digestibility.

Table 4: Effects of earthworm meal on nutrient digestibility of broiler chickens

Parameters	Control Treatment 1	Treatment 2	Treatment 3	Treatment 4	SEM	P-value
Crude Protein	67.28±1.50	62.55±10.79	64.87±4.03	70.68±5.80	2.02	0.66
Crude fat	88.25±0.80	88.90±3.77	86.20±2.05	87.12±3.06	0.77	0.89
Ash	$52.89±2.73^{a}$	$28.45±19.71^{b}$	$32.06±21.79^{b}$	$46.06±14.70^{a}$	5.80	0.49
Crude fibre	84.63±4.23	83.38±4.23	82.30±0.79	86.96±2.70	0.95	0.41
NFE	81.28±0.46	80.16±5.23	75.88±3.56	78.08±4.00	1.27	0.55

Values= means ±SD. Means bearing different superscript in a row differ significantly.

Effects of earthworm meal on Production cost of Broiler chicken

The Production cost was presented in Table 5. Highest production cost was recorded for Treatment 1 compared with the EWM based diets (Treatment 2-4). Contrarily, the gross

margin, net return , market margin and rate of return of capital was least for Treatment 1 compared to EWM based diets (Treatments 2 -4).

The economic of production revealed that cost of feed /kg of feed and cost of feed /gain were affected by the dietary inclusion of EWM . The cost indicator were highest in the control Treatment 1 and lowest in 1.5% EWM diet indicating credible economic benefit of the addition of EWM in the diet of broiler production. As a result of an increase in percentage cost of production as EWM increased in the diets , it may be economical to partially replace Fish meal with EWM up to 1.5% so as to lower cost of production and enhance broiler meat available and affordable for the populace. For instance , the partial inclusion of EWM with Fish meal (0.5 -1.5%) recorded increasing Rate of return of capital of 1.71 > 1.68 > 1.66 for dietary Treatments 2, 3 and 4 respectively.

Table 5: Economic Analysis for Profitability Determination of the Experimental Broiler Chicken

Parameters	**Treatment 1 (Control)**	**Treatment 2**	**Treatment 3**	**Treatment 4**
Purchase Price of chicks (Naira*)	48,000	48,000.00	48,000.00	48,000.00
Number of Birds	100	100	100	100
Total feed intake (Kg)	2503.20	1880.48	2941.68	2560.88
Cost of other inputs (medication 5% of feed) (Naira*)	17.45	17.45	17.45	17.45
Total cost of diets (Naira*)	34,895.80	33854.50	70865.92	72155.92
Labour cost(Naira* /Month)	10,000.00	10,000.00	10,000.00	10,000.00
Total variable cost (Naira*)	116,072.22	117,575.92	118865.92	120,155.92
Selling price (Naira*)	250,000.00	400,000.00	400,000.00	400,000.00
Gross margin (Naira)	238,392.78	282,424.08	281,134.08	120,155.92
Net return (Naira*)	238,365.33	282,396.49	281,106.18	279,815.83
Market margin	53.57	70.61	70.28	69.69
Rate of return of Capital	1.37	1.71	1.68	1.66

*Naira = Nigerian currency

Conclusion and Recommendation

This study revealed that the supplementation of Earthworm meal increased the final weight, average daily weight gain and average daily feed intake of broilers chickens which eventually resulting in the reduction of cost of feeding, rate of return of capital and subsequently making animal protein (broiler meat) available to the growing population . Thus, the use of earthworm meal will open a window for better bio- available protein source and which could possible reduce the supplementation cost in future.

This present study recommends that inclusion of earth worm meal at 1.5% could improve the growth performance and reduce economic of broiler chickens production.

Conflict of interest

The authors hereby acknowledged that there is no conflict of interest in this study

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