

ISSN: 2695-2556 (Online)

ISSN: 2651-5679 (Print)

AKSU Journal of Agriculture and Food Sciences 8(2) 144-153, 2024

© Faculty of Agriculture, Akwa Ibom State University, Nigeria

Performance Characteristics and Economic Analysis of Replacing Fishmeal with Earthworm Meal in Broiler Chicken Diet

Moshood A. Belewu,^{1*} Hauwa O. Sadiq,³ Kafayat. Y. Belewu,² Kehinde. M. Okukpe,¹ Oluwasayomipe I. Alli¹ and Maryam Olaniyi¹

¹Department of Animal Production, University of Ilorin Nigeria

²Department of Agricultural Economics and Farm Management

³Department of Fisheries, Aquaculture and Wildlife, University of Abuja

*Corresponding author: moshood.belewu@uniabuja.edu.ng; Tel: +2348021251967

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. Four hundred-day-old chicks of mixed sex were assigned to four dietary treatments (0.0, 0.5, 1.0 and 1.5% EWM) with 100 chicks per treatment. Each treatment was divided into four replicates with twenty-five birds per replicate. Diets were iso-caloric and iso-nitrogenous in nature. The experiment which lasted for 56 days was laid out as a completely randomized design (CRD), and data collected was subjected to analysis of variance (ANOVA) using IBM SPSS statistics version 20. The results revealed that body weight gain (BWG) increased significantly ($P < 0.05$) as the EWM increased in the diets. The highest weight gain was recorded for the EWM-based diets (diets 2-4). Feed Conversion Ratio (FCR) was significantly higher ($p < 0.05$) when EWM was added to the diets with diet 2 recording the best FCR. Interestingly, feeding EWM-based diets did not reduce growth performance. The rate of return of capital was 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 could be considered as an ingredient of choice to partially replace fishmeal for broiler chicken 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 the importation of fishmeal hence, the novel feedstuff (EWM) opens a window for better bio-availability of protein source and it could possibly reduce the production cost in the future.

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

1.0 Introduction

World poultry meat production increased from 15.1 million tonnes to 137 million tonnes between 1970 and 2020 (<https://www.poultryworld.net>). Nigeria's 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 the African continent will increase by 60% mostly in Nigeria (World Economic Forum, 2019). About, 192.69MT of poultry meat and egg products are consumed annually in Nigeria (Ritchiets, and Rose, 2020). However, the industry is faced with numerous challenges such as 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 fishmeal (FM). This ingredient is very expensive in Nigeria hence; it is pertinent to source for other alternative source to fishmeal without compromising quality. Earthworm, which is one of such alternative ingredients for use in animal feed, is readily available (Startford and Tacon, 2005).

Earthworm meal (EWM) contains protein content of between 65 and 77% and has similar amino acid profiles to fishmeal (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 fishmeal in terms of protein quality therefore, earthworm meal is considered rich to supplement or replace fishmeal in a livestock diet. Earthworm meal is richer than the percentage of fish protein (45%) and meat protein (51 percent) (Damayanti *et al.*, 2008).

It also contains proline amino acid of 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 for growing poultry chicken (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 fishmeal is now costly and scarce, it is essential to substitute EWM with fishmeal to minimize the cost of production in broilers. 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.

2.0 Materials and Methods

2.1 Experimental Site

The experiment was carried out at the University of Ilorin Teaching and Research Farm, Ilorin, Kwara state, Nigeria with coordinates of 8.291°N and 4.351°E. The wind was 13km/h, humidity of 89% and temperature of between 24 and 35°C (Eifediyi *et al.*, 2017).

2.2 Preparation of Earthworm Meal

Earthworms cultured using a process known as vermiculture was employed. This involves the artificial rearing or cultivation of worms. The earthworms were harvested and washed using water to separate manure from outside the 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 a homogenized form.

2.3 Experimental Birds and Management

All experimental protocols (suitable feed, housing, management and humane handling of animals) were per the University of Ilorin Research Policy on Animal Welfare. The study was undertaken on four hundred (400) mixed-sex day-old broiler chicks of the same hatch purchased from a reputable commercial hatchery (Zartech farm, Oyo state) 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, environment hygiene and biosecurity were followed throughout the experimental period. Feeding and watering were supplied *ad libitum*. The experiment was conducted for a period of eight weeks. The daily feed consumption, weight gain and feed conversion ratio were properly recorded and the partial economic analysis was calculated.

Average daily feed intake (ADFI) = Cumulative feed intake / Number of birds X number of days.

Average daily weight gain (ADG) (g/bird/day) = Final weight gain - Initial weight gain / number of days.

Feed conversion ratio (FCR): Feed /Gain = Cumulative feed intake (Kg) / Total weight gain (Kg).

2.4 Data and Chemical Analysis

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

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 as described by Duncan test.

Table 2.1: Composition of the experimental diets (Starter phase)**Nutritive value**

Ingredients (%)	Treatment 1 (Control)	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
Crude Protein (%)	21.53	21.33	21.13	20.93
ME (Kcal/Kg)	288.75	2987.05	2990.00	2995.20
Calcium (%)	1.34	1.31	1.30	1.36
Phosphorus (%)	0.85	0.83	0.81	0.80

EWM-Earth worm meal

Table 2.2: Composition of the experimental diets (finisher phase)

Ingredients (%)	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

3.0 Results and Discussion

3.1 Effect of Earthworm Meal on Productive Performance of Broiler Chicken

The Crude protein content of earthworm meal reported in table 2.2 contained 60.54% which fell within the values reported by Reinecke *et al.* (1991) and Nalunga *et al.* (2021) (50 to 73%) but higher than the values obtained by Gunya *et al.* (2018); Jankovic *et al.* (2020) and Musyoka *et al.* (2020) (50 to 59%). 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 broiler birds are summarized in Table 3.1. Addition of EWM to the diet resulted in significant increase in weight gain ($P < 0.05$) with EWM-based diets recording higher weight gain compared to the Treatment 1 (control). There was a significant effect ($P < 0.05$) of the diet on feed intake during the study period. However, inclusion of EWM up to 1.5% had a positive effect 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 Jankovic *et al.* (2015) and Jankovic *et al.* (2020) who reported decreased body weight gain in broiler chicken 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 crawls away from the feed and decomposes quickly after death; this 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 highest amount of feed while the least was noted for Treatment 1 (Control). This finding is in contrast with 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 levels of arginine and cysteine which were implicated as lowering the appetite of broiler chicken (Prayogi, 2011).

Table 3.1: 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 ^d ±71.52	1274.18 ^b ±78.94	1389.96 ^a ±324.86	1136.22 ^c ±246.38	96.61	2.59
Weight gain (g)	786.85 ^d ±69.57	1228 ^b ±80.29	1346.07 ^a ±323.67	1091.79 ^c ±246.24	93.80	0.18
Av. daily wt. gain (g/d/bird)	16.06 ^d ±1.42	25.08 ^b ±1.64	27.47 ^a ±6.60	22.28 ^c ±5.02	1.98	2.64
Av. daily feed intake (g/d/bird)	44.70 ^b ±11.35	33.58 ^c ±6.24	52.53 ^a ±10.40	45.73 ^b ±6.83	3.51	1.53
FCR	2.68 ^b ±0.92	1.34 ^a ±0.16	2.02 ^a ±0.86	2.07 ^a ±0.16	0.27	1.90

Values= means ±SD. Means bearing different superscript in a row differ significantly. Av. daily wt. gain=average daily weight gain, FCR=Feed conversion rate

3.2 Feed Conversion Ratio

The best FCR was noted for diets 2 > 3 > 4 and the least was diet 1 (Table 3.1). The FCR values noted showed that EWM based diet are better than the control. 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 broiler chicken 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).

3.3 Effects of Earthworm Meal on Nutrient Digestibility

There were 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 broiler chicken fed EWM based diet (Table 3.2). This showed that the chicken utilized the diets efficiently and effectively without any health hazard (Table 3.2). Experimental group fed 1.5% earthworm meal had higher means of crude protein and crude fiber (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 would decrease digestibility.

Table 3.2: Effects of earthworm meal on nutrient digestibility of broiler chickens

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

Values= means $\pm$ SD. Means bearing different superscript in a row differ significantly. NFE=Nitrogen free extract

3.4 Effects of Earthworm Meal on Production Cost of Broiler Chicken

The Production cost is presented in Table 3.3. 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 with EWM based diets (Treatments 2-4).

The economics of production revealed that cost of feed/kg of feed and cost of feed /gain were affected by the dietary inclusion levels of EWM. The cost indicator (feed intake, medications, labour, price of chicks, selling price of broiler chicken) were highest in the control and lowest in 1.5% EWM diet indicating credible economic benefit of the addition of EWM in the diet of broiler birds' 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 fishmeal with EWM up to 1.5% so as to lower cost of production and enhance broiler meat availability and affordability for the populace. For instance, the partial inclusion of EWM with fishmeal (0.5 -1.5%) recorded increased rate of return of capital of $1.71 > 1.68 > 1.66$ for dietary Treatments 2, 3 and 4 respectively (Table 3.3).

Table 3.3: 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	400	400	400	400
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	33,854.50	70,865.92	72,155.92
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	118,865.92	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

4.0 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 broiler chickens which eventually resulted in the reduction of cost of feeding, rate of return of capital and will subsequently make animal protein (broiler meat) available to Nigeria's growing population. Thus, the use of earthworm meal will open a window for better bio-availability of protein source that could possibly reduce the production cost in the future. This present study recommends that inclusion of earthworm meal at 1.5% could improve the growth performance and reduce economic of broiler chickens' production.

Conflict of Interest

The authors acknowledge that there is no conflict of interest in this study.

References

- AOAC (2010) Official methods of analysis of AOAC international. Association of Official Analytical Chemists International, 17th ed. Washington.
- Belewu, M. A., Tijani, A. A. and Inamette, F. J. (2013). Synergistic effect of *Aspergillus niger* and *Penicillium chrysogenum* on Jatropha cake: influence on performance of Sheep. *International Journal of Science and Nature* 4(4), 624-626.

- Cho, J. H., Park, C. B., Yoon, Y. G and Kim, S. C. (1998). Lumbricum 1. a novel proline rich antimicrobial peptide from the earthworm purification cDNA cloning and molecular characterization, *Biochemical and Biophysical. ACTA* 1408 (1) 67-76
- Dairo, F. A. S., Adesehinwa, A. O. K., Oluwasola, T. A. and Oluyemi, J. A. (2010). High and low dietary energy and protein levels for broiler chicken. *African Journal of Agricultural Research* 5: 2030-2038
- Damayanti, E., Julendra, H. and Sofyan, A. (2008). Antibacteria activity of earthworm meal (*Lumbricus rubellus*) with different methods to the *Escherichia coli*. Proceeding National Food Seminar.
- Dedeke, C. A., Owa, S. O. and Olurin, K.B. (2010). Amino acid profile of four earthworm species from Nigeria. *Agriculture and Biology Journal of North America* 1: 97-102.
- Edwards, C. A. and Niederer, A. (1988). The production and processing of earthworm protein. In: Earthworms in waste and environmental management.' (ed C.A.Edwards and E.F. Neuhauser). Academic Publishing, The Hague, The Netherlands, pp 169-180
- Eifediyi, E. K., Remison, S. U., Ahamefule, H. E., Azeez, K.
FAO (2018). African sustainable livestock (2050). Livestock and livestock spotlight. Nigeria cattle and poultry sectors. http://www.fao.org/3/CA2149EN/ca_2149en.pdf.
- Guerrero, R. D. (1981). The culture and use of *Perionyx excavatus* as a protein resource in the Phillippines. Dorwin Centenary Symp. On Earthworm ecology, Inst. Terrestrial Ecology UK Aug 30th Sep 4th . pp 250.
- Gunya, B., Muchenje, V. and Masika, P. J. (2018). The effect of *Eisenia foetida* meal as a protein source on sensory attributes of broiler meat. *Livestock Research Rural Development* 30.
- Gunya, B., Muchenje, V. and Masika, P. J. (2019). The effect of earthworm *Eisenia foetida* meal as a protein source on carcass characteristics and physico-chemical attributes of broiler. *Pakistan Journal of Nutrition* 18, 657-664.
- Hassan, N. G., Tuitoek, J. K. and Ambula, M. K. (2020). Acceptability (Measured as feed intake) by broilers fed earthworm meal (*Eisenia foetida*). *International Journal of Veterinary Sciences and Animal Husbandry*, 5 (4): 93-96
- Istiqomah, L., Sofyan, A., Damayanti, E. and Julendra, H. (2009). Amino acid profile of earthworm and earthworm meal (*Lumbricus rubellus*) for animal feedstuff. *Journal Indonesia Tropical Animal Agriculture* 34: 252-257.
- Jankovic, L.J., Petrujkic, B., Alekksic, N., Vucinic, M., Teodorovic, R., Karabasil, N., Relic, R., Draskovic, V. and Nenadovic, C. K. (2020). Carcass characteristics and meat quality of

- broiler fed on earthworm (*Lumbricus rubellus*) meal. *Journal of Health Veterinary Medicine Society* 71:2013 2040.
- Jankovic, L. J., Radenkovic-Damnjanovic, E., Vucinic, M., Sefer, D., Teodorovic, R., Dordevic, M. and Radisavljevic, K. (2015). Effects of Fish meal replacement by red earthworm (*Lumbricus rubellis*) meal on broiler's performance and health. *Acta Veterinaria* 65:271-286.
- Kucukersan, S., Kucukersan, K., Colpan, E and Goncuoglu, E., Reisli, Z. and Yesibag, D. (2005). The effect of humic acid on egg production and egg traits of laying hen. *Veterinary Medicine* 50:406-410
- Monebi, C. O. and Ugwumba, A. A. A. (2013). Utilization of earthworm, *Eudrilus eugeniae* in the diet of Heteroclaris fingerlings. *International Journal of Fish Aquatic* (2):19-25.
- Mulyono, A. M. W. (2008). Mutant of the fungus *Trichoderma* sp. Seluolink to improve quality of feed materials, Onggok for broiler chickens. Dissertation - Animal Science Studies programm postgraduate school Gadjak University.
- Musyoka, S. N., Liti, D. M., Ogello, E. O. and Meulenbrock, P. (2020). Using earthworm, *Eisenia fetida* to bio-convert agro-industrial wastes for aquaculture nutrition. *BioResource* 15: 574-587
- Nalunga, A., Komakeck, A.J., Jjagwe, J., Magala, H & Lederer, J (2021). Growth characteristics and meat quality of broiler chicken fed earthworm meal from *Eudrilus engeniae* as a protein source. *Livestock Science* 245: Retrieved from www.elsevier.com/locate/livsc
- Prayogi, H. S. (2011). The effect of earthworm meal supplementation in the diet on quails growth performance in attempt to replace usage of fish meal. *International Journal of Poultry Science* 10; 804-806.
- Reinecker, A. J., Hayes, J.P. and Cilliers, S. C. (1991). Protein quality of three different species of earthworm. *South African Journal of Animal Science* 21: 99-103.
- Ritchiets, H. and Rose, M. (2020). Meat and dairy production. Published online@ourworlddata.org. <https://www.ourworlddata.org/meat-production>.
- Sogbesan, A. O. and Ugwumba, A. A. (2008). Nutritional values of some non-conventional animal protein feedstuffs used as fishmeal supplement in aquaculture practice in Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences* 8 (1): 159-164.
- Startford, E. A. and Tacon, A. G. (2005). The nutritional evaluation of dried earthworm meal (*Eisenia foetida*, savigny, 1826) included at low levels in production diets for rainbow trout *Salmo gairdneri* Richardson, *Aquaculture Research*, 1985, 16 (3):213 - 222.

- Vielma, J., Koskela, J., Ruohonen, K., Jokinen, I. and Kettunen, J. (2003). Optimal diet composition for European whitefish (*Coregonus lavaretus*) carbohydrate stress and immune parameter responses. *Aquaculture* 225 (1-4) 3-16
- World Economic Forum (2019). Meat the Future series options for the livestock sector in developing and emerging economics to 2030 and beyond [http://www-w3weforum.org/docs/white paper- livestock-emerging % 20. economics pdp](http://www.weforum.org/docs/white%20paper-livestock-emerging%20economics.pdf).