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Growth Performance of Broilers Fed Earthworm Meal as an Alternative Protein Source

Aadil Ahmad[1], Nazam Khan[2], Ramesh Kumar Sharma[1], Vikas Mahajan[2], Akhil Verma[2], Imran Ahmad Ganai[1], Taiba Tariq[1] and Qazi Shehriyar Sahib[3*]

[1]Division of Animal Nutrition, FVSc & AH, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, R.S. Pura, Jammu and Kashmir, INDIA

[2]Division of Livestock Farm Complex, FVSc & AH, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, R.S. Pura, Jammu, Jammu and Kashmir,INDIA

[3]Animal Husbandry Department, Kishtwar, Jammu, Jammu and Kashmir, INDIA

**Corresponding author: QS Sahib; E-mail: qazi.sahib14@gmail.com*

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ABSTRACT

The current study was conducted to assess the effect of feeding earthworm meal (EWM) as unconventional protein source on growth traits of broiler chickens. A total of 240 day-old, straight-run,Cobb broiler chicks were randomly allocated to five treatment groups (48 birds per group) as per completely randomized design (CRD); each group comprising four replicates of 12 birds. The control group (C) received no EWM, whereas in treatment groups, EWM was incorporated @ 0.5%, 1.0%, 1.5%, and 2.0% and designated as T_1, T_2, T_3, and T_4, respectively. All the experimental diets were formulated to be isocaloric and isonitrogenous. The growth trial was conducted for a period of 42 days; the feed intake and body weight were recorded on weekly intervals. The inclusion of EWM up to 2% had no significant effect (p<0.05) on periodic feed intake, body weight changes, body weight gain, feed conversion ratio (FCR) and protein efficiency ratio (PER). The results indicated that EWM can be safely incorporated up to 2% in broiler diets as an alternative protein source.

HIGHLIGHTS:

- Inclusion of EWM upto 2% had no significant effect on feed intake and body biometrics of broilers.
- EWM can safely replace conventional protein sources upto 2% without compromising broiler performance.

Keywords: Broiler chickens, Earthworm meal, Growth traits, Unconventional protein source

The poultry sector represents one of the most organized and rapidly expanding agricultural subsectors, contributing significantly to the supply of affordable animal protein (Khan *et al*., 2022). Its high feed efficiency and short production cycle make it a critical component in meeting the rising global demand for protein. In India, the poultry industry was valued at INR 2,304 billion in 2024 and is projected to reach INR 8,430 billion by 2033, growing at a compound annual growth rate (CAGR) of 12.6%. The poultry population has increased to 851.81 million as per the 20th Livestock Census (2019), reflecting the growing demand for economical protein sources. However, escalating feed costs remain a major constraint to sustainable poultry production.

The Indian broiler industry ranked fourth globally and feed alone accounts for approximately 65–70% of total production cost (Chauhan *et al*., 2023); with protein sources constituting the most expensive component (Admasu *et al*., 2019). In this context, increasing attention

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has been directed toward unconventional feed resources such as algae, insects, and other invertebrates (Sahib *et al*., 2023). Among these, earthworm meal (EWM) has emerged as a promising alternative due to its high crude protein content (50-70%), balanced amino acid profile, good palatability, and lack of competition with human food resources (Parolini *et al*., 2020). Its protein quality has been reported to be comparable to or even superior to fish meal, and nutritionally advantageous over soybean meal (Bahadori *et al*., 2017). Additionally, EWM has been shown to enhance antioxidant enzyme activity in broilers without leading to harmful residue accumulation (Zang *et al*., 2018). The production of EWM through vermicomposting also offers environmental and economic benefits, including efficient recycling of organic waste and reduced dependence on imported feed ingredients (Belewu *et al*., 2024).

Many conventional protein sources such as fish meal (FM), meat-cum-bone meal (MBM), and soybean meal (SBM) are expensive and largely imported in regions like Jammu and Kashmir, highlighting the need for cost-effective, locally available alternatives. Despite its considerable potential, limited information is available on EWM derived from *Eisenia fetida* under the agro-climatic conditions of Jammu and Kashmir. Therefore, the present study was undertaken to evaluate EWM as a partial substitute for conventional protein sources and to determine its optimal inclusion level in broiler diets.

MATERIALS AND METHODS

Experimental Design

The experiment was conducted at the FVSc & AH, SKUAST-Jammu (J&K, India). A total of 240 day-old straight run broiler chicks (Cobb strain) were randomly divided into five treatment groups, each containing 48 birds, as per completely randomized design (CRD). Each group was further subdivided into four replicates of 12 birds each. Based basal diet provided to the birds were formulated according to ICAR (2013) recommendations. The experimental groups were designated as Control (C; containing no earthworm meal; EWM), and treatments T_1, T_2, T_3 and T_4 groups, EWM was incorporated @ 0.5%, 1.0%, 1.5% and 2.0%, respectively. The diets formulated were iso-nitrogenous and the CP (% on DMB) varied from 22.01 to 22.12% for pre-starter ration, 21.48 to 21.54% for starter ration and 19.48 to 19.54% for finisher ration, respectively. The calculated metabolizable energy (ME) levels were 3000 kcal/kg for the pre-starter, 3050 kcal/kg for the starter, and 3100 kcal/kg for the finisher diets across all treatment groups.

Preparation of Earthworm Meal (EWM)

Earthworms (*Eisenia fetida*) were cultured using cow dung and dairy farm waste at University Dairy Farm, SKUAST-Jammu, RS Pura, J&K, India. Worms were separated using an electric drum siever and collected in water. They were fasted for 4 hours to clear gut contents and then washed thoroughly. The worms were first sun-dried, followed by overnight oven drying at 45°C. The dried worms were finely ground to prepare earthworm meal and stored in bags until use.

Feed intake and Growth studies

The average feed intake was calculated by measuring the difference between the total feed provided to each replicate and the leftover feed collected at a consistent time each morning. This value was then divided by the number of birds in the respective replicate. The initial body weight of the birds was recorded replicate wise at the time of arrival (day-old) and subsequently on a weekly basis throughout the experimental period using a digital electronic weighing balance. Weighing was carried out in the morning hours prior to feeding to ensure accuracy and uniformity. Body weight gain was calculated by subtracting the previous recorded weight from the present recorded body weight. To access the actual effect of diet, body weight gain, FCR and PER were calculated. The FCR and PER was calculated by the following formula:

$$FCR = \frac{\text{Total Feed intake (g)}}{\text{Total gain in body weight (g)}}$$

$$PER = \frac{\text{Weight gain (g)}}{\text{Protein consumed (g)}}$$

Statistical analysis

The data obtained was subjected to one way analysis of variance by using method outlined by Snedecor and

Cochran (1994). The significance between individual pair of means was determined by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Feed intake

The daily feed intake (FI) of all treatment groups was recorded in grams and expressed as average weekly intake (Table 1). FI remained statistically comparable throughout the experimental period, ranging from 167.57 to 177.01 g in week 1, 379.54 to 398.06 g in week 2, 925.23 to 944.28 g in week 3, 941.38 to 967.04 g in week 4, 1000.33 to 1044.48 g in week 5, and 1074.51 to 1100.99 g in week 6. These findings are in agreement with earlier reports indicating that inclusion of EWM, fresh earthworms, or combinations of vermihumus (VH) and EWM at varying levels does not significantly influence FI in broilers or other poultry species (Bollido, 2021; Nalunga *et al*., 2021; Taye *et al*., 2024). In contrast, some studies have reported either increased FI (Gholami *et al*., 2015; Ekine and Onunkwo, 2020) or reduced FI (Prayogi, 2011; Bahadori *et al*., 2015). The non-significant variation in FI observed in the present study may be attributed to the provision of iso-caloric and iso-nitrogenous diets. Discrepancies with other reports could be due to differences in the form of earthworms used (fresh *vs.* dried), variations in earthworm and poultry species, inclusion levels, and the use of EWM in combination with VH. Overall, the present findings suggest that inclusion of EWM in broiler diets up to 2% does not adversely affect feed palatability or intake, indicating its potential as a safe and sustainable alternative protein source in broiler rations.

Periodic body weight and body weight gain

Body weight (BW) was recorded weekly throughout the experimental period, and body weight gain (BWG) was calculated accordingly. The growth performance data are presented in Tables 2 and 3. The initial BW of chicks ranged from 43.88 to 44.64 g at day 0, increasing to 198.8–209.52 g at week 1, 496.12–520.03 g at week 2, 1094.16–1136.45 g at week 3, 1587.22–1643.17 g at week 4, 2021.54–2073.41 g at week 5, and 2333.7–2393.60 g at week 6 across the treatment groups. No significant differences in BW were observed among treatments at any stage of the trial. Similarly, BWG did not differ significantly (p>0.05) across treatments. The present results are consistent with earlier studies reporting no significant effect of EWM supplementation on BW or BWG (Rezaeipour *et al*., 2014; Bahadori *et al*., 2017; Ekine and Onunkwo, 2020; Chashmidari *et al*., 2021). In quails, Prayogi (2011) reported comparable BWG at 5% and 10% EWM inclusion, with a significant decline at 15%.

In contrast, some authors have documented improved BW or BWG (Zang *et al*., 2018; Nalunga *et al*., 2021; Belewu *et al*., 2024; Taye *et al*., 2024), while other research reported reduced growth performance at higher inclusion levels (Janković *et al*., 2020). Such inconsistencies may be attributed to variations in earthworm species, form of inclusion (fresh vs. dried, or in combination with vermihumus), inclusion levels, duration of the experiment, poultry species, and differences in diet composition. Notably, studies reporting reduced growth often utilized fresh earthworms, which may lower feed palatability due to movement and rapid spoilage, thereby negatively influencing feed intake and subsequent weight gain. No

Table 1: Effect of earthworm meal inclusion on feed intake (g) of broiler chicken

Week	Groups					SEM	p-value
	C	T_1	T_2	T_3	T_4		
1	172.22	167.57	172.80	173.01	177.01	3.54	0.961
2	384.07	379.54	382.31	398.06	393.48	5.35	0.820
3	926.21	925.23	940.03	944.28	935.41	11.79	0.987
4	941.38	954.88	961.81	953.66	967.04	12.78	0.983
5	1003.65	1000.33	1010.64	1044.48	1023.45	14.26	0.894
6	1074.51	1084.80	1100.99	1098.01	1093.04	15.61	0.989

C, T_1, T_2, T_3 and T_4 groups- Earthworm meal was incorporated in broiler ration @ 0, 0.5, 1.0, 1.5 and 2.0%, respectively.

Table 2: Effect of earthworm meal inclusion on periodic body weight changes (g) of broiler chicken

Period	Groups					SEM	p-value
	C	T_1	T_2	T_3	T_4		
Day 0	44.53	44.34	43.88	44.64	43.99	0.33	0.950
Week 1	198.80	203.30	209.52	206.91	205.58	2.21	0.657
Week 2	496.12	505.71	516.46	520.03	512.12	6.41	0.82
Week 3	1094.16	1116.30	1136.45	1134.71	1122.11	9.19	0.642
Week 4	1587.22	1623.88	1643.17	1626.07	1616.28	11.02	0.645
Week 5	2021.54	2059.24	2073.41	2060.24	2046.74	12.80	0.798
Week 6	2333.70	2375.10	2393.60	2369.83	2357.67	15.41	0.834

C, T_1, T_2, T_3 and T_4 groups- Earthworm meal was incorporated in broiler ration @ 0, 0.5, 1.0, 1.5 and 2.0%, respectively.

Table 3: Effect of earthworm meal inclusion on body weight gain (g) of broiler chicken

Week	Groups					SEM	*p*-value
	C	T_1	T_2	T_3	T_4		
1	154.27	158.96	165.64	162.28	161.60	1.95	0.469
2	297.32	302.41	306.95	313.12	306.54	4.33	0.864
3	598.04	610.59	619.98	614.68	609.99	3.25	0.303
4	493.06	507.58	506.72	491.36	494.16	3.24	0.333
5	434.32	435.37	430.24	434.17	430.47	3.88	0.993
6	312.16	315.85	320.19	309.60	310.93	4.66	0.965

C, T_1, T_2, T_3 and T_4 groups- Earthworm meal was incorporated in broiler ration @ 0, 0.5, 1.0, 1.5 and 2.0%, respectively.

such adverse effects were observed in the present study, suggesting that inclusion of EWM up to 2% remains within a safe and nutritionally adequate range, supporting the use of EWM as a viable alternative protein source at this level.

Feed conversion ratio (FCR)

Feed conversion ratio (FCR) was calculated on a weekly basis (Table 4). No significant differences ($p>0.05$) were observed among treatment groups throughout the experimental period. Weekly FCR values for C, T_1, T_2, T_3, and T_4 ranged from 1.12 to 1.10 in week 1 and from 3.46 to 3.53 in week 6. These results are in agreement with previous studies reporting no significant effect of EWM inclusion on FCR in broilers (Rezaeipour *et al*., 2014; Bahadori *et al*., 2017; Ekine and Onunkwo, 2020; Chashmidari *et al*., 2021; Bollido, 2021). Variations reported in other studies may be attributed to differences in diet formulation (particularly non-iso-caloric and non-iso-nitrogenous diets), form of EWM, species used, and experimental conditions. Overall, the comparable FCR across treatments suggests that inclusion of EWM up to 2% does not adversely affect feed efficiency and is comparable to conventional protein sources.

Protein Efficiency Ratio (PER)

The average weekly PER of broiler chickens under different dietary treatments is presented in Table 5. Weekly PER values ranged from 1.47 to 4.10 in the control (C), 1.47 to 4.35 in T_1, 1.47 to 4.40 in T_2, 1.42 to 4.29 in T_3, and 1.44 to 4.17 in T_4. No significant differences ($p>0.05$) were observed among the treatment groups throughout the experimental period. The comparable PER across treatments indicates that protein derived from EWM was utilized as efficiently as that from the basal diet. These findings are consistent with those of Rezaeipour *et al*. (2014) and Bahadori *et al*. (2015), who also reported no significant variation in PER with dietary inclusion of

Table 4: Effect of earthworm meal inclusion on feed conversion ratio (FCR) of broiler chicken

Week	Groups					SEM	*p*-value
	C	T_1	T_2	T_3	T_4		
1	1.12	1.06	1.05	1.07	1.10	0.02	0.920
2	1.30	1.26	1.25	1.28	1.29	0.03	0.992
3	1.55	1.52	1.52	1.54	1.54	0.02	0.988
4	1.91	1.88	1.90	1.94	1.96	0.03	0.951
5	2.31	2.30	2.35	2.41	2.39	0.04	0.928
6	3.46	3.44	3.45	3.55	3.53	0.07	0.987

C, T_1, T_2, T_3 and T_4 groups- Earthworm meal was incorporated in broiler ration @ 0, 0.5, 1.0, 1.5 and 2.0%, respectively.

Table 5: Effect of earthworm meal inclusion on protein efficiency ratio (PER) of broiler chicken

Week	Groups					SEM	p-value
	C	T_1	T_2	T_3	T_4		
1	4.10	4.35	4.40	4.29	4.17	0.10	0.881
2	3.54	3.64	3.66	3.60	3.56	0.09	0.993
3	3.01	3.08	3.08	3.04	3.05	0.05	0.991
4	2.70	2.73	2.71	2.65	2.63	0.05	0.965
5	2.20	2.22	2.17	2.12	2.15	0.04	0.936
6	1.47	1.47	1.47	1.42	1.44	0.03	0.983

C, T_1, T_2, T_3 and T_4 groups- Earthworm meal was incorporated in broiler ration @ 0, 0.5, 1.0, 1.5and 2.0%, respectively.

EWM at different levels in broiler diets. Although limited literature is available on this parameter, the present results suggest that inclusion of EWM at the tested levels does not adversely affect protein utilization efficiency. Furthermore, the birds' ability to convert dietary protein into body mass remained unaffected, supporting the potential of EWM as a viable alternative protein source in broiler nutrition.

CONCLUSION

The findings of the present experiment revealed that conventional protein sources can be successfully replaced by EWM up to 2.0% level without any adverse effect on feed intake and growth of broiler chickens. However, further studies using large number of birds for long duration are recommended to ascertain the physiological and productive performance of broiler chickens.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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