International Journal of Veterinary Sciences and Animal Husbandry

ISSN: 2456-2912
VET 2020; 5(4): 93-96

www.veterinarypaper.com
Received: 23-05-2020
Accepted: 25-06-2020

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Acceptability (measured as feed intake) by broilers of red earthworm meal (*Eisenia Foetida*)

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Abstract
Red earthworm meal (*Eisenia foetida*) are potential to be utilized as feed resource due to their good nutritional composition. However, it is not known whether broilers can consume feeds containing significant levels of earthworm meal. This study determined acceptability of red worms by broiler chickens. Three experimental broiler finisher diets were formulated to be isonitrogenous and isocalorific. Earthworm meal substituted fish meal in experimental diets. Diet 1 (control) containing no earthworm meal, diet 2 earthworm meal replaced 25% of fish meal and diet 3, earthworm meal replaced 50% of fish meal. Acceptability of diet was determined using two-choice test method. In each cage with a single broiler, two diets were offered to the broiler such that there were three combinations; i.e. diet 1 and diet 2; diet 1 and diet 3; diet 2 and diet 3. Feed intake was used to predict the acceptability of the diet. There were no variations (P >0.05) in acceptability of different levels of red earthworm meal. Birds did not show preferences for any of the dietary inclusion levels of red earthworm meal. It is concluded that earthworm meal from *E. foetida* can replace up to 50% fishmeal in broiler finisher feed without affecting feed intake. Therefore, *Eisenia foetida* meal is a promising protein source for broilers.

Keywords: alternative protein, broiler diets, conventional protein, finisher feed

Introduction
The common conventional protein feed resources for chickens in Kenya are fishmeal and soybean meal. These conventional protein feedstuffs are restrictive (Veldkamp *et al.* 2012) [17] because they are expensive. Similarly, fishmeal cannot be included at levels beyond 10% because of the taint passed into broiler meat (Swick 1999) [16]. Therefore, this necessitates a need for alternative or replacement sources of protein that can substitute fishmeal and or soybean meal. One such alternative is the red earthworm meal.

The possibility and potential of using red earthworm meal as a feed resource for livestock has been reported by several researchers (Hilton 1983; Sogbesan and Ugwumba 2008; Gunya *et al.* 2016) [7, 14, 6]. This is due to its good nutritional composition. The protein quality of earthworm meal is almost similar to that of fish meal which is a conventional protein source used in poultry industry (Gunya *et al.* 2016) [6]. The protein content of *Eisenia foetida* ranges from 58 % to 71 % on dry weight basis (Zhenjun *et al.* 1997; Moreki and Tiroesele 2012) [19, 10]. The protein requirements for various classes of broiler chicken is estimated to be between 18-23% for optimal growth (NRC 1994) [12].

In addition, other studies showed that earthworm is rich in essential amino acids, especially lysine. This amount of lysine in earthworm meets the lysine required by growing poultry (Stafford and Tacon 1985; Edwards and Niederer 1988; Vielma *et al.* 2003) [15, 5, 18]. It is evident that the nutritional composition of red worms was overemphasized. However, it is not known whether broilers can consume feeds containing significant levels of earthworm meal. This has made it complex to include them into feed formulation by nutritionists and farmers. The acceptability of *E. foetida* was evaluated using feed intake of feeds containing the earthworm meal. Acceptability of diet was determined by using two-choice test method as described by Kane *et al.* (1981) [8]. Therefore, the objective of this study was to determine acceptability of red worms by broiler chickens.

Materials and Methods

Study site

The feeding experiment was carried out at Poultry unit at Tatton Agriculture Park (TAP) in Egerton University. The University is geographically situated at S 0˚22'11.0", E 35˚55'58.0" within the Kenyan Rift Valley in Njoro, Nakuru County. It has an altitude of 1,800 m above sea level with temperatures ranging between 22 ˚C and 17 ˚C on average. The average annual rainfall in the area is 1,200 mm per year.

Source and processing of red earthworm meal

Fresh red earthworms were obtained from a commercial farm (Kinangop Organics Farm, Kenya), where it is being used in making compost manure. Red earthworms were transported while afresh to Egerton University, department of Animal Sciences and rinsed in water and kept in bowel for 30 minutes to evacuate their guts (Akpodiete and Okagbere 1999) [1]. The worms were passed through boiling water for a minute as described by Bou-Maroun *et al.* (2013) [3], thereafter, spread in sunlight on a polythene. The dried red worms were milled into a powder using a mortar and pestle.

Experimental birds and housing

Nine 28-days old mixed sex broiler chickens of average weight of about 700 g were obtained from a commercial farmer in Nakuru and randomly placed in individual cages whose width, length and height were measuring 1 m by 3 m by 3 m respectively. Feed and fresh water were accessible *ad libitum* throughout the study period. The house floors were covered with six cm of wood shavings as litter material. The experimental cages were constructed within a house in which a 1 m high wall was covered with wire mesh. The wire mesh was allowed for ventilation and natural light.

Experimental diets

Three experimental broiler finisher diets were formulated to be isonitrogenous and isocalorific. Earthworm meal substituted fish meal in experimental diets. Diet one was the control treatment containing no earthworm meal. In the second diet, earthworm meal replaced 25% of fish meal and in diet three, earthworm meal replaced 50% of fish meal (Table 1).

Experimental procedures

The acceptability of broiler chicken diets containing varying levels of red earthworm meal were determined using feed intake in a two-choice test method as described by Kane *et al.* (1981) [8]. In each cage with a single broiler, two diets were offered to the broiler such that there were three combinations; i.e. diet 1 and diet 2; diet 1 and diet 3; diet 2 and diet 3. Each combination was randomly allocated to an individual bird in cage resulting to three replications per combination. The diets were placed in plates and locations for the two diets in the cage were interchanged daily to avoid association of location with a particular diet. Feed (the two plates in each cage) was available at all times. A seven-day adaptation period was allowed and a seven-day feed intake data collection followed. At the end of the experiment, the feed consumed from each plate was determined on the cage basis. Feed intake was used to predict the acceptability of the diet.

Statistical analysis

The intake of each diet was analyzed statistically using general linear model (GLM) procedure of SAS (2009) and the differences among mean were tested for significance using Tukey test.

Table 1: Composition of experimental diets and calculated nutrient composition

Ingredients	Diet 1	Diet 2	Diet 3
White maize	75	75	75
Corn oil	1	1	1
Soybean meal	14	14	14
Fish meal	8	6	4
Earthworm meal	0	2	4
Di-calcium phosphate	0.45	0.45	0.45
Limestone	1.10	1.10	1.10
Iodized salt	0.20	0.20	0.20
Premix	0.25	0.25	0.25
Total	100	100	100
Calculated			
CP (%)	17.97	17.87	17.76
ME Kcal/Kg	3160	3138	3115
Analyzed (%)			
CP	16.80	16.72	16.70
ME, MJ/Kg	16.4	16.0	16.0
DM	88.67	89.98	89.31
Ash	5.09	4.97	5.28
CF	2.15	1.95	1.86

CP=crude protein, ME= metabolizable energy, DM= dry matter, CF= crude fibre

Results

Acceptability of red earthworm meal (*Eisenia foetida*) by broiler chickens

The results for this trial are presented in Table 2. There are no variations (p >0.05) in acceptability of different levels of red earthworm meal. Birds did not show preferences for any of the dietary inclusion levels of red earthworm meal.

Table 2: The feed intake of broilers given various diets over the seven-day period

Experimental diet	Mean intake g/d ± S.E
Diet 1 vs Diet 2	
Diet 1 (Control)	64.1 ± 4.39[a]
Diet 2 (earthworm meal replaced 25% fishmeal)	63.1 ± 4.39[a]
Diet 1 vs Diet 3	
Diet 1 (Control)	62.5 ± 5.15[a]
Diet 3 (earthworm meal replaced 50% fish meal)	60.5 ± 5.15[a]
Diet 2 vs Diet 3	
Diet 2 (earthworm meal replaced 25% fishmeal)	66.0 ± 4.24[a]
Diet 3 (earthworm meal replaced 50% fish meal)	62.1 ± 4.24[a]

[a]Means in the same column with different superscripts do not differ (P >0.05), S.E= standard error

Table 3: Statistical comparisons for each diet

Statistical comparisons	*p*-values
Diet 1 vs Diet 2	0.88
Diet 1 vs Diet 3	0.79
Diet 2 vs Diet 3	0.52

Table 4: Average feed intake for each diet

Diet	Average daily intake g/d ± SD
Diet 1	63.3 ± 2.8
Diet 2	64.6 ± 2.8
Diet 3	61.3 ± 3.9

SD= standard deviation

Discussion

Fishmeal (omena) and soybean meal are the most common protein sources in the poultry feed industry in Kenya. However, these protein feedstuffs are both in limited supply and expensive because they are being competed for by other livestock. This has necessitated to look for alternative protein sources for poultry that can substitute fish meal and soybean meal. Some of these alternatives are meat and bone meal, hydrolyzed feather meal, blood meal, snail meal and silkworm pupae. Earthworm meal is another alternative but has not been tried in Kenya although interest is growing in other parts of the world.

The evaluation of red earthworms as innovative feed ingredients for poultry (Lourdumary and Uma 2013) [9] has been recently carried out since the meal may be suitable for substituting the conventional protein sources like fish meal. However, palatability and acceptability of red earthworm meal as feed ingredient is still unknown, hence this trial. The current trial represents the first feed choice trial testing the inclusion of an earthworm meal in the diet of broiler chickens. The results of this study deduced that there is no significant difference in acceptability of red earthworm meal when included at 0%, 25% and 50% in broiler diets as a replacement to fishmeal.

The average daily intake of about 60 g for the diets is in line with NRC guidelines for broiler feeding considering the growth stage (NRC 1994) [12]. Fed broilers with red earthworm meal at inclusion levels of 0%, 1%, 3%, 5% and 10% replacing fish meal as a protein source. Birds fed on 5% red earthworm meal had superior results in terms of intake. This means that earthworm meal is acceptable to birds at 5% level of inclusion. Similar results were observed where birds did not show any preference when soybean oil was replaced by black soldier fly at 50 % and 100% respectively (Schiavone *et al.* 2017) [13].

When free-range chicken fed either a control diet or a diet in which gluten meal was replaced with Tenebrio molitor meal, the same average daily feed intake was observed (Biasato *et al.* 2016) [2]. Similar results were found when a Tenebrio molitor meal replaced soya bean meal with hulls in the diet for broiler chickens (Bovera *et al.* 2015) [4]. The results of this study are inconsistent with the findings by Ngoc *et al.* (2016) [11] which concluded that inclusion of earthworm meal at large quantities in chicken diets makes the feed unpalatable due to presence of coelomic fluid in it.

Conclusion

It is concluded that earthworm meal from *E. foetida* can replace up to 50% fishmeal in broiler finisher feed without affecting feed intake. Therefore, *Eisenia foetida* meal is a promising protein source for broilers. Further research is necessary to evaluate its acceptability for broiler starters (0-28 d) and replacement levels above 50%.

Acknowledgement

The authors wish to thank African Development Bank (AFDB) for financial support to carry out this study. Also, much gratitude to the department of Animal Sciences, Faculty of Agriculture, Egerton University Kenya for academic support.

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