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The Effect of Earthworm (*Eisenia fetida*) and Vermihumus Meal in Diet on Broilers Chicken Efficiency and Carcass Components

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ABSTRACT: The present study evaluated the effects of different levels of earthworm (*Eisenia fetida*) and vermihumus meal on broiler chicken efficiency and carcass components. For this purpose, 300 one-d old broiler chickens (Ross 308) were tested in a completely randomized design with 5 dietary treatments (1. control, 2.1% vermihumus meal, 3. 1% earthworm meal + 1% vermihumus meal, 4.2% earthworm meal + 1% vermihumus meal, 5.3% earthworm meal + 1% vermihumus meal) and 5 replications in which 12 chickens were randomly divided in each pen. The results showed that feed intake and feed conversion ratio significantly decreased in whole period with increasing the amount of earthworm meal (P <0.05). The effect of experimental treatments was not significant on weight gain (P> 0.05). The effect of treatment on some carcass components was not significant (P> 0.05). In total, the results showed that 2% and 3% of earthworm meal improved the feed conversion ratio of broiler chickens.

Keywords: broiler chicken, earthworm meal, vermihumus, efficiency, carcass components

INTRODUCTION

In most countries, the poultry industry depends on imported feeds, especially feeds rich in protein and energy. This leads to an increase in poultry production costs, which ultimately results in an increase in the market price of poultry meat. Chicken consumption has increased in recent years. Since 2007 by now, chicken consumption has increased by 3 kg per person (13 percent growth). Thereby, poultry industry is important due to high demand for animal protein but most of those involved in the industry encounter some problems (Mirzaei *et al.*, 2012). On the other hand, poultry industry requires alternative sources of animal protein due to high cost of high-quality fish meal for poultry feed and decline of fish stocks and competition for feeding livestock, especially in developing countries (Sales and Janssens, 2006). Some of these alternatives are meat and bone meal, hydrolyzed feather meal, blood meal, snail meal, silkworm pupae, earthworm meal, vermicompost, etc. These feedstuffs should provide essential and non-essential amino acids required by growing birds (Istiqomah *et al.*, 2009). One of these alternatives is earthworm meal. Many scientists have reported the possibility of using this meal (Hilton, 1983; Yaqub, 1991; Edwards, 1998; Sogbesan and Ugwumba, 2008; Sogbesan and Madu, 2008). Earthworm meal is not only comparable but also superior to fish meal in terms of protein quality. Thus, earthworm meal is potentially an excellent substitute for fish meal in livestock diet. Earthworm meal contains 65.6% crude protein (Damayanti *et al.*, 2008). This percentage is higher than the percentage of fish protein (45%) and meat protein (51 percent) (Prayogi, 2011). 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). 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 (Guerrero, 1981; Stafford and Tacon, 1984; Edwards and Niederer, 1988; Vielma *et al.*, 2003). Edwards (1985) conducted an experiment and concluded that earthworm meal accelerated the growth of broiler chickens, increased formation of muscle tissue and improved food efficiency. Vermihumus is a source of humic acid. Humic substances as a component of organic material in soil humus are the compounds created as a result of physical, chemical and microbiological alteration of biological molecules called humification. These compounds are very important because these are available resources and are composed of nonliving organic matters (Eladia *et al.*, 2005). In this context, Kucukersan *et al.* (2005) showed that humic acid improves food intake and feed efficiency in poultry.

Earthworm meal and vermihumus mixture through intestinal microflora (Husseiny *et al.*, 2008) due to high protein content (Vielma *et al.,* 2003) improved efficiency. As it is clear, the average weight gain of broiler chicken is directly related to the level of dietary protein. Furthermore, Yasar *et al.* conducted a study in 2002 and concluded that humic acid can lead to weight gain in mice. In addition to improved weight gain, increased intestinal epithelial mass food intake was observed in mice fed with humic acid.

Earthworm as a protein source contains essential and non-essential amino acid, especially lysine in *Eisenia fetida*. Therefore, earthworm is used as the richest food source for breeding such animals as poultry and aquatic due to abundance of animal protein in their structure (Vielma *et al.*, 2003). Sofyan *et al.* conducted a study in 2010 and showed that *Lumbricus rubellus* earthworm meal significantly led to gain weight and improved feed conversion ratio in broiler chickens.

A study evaluated the effect of earthworm nutritional supplements on growth and meat quality in chick broilers. It showed that diets containing 2% earthworm led to weight gain in 10 weeks and increased the percentage of breast meat and leg in broiler chickens (Vu *et al.*, 2009).

Prayogi (2011) examined four levels of (0%, 5%, 10% and 15%) earthworm meal instead of fish meal in quail diet. He showed that earthworm meal at 10% dietary supplement significantly increased quail growth performance by decreasing the feed conversion ratio and increasing body weight. Arginine, cysteine and tryptophan were increased while glycine and tyrosine amino acids were decreased based on lysine amino acid ratio with increasing the amount of earthworm meal in diet (Prayogi, 2011). Amino acids imbalance changes the amino acid pattern in the body. Appetite decreases and food intake is decreased with changes in concentration of amino acids (Burman and Burgess, 1986). Therefore, the present study aimed to investigate the effect of vermihumus and earthworm meal on broiler chicken efficiency and carcass components.

MATERIALS AND METHODS

A. Location and specification of the experiments

This experiment was conducted at 2 September 2014 for 42 days at broiler chicken breeding research house in Jahad Keshavarzi Research Center (Ilam Province, Iran). The breeding house was shelved. In each hall, 25 shelves were allocated to experimental treatments.

B. Breeding Management

In this experiment, 300 one-d-old broiler chickens (308 Ross) were purchased from Kermanshah Baharan-Toyur Hatchery Corporation (Kermanshah, Iran). The purchased chicks were transferred to breeding hall. Mean body weight of the chickens was 43 g and age of the breeder herd was 46 weeks.

C. Controlling the breeding hall

Electric heaters were used to heat the hall during the first week of breeding. The heaters were turned on 24 hours before the chickens were transferred to the hall. Room temperature was kept at a range from 31 to 33°C during the first week. Room temperature was reduced to 3°C per week as chicken's grower older. The room temperature was 18°C to 21°C in the last week of breeding period (the sixth week). The hall was fully lightened during 24 hours every day.

D. Vaccination program

Vaccination program was applied as recommended by District Veterinary Office to prevent bronchitis, Newcastle and Gumboro diseases. Multivitamin soluble in water were administered to the chicken in order to avoid the stress caused by vaccination at 24 hours before and after vaccination. Chickens were not allowed to drink water 2 hours before vaccination.

E. Preparing experimental treatments

Ross 308 hybrid nutritional needs (2009) was used to determine nutritional needs of the chickens in different periods of breeding and estimate the nutrient components of the diet. UFFDA software was used for feed formulation identical starting diet was used for all treatments from the first day to the fourteenth day. Growth diet was used from the 15th to 28th days. Finisher diet was used from the 29thto 42nd days. During breeding period, diet and water were offered ad libitum to the chicken. Diet ingredients are shown in Table 1. This experiment was performed in a completely randomized design with 5 treatments and 5 replicates and 12 chickens per replication. Nutritive values of dietary earthworm meal and vermihumus are shown in Tables 2 and 3. Experimental treatments were as 1: Control (basic diet without earthworm meal and vermihumus), Treatment 2: Diet containing 1% vermihumus without earthworm meal, Treatment 3: Diet containing 1% earthworm meal and 1% vermihumus, Treatment 4: diet containing 2% earthworm meal and 1% vermihumus and Treatment 5: diet containing 3% earthworm meal and 1% vermihumus.

Table 1. Ingredients and chemical composition of experimental diets.

	Starter (1-14 days)					Gower(15-28 days)	Finisher (29-42 days)
Ingredients (%)	**Basic ingredients**	**1% Vermihumus without Earthworm meal**	**1% Vermihumus with 1% Earthworm meal**	**1% Vermihumus with 2% Earthworm meal**	**1% Vermihumus t with 3% Earthworm meal**	**Basic ingredients**	**Basic ingredients**
Corn gain	51.32	50.02	51.28	52.54	52.75	58.59	60.97
Corn gluten	7	7	7	7	7	-	-
Vegetable Oil	1.33	1.7	1.33	0.95	0.73	2.43	3.43
Soybean meal	35.29	35.48	33.65	31.83	30.95	34.74	31.62
Methionine	0.25	0.25	0.25	0.24	0.23	0.27	0.23
Lysine	0.39	0.39	0.39	0.38	0.35	0.17	0.11
Threonine	0.07	0.07	0.07	0.06	0.04	0.06	0.04
Choline	0.1	0.1	0.1	0.1	0.1	0.1	0.1
DCP	2	1.97	1.94	1.9	1.86	1.77	1.62
$CaCO_3$	1.29	1.07	1.07	1.06	1.06	1.03	1.03
$NaHCO_3$	0.53	0.35	0.34	0.33	0.31	-	-
NaCl	0.1	0.1	0.1	0.1	0.11	0.34	0.35
Premix*	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EM	0	0	1	2	3	0	0
VH	0	1	1	1	1	0	0
Nutrient content (% DM)							
ME (kcal/kg)	2920	2990	2990	2990	2990	3000	3100
Crude protein	24.29	24.34	24.34	24.34	24.34	20.44	19.23
Lysine	1.34	1.34	1.34	1.34	1.34	1.12	1
Methionine	0.61	0.61	0.61	0.61	0.61	0.55	0.49
Methionine + Cystine	0.96	0.96	0.96	0.96	0.96	0.83	0.76
Threonine	0.84	0.84	0.84	0.84	0.84	0.72	0.66
Tryptophan	0.23	0.23	0.22	0.21	0.21	0.22	0.2
Arginine	1.38	1.38	1.37	1.36	1.38	1.27	0.18
Isoleucine	0.91	0.91	0.91	0.91	0.92	0.77	0.72
Valline	1	1	1	1.01	1.02	0.85	0.8
Leucine	2.17	2.17	2.17	2.18	2.2	1.59	1.51
Ca	1.03	1.03	1.03	1.03	1.03	0.88	0.84
Available P	0.49	0.49	0.49	0.49	0.49	0.44	0.41
Na	0.16	0.16	0.16	0.16	0.16	0.16	0.16
K	0.88	0.89	0.87	0.86	0.86	0.86	0.81
Cl	0.18	0.18	0.18	0.18	0.18	0.29	0.28
DCAD	244.31	244.25	234.7	225.15	219.61	209.21	198.28
Leucine	1.85	1.85	1.81	1.77	1.74	1.73	1.65
Linoleic acid	1.34	1.31	1.32	1.34	1.33	1.39	1.41
Crud fat	3.43	3.75	3.42	3.08	2.87	4.63	5.69
Crud fiber	3.62	3.61	3.51	3.4	3.35	3.55	3.37

*Provides per kg of diet: 3600000, IU vitamin A; 800000, IU vitamin D3; 7.2g vitamin E; 0.8g. vitamin K3; 0.7g vitamin B1; 2.64g B2; 4g B3; 3.92g D-pantothenic acid; 1.176g B6; 0.4g B9; 6mg B12; 40mg H2; 100g choline chloride; 40g Mn; 33.88g Zn, 20g Fe; 4g Cu; 0.4g I; 0.08g Se.

F. Vermihumus and earthworm meal used in the experimental diets

In this experiment, earthworm meal and vermihumus were used as a source of humic acid (AmizeTabiat Co., Tehran, Iran). A sample of earthworm meal was analyzed for the amino acid profile (Evonik, Germany).

Table 2: Chemical composition of vermihumus.

Ingredients	(% DM)
Crude protein	7.27
Crude fat	0.14
Ash	64.86
Ca	8.97
P	0.7
Humic acid	1.86
Folic acid	< 0.1

Table 3. Amino acid profiles and chemical composition of earthworm (*Eisenia fetida*) meal.

Ingredients	(%DM)
Dry mater	91
Crude protein	65.68
ME (kcal/kg)	3258
Fat	7.03
Ca	0.45
P	1.22
Methionine	1.2
Cystine	0.95
Methionine + Cystine	2.15
Lysine	4.44
Threonine	2.99
Arginine	4.41
Isoleucine	2.95
Leucine	5.02
Valline	3.22
Histidine	1.74
Phenylalanine	2.72
Glycine	3.46
Serine	2.94
Proline	2.41
Alanine	3.44
Asparagine	6.54
Glutamine	8.76

G. Traits studied in the experiment

During breeding period, weight gain and consumed feed was measured per week at the end of each experimental period. Food conversion ratio was calculated.

Equation 1.

Weight of dead birds + (chicken body weight at the beginning of the period - chicken body weight at the end of each period) = weight gain per unit (g)

Equation 2 was used to calculate the average daily weight gain of chickens as follows.

Equation 2.

$$\text{Average daily weight gain (g)} = \frac{\text{weight gain per unit at each period}}{\text{day chicken}}$$

(i) Food conversion ratio calculation
Food conversion ratio was calculated for periods of 1 to 14 days, 15 to 28 days, 29 to 42 days and 1 to 42 days. Food conversion ratio was calculated by dividing the average daily feed intake to average daily weight gain of chickens for each period. Equation 3 was used to calculate the feed conversion ratio.
Equation (3)

$$\text{Feed conversion ratio} = \frac{\text{Average daily feed intake (g)}}{\text{Average daily weight gain (g)}}$$

(ii) Production Index
Equation 4 was used to calculate the production index.
Equation (4)

$$\text{Production index} = \frac{\text{Survival percentage} \times \text{average weight at the end of period}}{\text{Food conversion ratio} \times \text{the number of breeding days}} \div 10$$

(iii) Protein Efficiency: Equation 5 was used to calculate the protein efficiency after calculating the consumed protein according to percentage of dietary protein.

Equation (5) $\text{Protein efficiency} = \frac{\text{Consumed protein}}{\text{Body weight gain}}$

(iv) Energy efficiency: Energy efficiency was calculated using equation 6 after calculating the consumed protein according to the dietary energy.
Equation (6)

$$\text{Energy efficiency} = \frac{\text{Consumed energy}}{\text{Body weight gain}}$$

(v) Measured parameters after slaughter: After slaughter and packing operations and separating the head and legs and emptying the contents of abdomen (carcass weight ready to cook), weights of kidney, lung and heart were calculated based on percentage of living weight using equation 7.
Equation (7)

$$\text{Carcass components percent} = \frac{\text{Carcass components weight (g)}}{\text{Living body weight (g)}} \times 100$$

H. Statistical Analysis
The results of experiment were analyzed in a completely randomized design with five diets and five replications. SAS software (2001) was used to analyze the data.
The following statistical model was used for statistical analysis:

$Y_{ij} = \mu + T_i + e_{ij}$

Y_{ij}: comparable trait
μ : mean of comparable trait
T_i : effect of treatment
e_{ij} : experimental error

RESULTS AND DISCUSSION

A. Daily intake of energy and protein
The results of energy and protein intake are shown in Table 4. The results showed that daily energy and protein intake were not affected by treatments and were not significantly different (P> 0.05). Rezaeipour *et al.* (2014) used 5 and 10 % earthworm meal and showed that minimum consumed protein was observed at 5% level of earthworm meal. However, the difference between treatments is not noticeable since levels of used earthworm meal are close to each other.

B. Energy and protein efficiency
The results of effects of experimental treatments on energy and protein efficiency are shown in Table 4. The effect of treatments on protein and energy efficiency was not significant (P> 0.05). Rezaeipour *et al.* (2014) reported that protein efficiency percentage increased with increasing level of earthworm meal from 5% to 10% numerically but was not significant. Since protein efficiency is dependent on various sources of protein based on previous studies. Ignacio *et al*. (1993) reported that protein efficiency for earthworm meal and casein was not statistically significant in rats.
Nguyen and Ulfert (2009) showed that using earthworm meal in fish diet increased protein and energy efficiency compared to the control group. Tuan and Focken (2009) replaced 30%, 70% and 100% earthworm meal instead of fish meal in common carp diet and reported that protein and energy efficiency increases.
The effect of treatments on protein efficiency ratio (PER) and energy efficiency ratio (EER) are also shown in Table 5.

Table 4: Effect of dietary treatment on protein and energy intake.

Treatment	Energy intake (kcal/d)				Protein intake(g)			
	1-14 days	15-28 days	29-42 days	1-42 days	1-14 days	15-28 days	29-42 days	1-42 days
1	98.044	250.24	512.63	286.97	8.15	17.05	31.79	19.00
2	101.65	260.06	503.11	288.27	8.45	17.72	31.20	19.12
3	99.56	255.41	507.33	287.43	8.28	17.40	31.47	19.05
4	97.74	245.12	502.35	281.73	8.13	16.70	31.16	18.66
5	98.93	243.0	484.86	275.62	8.23	16.56	30.07	18.28
SEM	1.08	2.80	4.11	1.72	0.09	0.19	0.25	0.11
P-Value	0.82	0.28	0.28	0.08	0.82	0.28	0.28	0.08
Sequence for earthworm meal								
Linear	0.79	0.14	0.06	0.01	0.79	0.14		0.01
Quadratic	0.63	0.21	0.46	0.14	0.63	0.21		0.13

1- Control, 2- 1% vermihumus, 3- 1% Earthworm meal + 1% vermihumus, 4- 2% Earthworm meal + 1% vermihumus, 5- 3% Earthworm meal + 1% vermihumus

Table 5. Effect of dietary treatment on protein efficiency ratio (PER) and energy efficiency ratio (EER).

Treatment	Energy efficiency ratio (kcal/kg)				Protein efficiency ratio (g/g)			
	1-14 days	15-28 days	29-42 days	1-42 days	1-14 days	15-28 days	29-42 days	1-42 days
1	0.24	0.20	0.16	0.20	2.89	3.03	2.61	2.85
2	0.23	0.20	0.16	0.20	2.79	3.05	2.59	2.81
3	0.23	0.21	0.16	0.20	2.85	3.05	2.63	2.85
4	0.24	0.21	0.16	0.20	2.88	3.12	2.72	2.91
5	0.23	0.21	0.17	0.20	2.83	3.16	2.78	2.90
SEM	0.002	0.001	0.001	0.001	0.02	0.02	0.02	0.01
P-Value	0.76	0.54	0.11	0.16	0.76	0.54	0.11	0.18
Sequence for earthworm meal								
Linear	0.82	0.09	0.01	0.03	0.82	0.09	0.01	0.04
Quadratic	0.79	0.78	0.31	0.39	0.79	0.78	0.31	0.55

1- Control, 2- 1% vermihumus, 3- 1% Earthworm meal + 1% vermihumus, 4- 2% Earthworm meal + 1% vermihumus, 5- 3% Earthworm meal + 1% vermihumus.

C. The relative weight of carcass components

The results of effect of treatments on some carcass components are shown in Table 6. The results showed that the effect of treatments on carcass internal components were not significant (P> 0.05). These results were consistent with those obtained by Resnawati (2002). Resnawati showed that using 0%, 5%, 10% and 15% earthworm meal in broiler diets did not affect the heart relative weight.

Table 6: Effect of dietary treatment on carcass characteristics.

Treatment	**Carcass characteristics**		
	% Kidney weight(g)	% Heart weight(g)	% Lung weight(g)
1	0.46	0.39	0.50
2	0.47	0.42	0.63
3	0.43	0.41	0.59
4	0.54	0.42	0.65
5	0.54	0.47	0.66
SEM	0.01	0.01	0.02
P-Value	0.14	0.08	0.29
Sequence for earthworm meal			
Linear	0.05	0.01	0.07
Quadratic	0.35	0.62	0.51

1- Control, 2- 1% vermihumus, 1% Earthworm meal + 1% vermihumus, 2% Earthworm meal + 1% vermihumus, 3% Earthworm meal + 1% vermihumus.

Rezaeipour *et al.* (2014) used 2%, 3%, 4%, and 6% *Eisenia fetida* earthworm meal on broilers and showed that heart weight was not affected in none of the earthworm meal percentage while the breast weight was only affected by 2% and 3% of the treatments. The present study showed that using 1% vermihumus does not significantly affect the relative weight of internal organs. These results are consistent with those obtained by Ahmadi and Karimi Torshizi (2014) and Celik *et al.* (2008). The latter showed that vermihumus and humic acids do not have a significant effect on relative weight of internal organs. Khajavi *et al.* (2015) using 0, 0.5, 1.0 and 1.5 % vermihumus in broiler diets reported increase in thigh meat oxidative stability and hence better meat quality, while growth performance and carcass percentage did not influenced. Thus, it can be concluded that using 1% vermihumus and 3% earthworm meal have not a negative effect on carcass components.

CONCLUSION

According to the results, it can be stated that feeding the broilers with diets containing earthworm meal and vermihumus do not have a significant effect on protein and energy efficiency as well as consumed protein and efficiency. The effect of experimental treatments on some carcass components was not significant. Thus, it can be concluded that using 1% vermihumus and 3% earthworm meal have negative effect on carcass components.

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REFERENCES

Ahmadi, M., Karimi Torshizi, M.A., (2014). Evaluation of raise and carcass characteristics of Japanese's quails fed with different levels of vermihumus. *7th National conference in scientific agriculture finds*, 786-789.

Burman, K.N., Burgess, AD., (1986). Responses to amino acid. Nutrient Requirements of Poultry and Nutritional Research. *Poultry Sci. Symposium.* Kent TN 15.

Celik, K., Uzatici, A., Akin, A.E.,(2008). Effects of dietary humic acid and *Saccharomyces cerevisiae* on performance and biochemical parameters of broiler chickens. *Asian Journal of Animal and veterinary Advances.* **3**(5): 344-350.

Cho, J.H., Park, C.B., Yoon, Y.G., Kim, S.C., (1998). Lumbricin I, a novel proline-rich antimicrobial peptide from the earthworm: purification, cDNA cloning and molecular characterization. *Biochim. Biophys. Acta.* **1408**(1): 67-76.

Damayanti, E., Julendra, H., Sofyan, A., (2008). Antibacteria activity of earthworm meal (*Lumbricus rubellus*) with different methods to the *Escherichia coli*. *Proceedings. National Food Seminar, Yogyakarta*, January **17**, P. 54-60.

Edwards, C.A., (1985). Production of Feed Protein from Animal Waste by Earthworms. Phil. Trans. R. Soc. Lond. B **310**: 299 - 307.

Edwards, C.A., (1998). The use of earthworms in the breakdown and management of organic wastes, in C.A. Edwards. *Earthworm Ecology*: 327-376. Boca Raton, FL: CRC Press.

Edwards, C.A., Niederer, A., (1988). The production and processing of earthworm protein. In: 'Earthworms in waste and environmental management.' (pp 169-180). (Ed C. A. Edwards and E.F. Neuhauser). Academic Publishing, The Hague, Netherland.

Eladia, M., Mendez, P., Havel, J., Patocka, J., (2005). Humic substances-compounds of still unknown structure: applications in agriculture, industry, environment, and biomedicine. *J. Appl. Biomed.* **3**: 13.24.

Guerrero, R.D., (1981). The culture and use of Perionyx excavatus as a protein resource in the Phillippines. Dorwin Centenary Symp. On Earthworm ecology (pp 250). *Inst. Terrestrial Ecology* UK.

Hilton, J.W., (1983). Potential of freeze-dried worm meal as a replacement for fishmeal in trout diet formulations. *Aquaculture.* **32**: 227-283.

Husseiny, E.L, O.M., Abdallah, A.G., Abdel, L.K.O., (2008). The Influence of Biological Feed Additives on Broiler Performance. *International Journal of Poultry Science*, **7** (9): 862-871.

Ignacio, A., Carlos, A., Luois, A. and Hebel, P., (1993). Nutritional and toxicological evaluation of earthworm (Eiseniafoetida) meal as protein source for animal feed. *Animal Feed Science and Technology,* **42**, 165-172.

Istiqomah, L., Sofyan, A., Damayanti, E., Julendra, H., (2009). Amino acid profile of earthworm and earthworm meal (*Lumbricus rubellus*) for animal feedstuff. *J Indo. Tropical anim. Agi.* **34**(4): 253-257.

Khajavi,H.R., KarimiTorshizi, M.A. and Ahmadi, H. (2015). Effect of feeding different levels of dietary vermi-humus on growth performance and meat quality in broiler chickens. *Journal of Animal Production.* **16**(2): 49-58.

Kucukersan, S., Kucukersan, K., Colpan, I., Goncuogle, E., Reisli, Z., Yesilbag, D., (2005). The effects of humic acid on egg production and egg traits of laying hen. *Vet. Met- Czech,* **50**(9), 406-410.

Mirzaei, S., Zaghari, M., Aminzadeh, S., Shivazad, M., (2012).The effects of non-starch polysaccharides content of wheat and xylanase supplementation on the intestinal amylase, aminopeptidase and lipase activities, ileal viscosity and fat digestibility in layer diet. *Iranian journal of biotechnology,* Vol. **10**, No. 3: 208-214.

Nguyen, N.T., Ulfert, F., (2009). Earthworm meal as potential protein source in diets for common carp. Biophysical and socio-economic frame conditions for the sustainable management of natural resources, Hamburg.

Prayogi, H.S., (2011). The Effect of Earthworm Meal Supplementation in the Diet on Quail's Growth Performance in Attempt to Replace the Usage of Fish Meal. *International Journal of Poultry Science* **10**(10): 804-806.

Resnawati, H., (2002). Caracass production and internal organs of broiler fed earthworm (*Lumbricus rubellus*) meal. Seminar Nasional Teknology PeternakandanVeteriner. 294-297.

Rezaeipour, V., Aghajan Nejad, O., Youseftabar Miri, H., (2014). Growth performance, blood metabolites and jejunum morphology of broiler chickens fed diets containing earthworm (*Eisenia foeitida*) meal as a source of protein. *International Journal of Advanced Biological and Biomedical Research*. **2**(8), 2483-2494.

Sales, J., Janssens, P.J.G., (2006). Nutrient requirements of Ornamental fish. Review.*Aquatic Living Resour*. **16**: 533-540.

Sogbesan, A.O., Madu, C.T., (2008). Evaluation of earthworm (Hyperiodilluseuryaulos, clausen, 1914; oligocheata: eudrilidae) meal as protein feedstuffs in diet for *Heterobranchus longifilis* Valenciennes, 1840 (teleostei, clariidae) fingerlings under laboratory condition. *J. Environmental Sci.* **2** (1): 23-31.

Sogbesan, A.O., Ugwumba, A.A.A., (2008).Nutritional Evaluation of Termite (Macrotermessubhyalinus) Meal as Animal Protein Supplements in the Diets of Heterobranchuslongifilis (Valenciennes, 1840) Fingerlings. *Turkish J. Fisheries. Aquatic Sci*. **8**: 149-157.

Sofyan, A., Julendra, H., Damayanti, E., Sutrisno, B., Wibowo, M.H., (2010). Performa dan Histopatologyi Ayam Broiler yang Diinfeksidengan Salmonella pullorum SetelahPemberian Imbuhan Pakan Mengandung Tepung Cacing Tanah (*Lumbricus rubellus*). *Media Peternakan*. 31-35.

Stafford, E.A., Tacon, A.G.J., (1984).Nutritive value of the earthworm, Dendrodrilus sub rubicundus, gown on domestic sewage, in trout diet. *Agicultural Wastes.* **9**(4): 249-266.

Tuan, N.N., Focken, U., (2009). Earthworm meal as potential protein source in diets for common carp (*Cyprinus carpio* L.). Biophysical and Socio-economic Frame Conditation for the Sustainable Management of Natural Resources.

Vielma, R. R., Ovalles, D.J.F., Leon, L.A., Medina, A., (2003). Nutritional value of earthworm flour (Eiseniafoetida) as a source of amino acids and its quantitative estimation through reversed phase Chromatogaphy (HPLC) and pre-column. *Ars Pharmaceutica.* **44**(1):43-58.

Vu, D.T., Han, Q.H., Nguyen, D.L., Nguyen, V.D., 2009. Use of redworms (*Perionyx excavates*) to manage agricultural wastes and supply valuable feed for poultry. Irrd21/11/ton21192.htm.

Yaqub, H., 1991. Earthworm and maggot meals as a potential fish meal replacement. Thesis. Institute of Renewable Natural Resources U.S.T., Kumasi, Ghana.

Yasar, S., Gokcimen, A., Altunas, I., Yonden, Z., Petekkaya, E., (2002). Performance and ilealhistomorphology of rats treated with humic acid preparations. *J. Anim. Physi. Anim. Nutr.* **86**: 257-264.