Protein quality of three different species of earthworms

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No difference in protein quality was noted between three species of earthworms, as evaluated by net protein utilization and relative nutritive values in growing chickens. Similar growth responses per g nitrogen intake were obtained for the earthworm meals, a broiler starter diet and a commercial fish meal sample. The results thus indicate that no harmful substances which might have had a depressing effect on the utilization of amino acids, accumulated in the bodies of the earthworms.

Netto proteïenbenuttingswaardes en relatiewe voedingswaardes is by kuikens gebruik om moontlike verskille in proteïenkwaliteit tussen drie spesies erdwurms vas te stel. Geen benuttingsverskille is tussen die drie wurmproteïene waargeneem nie, ook nie waar dit met 'n braaikuiken-aanvangsrantsoen of 'n monster vismeel vergelyk is nie. Die gevolgtrekking word gemaak dat alhoewel die voedingsgewoontes van die erdwurms mag verskil, daar geen stowwe in die liggaam ophoop wat aminosuurbenutting in kuikens benadeel nie.

Keywords: Earthworm meal, nutritive value, protein source, poultry

Introduction

Certain detritophagous earthworm species have the potential to play a role in composting organic wastes on an industrial scale (Graff, 1974, 1981; Schultz & Graff, 1970; Edwards, 1988). It has also been shown that they can be harvested, dried and utilized as a protein source for chickens (McInroy, 1971; Sabine, 1983; Fisher, 1988; Reinecke & Alberts, 1987; Alberts & Reinecke & Venter, 1988). Feeding trials by Reinecke (1990) in which growth, food consumption and efficiency of food conversion were determined led to the conclusion that worm meal has a potential as protein source in diets of broilers. Fisher (1988) also concluded that earthworm meal as a component of poultry feeds has an excellent chemical composition. However, the potential importance of this product to the animal production industry is still limited since conventional production and harvesting methods presently being used will not suffice to produce sufficient quantities of protein to render the concept economically viable. Fisher (1988) determined that in 1984 the value of earthworm meal was about hundred pounds sterling more than soyabean meal and roughly equivalent to meat and bone meal. Reinecke (1990) stated that special high density production systems will first have to be developed before earthworm meal could be considered as an alternative source of protein.

Fisher (1988) pointed out that methods for maximising yield as well as the differences between worm species merit further investigation. The selection of the most suitable species on which the development of a high density production system should be based, becomes important. Not only must the basic biology of such a species be known but its potential usefulness in terms of protein quality must be researched.

The general biology of three vermicomposting species have been studied intensively namely *Perionyx excavatus* (Reinecke & Hallatt, in press), *Eisenia fetida* (Venter & Reinecke, 1988) and *Eudrilus eugeniae* (Viljoen & Reinecke, 1989). *P. excavatus* is a tropical species from India, *E. fetida* a cosmopolitan species from Europe while *E. eugeniae* is a tropical species from West Africa. These species differ significantly regarding their tollerances for environmental conditions and their reproductive capabilities.

Although all three species can live and reproduce on organic waste such as cow manure very little is known about their specific feeding habits. Hence they might differ in their ability to detoxify harmful bacteria. Furthermore, due to differences in feeding habits it is possible that toxic substances, which could inhibit or reduce the utilization of amino acids, could accumulate in the body of the worms and thus effect the protein quality of the dried worm meal. The purpose of the present study was to determine whether differences in protein quality existed in the dried meal made from the three different species of earthworms.

Procedure

Three species of earthworms (*Eisenia fetida, Eudrilus eugeniae* and *Perionyx excavatus*) were cultivated in concrete pits, using cattle manure as a source of nutrients described by Reinecke, Alberts & Venter (1989). After harvesting, the worms were sundried to a constant moisture

Table 1 Composition of test diets (g/kg)

	Protein source														
	Source A			Source B			Source C			Source D			Source E		
Dietary component	4,5%	9,0%	13,5%	4,5%	9,0%	13,5%	4,5%	9,0%	13,5%	4,5%	9,0%	13,5%	4,5%	9,0%	13,5%
E.fetida	68	136	204												
E.eugeniae				77	154	231									
P.excavatus							73	146	219						
Fish meal										74	148	221			
Broiler start													205	409	614
Starch/Sucrose mix (50:50)	802	734	666	793	716	639	797	724	651	796	722	649	665	461	256
Maize oil	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
Cellulose	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Vitamin/Mineral premix *	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55

Supplies per kg/diet: 8 mg Cu; 70 mg Mn; 75 mg Fe; 50 mg Zn; 0,1 mg Se; 0,3 mg I; 540 mg Mg; 1 270 mg K; 8 000 IU Vitamin A; 3 000 IU Vitamin D; 10 IU Vitamin E; 3 mg Vitamin K_1; 2.5 mg Thiamin; 5 mg Riboflavin; 4 mg Pyridoxine; 2,0 mg Folic Acid; 0,01 mg Vitamin B_{12}; 0,2 mg Biotin; 11,5 mg Calcium D-pantothenate; 50 mg Nicotinic Acid; 490 mg Choline Chloride; 50 mg Ethoxyquin.

Source A – *E. fetida*
Source B – *E. eugeniae*
Source C – *P. excavatus*
Source D – Fish meal
Source E – Broiler start

Table 2 Relationship between body moisture and nitrogen intake in chicks fed on different protein sources

Protein source	Correlation coefficient	Inter-cept	Std error	Slope	Std error	Error ss	Df	NPU	RNV
E. fetida	0,91	19,41	0,85	1,38	0,13	78,07	25	34,2	103,7
E. eugeniae	0,91	18,77	0,87	1,44	0,14	86,98	24	38,2	107,8
P. excavatus	0,92	18,26	0,88	1,51	0,13	94,99	25	32,3	113,1
Fish meal	0,91	21,67	0,84	1,02	0,09	103,22	25	32,4	76,4
Broiler starter	0,90	20,85	0,99	1,33	0,13	104,93	24	34,0	100,0

NPU = net protein utilization

RNV = relative nutritive values

Slopes expressed as % of the slope of the broiler starter diet.

level and a meal prepared by passing the material through a laboratory hammermill.

Net protein utilization (NPU) values for the three species were determined according to the method of De Muelenaere, Quicke and Wessels (1960) using the following equation:

$$NPU = (Bf - Bk + Ik) / If \times 100$$

Where Bf and Bk = nitrogen (N) content in grams of the carcass of chickens which received the test protein and the N-free diet respectively, and Ik and If the respective N-intake in grams of chickens fed on the aforementioned diets. In the present experiment Bk and Ik were common values to all groups and could thus be omitted from the calculations.

In the same experiment, relative nutritive values (RNV) of the earthworm meals were also determined (Hegsted, Neff & Worcester, 1968; Donnelly, McDonald & Rattray, 1983) as an alternative approach to evaluate protein quality. A linear growth response is observed when diets of differing protein content are fed to chicks, where the highest level is below that which maximises growth. The slope (b) of the linear regression, $y = a + bx$, between response (y) and protein consumed (x), represents the apparent efficiency of dietary protein utilization. Regressions can be established for different protein sources, and as the intercepts (a) for the lines are similar, slopes can be compared to a standard or reference protein by using the RNV technique:

$$RNV = b_t / b_r$$

Were b_t = slope of the response to the intake of test protein, b_r = slope of the response to the intake of the reference standard protein.

RNV had been used by a number of workers (Siebrits, Esterhuyse & Kemm, 1986) to estimate protein quality of feedstuffs and in those determinations lactalbumin was used as a reference material to which the test materials were compared. However, in the present study, protein utilization efficiency estimates for birds fed the different protein sources were compared to those of birds fed on a broiler starter diet.

Material and Methods

Fifteen test diets (Table 1) were prepared by adding increasing amounts of the various protein materials, at the expense of a sugar/starch mix in a N-free diet, in order to obtain dietary protein levels of 4,5; 9,0; and 13,5%. Each diet was fed to 9 replicate groups of chickens (two chickens

Table 3 Mean weight gain and feed consumption of chickens fed on different protein sources (g/bird/7 days)

	Dietary protein levels					
	4,5%		9,0%		13,5%	
Source	Body mass gain (g)	Feed intake gain (g)	Body mass gain (g)	Feed intake gain (g)	Body mass gain (g)	Feed intake gain (g)
E. fetida	–22,82	79,30	69,22	93,67	142,73	92,61
E. eugeniae	-27,51	73,33	68,25	97,12	144,69	103,36
P. excavatus	25,62	77,38	63,07	95,00	133,84	91,89
Fish meal	3,57	76,44	82,60	106,11	145,60	116,28
Broiler starter	6,37	87,61	95,90	116,78	167,30	113,50

Table 4 Determined amino acid composition of the different protein sources (g/16g nitrogen)

	E. fetida	*E. eugeniae*	*P. excavatus*	Fish meal	Broiler starter
Threonine	4,47	4,30	4,20	3,84	3,33
Serine	4,44	4,50	4,61	14,30	4,12
Valine	6,00	5,95	5,88	5,00	3,95
Methionine	1,80	1,75	1,90	2,66	2,08
Isoleucine	4,60	4,58	4,55	4,06	3,58
Leucine	9,80	9,60	9,85	7,80	6,42
Tyrosine	3,50	2,95	3,41	3,69	2,87
Phenylanine	3,58	3,20	3,62	3,08	3,30
Histidine	3.37	3.10	3.22	2.23	0.91
Lysine	7.76	7.85	7.80	7.15	4.99
Arginine	9.56	9.20	9.33	4.62	6.24
% Protein	66.13	58.38	61.63	61.00	22.00

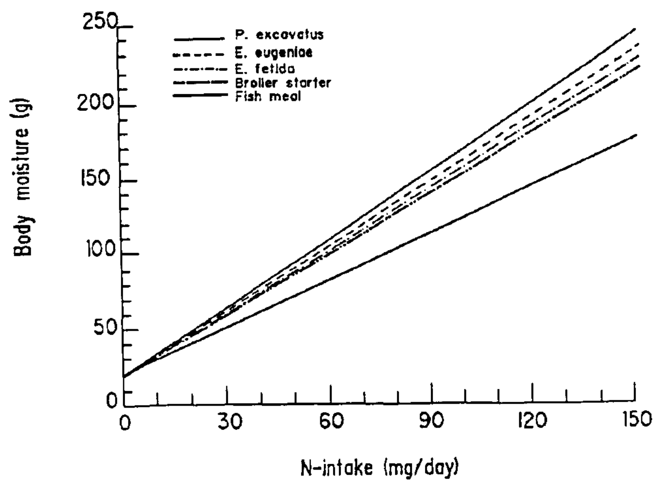

Figure 1 Relationship between nitrogen intake and body moisture of growing chickens.

per replicate) in a temperature-controlled multicage battery unit.

The chickens, Amber-Link males were obtained from a local hatchery and reared from day-old to 10 days of age on a commercial chick starter diet and a homogeneous weight group was then selected after a six hour fast. These were randomly distributed between the treatments and body weights were recorded for each replicate at the start and again at the termination of the 7 day experimental period. Feed intake was measured for the test period. At the conclusion of the experiment the chicks were killed with chloroform and dried to constant weight in a forced-draught oven at 75 °C and body moisture content determined.

The dried carcasses (including feathers), from each replicate, were minced thoroughly (5 times), using an industrial meat mincer, whereafter samples were taken for analyses. Samples were defatted by ether extraction and protein analyses were conducted on the dry defatted samples using the Kjeldahl method. All analyses were carried out in duplicate and in accordance to recommendations laid down by the Association of Official Analytical Chemists (1975).

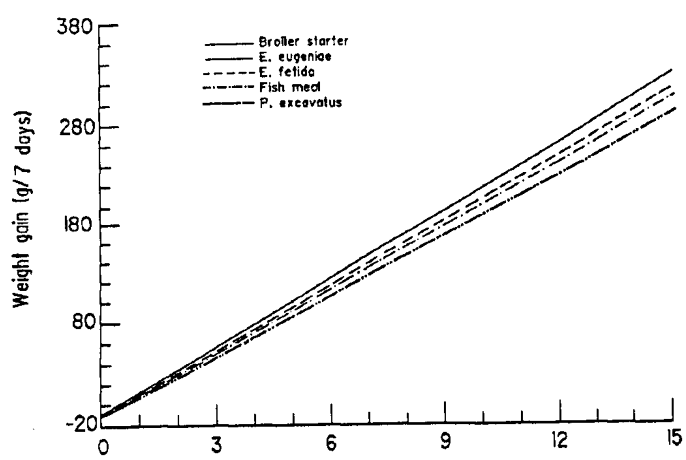

Figure 2 Relationship between protein intake and body weight gain of growing chickens.

Regression lines for various protein sources were compared by means of analysis of covariance and NPU-values were analysed by analysis of variance (Snedecor & Cochran, 1980).

Results and Discussion

Excessive variation occurred in carcass N-values for replicates within treatments. Inspection of the samples showed that this was probably due to improper grinding of feathers in the mincer and it was therefore decided to use carcass moisture instead of protein values, to calculate NPU values. Many scientists (Wessels & Bundock, 1986; Hegsted *et al.* 1986; Wessels, 1970 and Wessels & Marshall, 1975) have concluded that body water is so closely correlated (0,95–0,99) with body protein that it may be used to estimate body protein. The use of protein gain is theoretically more appropriate, but measurement of carcass protein involves much more variable procedures and smaller sample sizes than does measurement of carcass moisture. The theoretical advantage of protein gain as response parameter may therefore be obscured by practical dificulties and as comparisons in the present study were only made within the same experiment, the use of carcass moisture was justified.

From the results shown in Table 2 it will be noted that the correlation coefficient between carcass moisture and N-intake was 0,9 or higher for all protein sources. No significant difference ($P > 0,5$) existed between the slopes of the regression lines relating carcass moisture and N-intake and it can thus be assumed that the utilization of the protein from the various earthworm meals, fish meal and the broiler starter meal was equal. The NPU values given in Table 2 confirm this observation.

Comparing the amino acid content of the different protein sources (Table 4), shows that fish meal is highly deficient in arginine. This could have had a detrimental effect on the utilization of protein in fish meal, since chicks have a high requirement for arginine (a ratio of 105 to 100 in relation to lysine). This is only speculation since all three worm proteins were deficient in methionine.

The amino acid content of *E. fetida, E. eugeniae* and *P. excavatus* are similar and as no difference in growth ($P >$ 0,05) was observed between these protein sources, it can be concluded that these worm proteins were equal in their ability to promote growth in chicks. Hence the possibility of toxic substances which could have accumulated in the body tissues of worms, can be rejected.

Protein in the broiler starter meal represents a combination of amino acids which maximizes growth of broilers. As the amino acid utilization of the worm proteins were comparable and even slightly better than for the broiler starter protein (Table 2), it is clear that earthworm meals can serve as a suitable protein source for growing chickens.

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