VERMITECHNOLOGY AS A POTENTIAL SOURCE OF EARTHWORM MEAL FOR REPLACEMENT OF FISHMEAL IN POULTRY DIETS: A REVIEW

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ABSTRACT
Earthworms are regarded as ecosystem engineers for their ability to modify soils and plant communities. They are a good source of protein and are therefore used as live fish food and bait. Recently, they are being fed to livestock and fish as high quality protein supplements to replace fishmeal in fish and poultry diets because of the high cost of fishmeal, and for their high protein contents (above 60%). Large scale production of earthworm meal can be achieved through vermicomposting and vermiculture technologies: which are inexpensive and locally-available, using epigeic and endogeic species of earthworms that are prolific breeders and have high biomass production. The dynamic and growing poultry industry in Nigeria require a cheap, non-conventional but high quality animal protein ingredient that is readily available in large commercial quantities throughout the year to replace fishmeal. And earthworm meal produced through vermitechnology has the greatest potential of meeting this need, thus saving the nation millions of naira expended yearly on the importation of fishmeal from all parts of the world.

INTRODUCTION

Earthworms are soil invertebrates that belong to the phylum *Annelida* and are found throughout the world. They are commonly referred to as ecosystem engineers for their ability to modify soils and plant communities (Hale *et al.*, 2005). They improve the physical structure of the soil, improve soil fertility and improve plant growth and health. Also, large population of earthworm suppresses weed growth, clean up dangerous chemicals in the environment (such as hexachlorocyclohexane) and improves water absorption capacity of the soil, thus preventing soil erosion (Barley, 1961). In aquaculture, earthworm has been found to be a good source of protein and is therefore used as live fish food and bait. Ita *et al.* (1984) reported that the most preferred bait by anglers for sport fishing in the Kainji Lake was earthworms while Tomlin (1983) observed that in North America, there was a strong demand from about 50 million anglers for baitworms. Recently, because of the increased price of fishmeal (which is the sole animal protein source in poultry diets), earthworm is being fed to livestock and fish as a high quality protein supplement (Ravindran *et al.*, 1993). To ensure regular supply of this non-conventional animal protein source throughout the year, large scale cultivation and culturing of earthworms through vermiculture and vermicomposting technologies are being developed, for partial or total replacement of fishmeal in poultry diets.

Why Earthworm Meal?

Earthworm meal prepared from different earthworm species have been reported to contain high protein. Sogbesan *et al.* (2007) reported a crude protein value of 63.04% for *Hyperiodrilus euryaulos* as compared to 71.64% for Clupeid fishmeal (Table 1). Guerrero (1983) reported 69.8% CP for *Perionyx excavatus* while Medina *et. al.* (2003) reported 61.8% for *Eisenia foetida*. Also, the essential amino acids profile of earthworm meal compares favourably with that of fishmeal; with earthworm meal having a higher percentage of methionine than fishmeal (Table 2).

Vermiculture and vermicomposting technologies

Vermicomposting is the biological non-thermophilic decomposition or degradation of organic matter when earthworms feed on organic waste materials. It is used as a popular waste management option in the Americas, Europe and the Indian sub-continent, producing organic fertilizers called vermicomposts as well as earthworm biomass (Mainoo, 2007). The vermicomposts contain not only earthworm castings, but also bedding materials and organic wastes at various stages of decomposition. Hence, vermicomposts often contain 5 to 11 times more nitrogen, phosphorus and potassium than the surrounding soils and is superior to the original manure as a fertilizer. This is because secretions in the intestinal tracts of earthworms, along with soil passing through their gut, make nutrients more concentrated and available for plant uptake, including micronutrients (Dickerson, 2009). Many earthworm species used for vermicomposting around the world are epigeic (i.e. they live in the upper litter layer of the soil, typically ingesting litter materials extensively). Examples include the following: *Eisenia foetida*, *Eisenia andrei*, *Eisenia hortensis*, *Eisenia veneta*, *Perionyx excavatus*, *Eudrilus eugeniae*, *Amynthas cortices* and *Amynthas gracilis*. Of all these species however, only *Eudrilus eugeniae* (Kinberg) and *Perionyx excavatus* (Perrier) are the most commonly used earthworms for vermicomposting in tropical and sub-tropical countries (Giraddi., *et. al.*, 2002). For example, in a 20 day trial in Accra, Ghana, Mainoo (2007) determined that *Eudrilus eugeniae* decomposed 99% of pineapple fibres and 87% of pineapple peels supplied indicating that this earthworm species is a good vermicomposter.

Vermiculture, on the other hand, is the household rearing of earthworms, using locally-available and inexpensive technology, to produce them in large commercial quantities. Species of earthworm most suitable for vermiculture are endogeic earthworms (i.e. those found in the first 10 to 20cm layer of the soil). In Nigeria, the most culturable species is the semi-arid zone earthworm, *Hyperiodrilus euryaulos* (Sogbesan *et. al.*, 2007). But anecic earthworms are deep burrowing earthworms that come to the surface only to feed. A good example is the *Lumbricus terrestris* (the North American Night Crawler). It is not good for vermiculture.

During vermiculture, the earthworms are fed fermented, sun-dried and grinded poultry droppings and vegetables (*Amaranthus* species) at 10% of their body weights. This is because the growth rate of earthworms have been shown to strongly correlate with the particle size of organic materials ingested; and finer materials are more preferred and readily ingested and assimilated than coarse ones (Curry and Schmidt, 2007).

ECONOMIC POTENTIAL OF EARTHWORM MEAL AS A FISHMEAL REPLACER

Earthworm meal can be used to replace fishmeal completely in fish feed without any adverse effect on the growth performance of the fish species (Ogbe *et. al.*, 2004). Earthworm can be cultured in wooden boxes initially lined with banana leaves and old newspapers and covered with substrate of up to 5cm level before the worms are introduced (Sogbesan *et. al.*, 2007). Worm bins can also be made of plastic or from recycled containers like old bathtubs, barrels or trunks. And earthworms have high reproductive rate and biomass production. Sogbesan *et. al.* (2007) reported highest biomass production of 25.7g earthworm/week in cellulose substrate, 22.9g earthworm/week in dry neem leaves and soil substrate and lowest value of 17.8g earthworm/week in soil substrate for *Hyperiodrilus euryaulos* (Clausen); while Giraddi *et. al.* (2008) reported mean fecundity of 6.75 cocoons/week and 2.63 cocoons/week for *E. eugeniae* and *P. excavatus* respectively. Hence, earthworms can be regarded as prolific breeders.

CONCLUSION

The dynamic and growing poultry industry in Nigeria requires a non-conventional feed ingredient that is cheap, of high protein quality and readily available in large commercial quantities throughout the year to replace fishmeal in poultry diets. Earthworm meal produced through vermiculture and vermicomposting technologies has the greatest potential of meeting this need, thus saving the nation millions of hard-earned foreign exchange expended each year on the importation of fishmeal from all parts of the world.

Table 1: Proximate and Mineral Composition (DM %) of tested Animal Protein Sources

Composition	Earthworm Meal	Clupeid Fishmeal
Crude protein %	63.04	71.46
Ether extract %	5.90	7.97
Crude fibre %	1.90	1.18
Ash %	8.90	18.22
Nitrogen Free Extract %	13.76	3.17
Moisture %	8.6	8.89
Dry matter %	91.40	90.21
Gross energy kJ/100g	1968.24	2074.09
Sodium (g/100g)	0.43	0.91
Calcium (g/100g)	0.53	3.53
Potassium (g/100g)	0.62	0.96
Phosphorus (g/100g)	0.94	2.40
Magnesium (g/100g)	NA	0.08

Source: Sogbesan *et al.* (2007)

Table 2: Essential amino acids composition (g/16Ng dry matter) and amino acids indices of earthworm meal and Clupeid fishmeal

Amino acid composition	Earthworm Meal	Clupeid Fishmeal
Arginine	2.83	5.34
Histidine	1.47	4.19
Isoleucine	2.04	2.62
Leucine	4.11	8.31
Lysine	6.35	10.96
Methionine	5.30	2.26
Phenylalanine	6.26	5.52
Threonine	4.43	5.28
Valine	4.43	5.88
Tryptophan	0.88	0.97
Total essential amino acids	37.99	51.33
Crude protein %	63.04	71.64
EAAI (%)	71.50	96.70
Chemical score/protein score (%)	36.10	48.80
TEAA: Crude protein	0.60	0.72

Source: Sogbesan *et al. (2007)*

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