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Full Length Research Paper

Partial replacement of fish meal by earthworm meal

(Libyodrilus violaceus) in diets for African catfish,

Clarias gariepinus

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A seven-week feeding trial was conducted to examine the possibility of replacing fish meal with

earthworm meal in the diets of the African catfish, Clarias gariepinus fry. Fish meal protein was

replaced by earthworm meal at 0% (D0); 15% (D15); 25% (D25); 35% (D35); and 50% (D50). The diets

were isonitrogenous (54%) and fed thrice daily to triplicate groups of African catfish fry at 5% body

weight. Diet had a significant effect on growth performance and feed utilization (p=0.05). Final

weight, weight gain, daily weight gain, and specific growth rate, were highest in fish fed diet D25. A

similar pattern of growth was observed for length measurements. Fish fed diets exceeding 25%

replacement of fish meal with earthworm meal had depressed growth. Feed conversion ratio was

highest in fish fed D35. Mortality was not dependent on diet. It is concluded that fish meal can be

substituted with earthworm meal up to 25% in the diet of C. gariepinus fry without adverse effects on

growth and nutrient utilization.

Key words: Earthworm meal, fish nutrition, African catfish (Clarias gariepinus), Libyodrilus violaceous.

INTRODUCTION

Fish meal is the most common source of protein for aqua

feeds. However, the cost of fish meal is on the rise,

because of its competing use as feed ingredient by other

animals (livestock, ruminants etc.). It is therefore

necessary to find alternatives to fish meal in the

preparation of animal diets.Various workers have

attempted to use other locally available cheap protein

sources (e.g. plant protein, agricultural by- products,

fishery by-products, terrestrial animal by -products, grain

legumes, oil seed plants etc.) in animal feeds. Plant

protein sources have been used as alternatives in the

diets of fish with some measure of success particularly

grain legumes (Zhou et al., 2005; Emre et al., 2008;

Monentcham et al., 2010; Lim et al., 2011). A major

setback in the use of plant proteins however, is the

presence of antigrowth factors. Other workers have also

used other animal sources such as poultry by- product

(Tucker et al., 2005; Shapawi et al., 2007), meat and

bone meal (Gimenez et al., 2009) with favourable results

in some cases.The use of earthworms has also been

documented. Earthworms are abundant in most parts of

Africa and their nutritional values have been determined.

They possess amino acid profiles similar to fish (Dedeke

et al., 2010a) and have been used as protein

supplements in the diets of fish (Hilton, 1983; Sogbesan

et al., 2007; Monebi and Ugwumba, 2013).

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Stafford and Tacon (1985) showed that replacing fishmeal

with earthworm meals at low levels of inclusion in the diet

for rainbow trout did not have any adverse effect on the

growth performance or feed utilization efficiency of the

species. This study was aimed at evaluating the potential

of earthworm (Libyodrilus violaceus) meal as an

alternative to fish meal in Clarias gariepinus fry diets.

MATERIALS AND METHODS

Fish larvae production

The larvae were spawned from brood stock obtained from Zartech

Farms, Ibadan, Oyo State. They were fed with Artemia nauplii for

three days after the yolk had been absorbed and afterwards placed

on a commercial feed (0.2 mm) for four weeks until they attained a

mean weight of 0.19 g (2.63 -2.7 cm) before they were subjected to

experimental diets.

Collection of earthworms

The earthworms were collected between the months of August and

October, 2006 during the rainy season when the adult stages of

earthworms were available. Collections were made along the banks

of streams and flood plains or limicolous environment in Ago-Iwoye,

Ijebu North Local Government area, Ogun State, Nigeria, lying on

longitude 4°32’E, latitude 7°30’N at an altitude of 76m above sea

level with mean annual rainfall of 1,779 mm and mean annual

temperature of 27°C. Digging and hand sorting method (Owa,

1992) was employed. The collected earthworms were transferred in

plastic containers filled with humus to the laboratory for further

sorting and identification.

Diagnostic features of Libyodrilus violaceus

It has a pale albinoid zone around the clitella region. The male pore

is unpaired and the penial setae are simple. The spermathecal

diverticulum and receptaculum are paired. The spermathecal atrium

is paired and circumenteric. The setal distance is ab = cd and the

euprostate is baggy and laterally placed.Identification was done

using the method of Owa (1992).

Experimental diets

Five experimental diets (Table 1) were formulated to replace fish

meal protein with earthworm meal protein (EW) at 0% (D0), 15%

(D15), 25% (D25), 35% (D35) and 50% (D50). The diets were

isonitrogenous (54%).

Feeding trials

The experimental feeding trials were conducted in a recirculation

system, using a Completely Randomized Design (CRD) with five

treatments and three replicates consisting of fifteen plastic tanks

(each tank measured 0.6 m long × 0.3 m wide × 0.3 m deep with a

total volume of 0.054 m3 water occupying 50% of the total volume).

The larvae were randomly distributed into the plastic tanks at a

stocking density of 50 fry/tank. The diets were fed to the fry on the

basis of 5% body weight (dry matter) per day thrice daily at 06.30,

12.30 and 18.30 h.

Data collection

During the experimental period water temperature was measured

using hand held Hg thermometer (24.3 to 24.7°C). pH was

measured using a Mettler Toledo digital pH meter with glass

electrode (7.4-7.5). Dissolved oxygen (DO) was measured using a

Jenway Dissolved Oxygen Meter, Model 970 with a % Oxygen

saturation determination of -5 to 25% (9.8 to10.6 mg/L). The fry

were batch weighed and length measurements taken at ten day

intervals. The weights (W) of the fry were determined by a top

loading electronic Mettler balance to the nearest 0.01 g while the

lengths (L) of the fry were determined with a ruler to the nearest

0.01 cm. The specific growth rate (SGR) was determined by the

formula SGR (%/day) = 100 x (lnWt – lnWo)/t where lnWt is natural

logarithm of final weight, lnWo in natural logarithm of initial weight

and t is days of experiment. The daily weight gain (DWG) (g/day) =

(Wt – Wo)/t. Daily length gain (DLG) (cm/day) = (lt – lo)/t where It is

the final length and lo is the original length. The survival rate (X%)

of fry was determined by the equation X% = (Nt/No) x 100 where

No is initial number of fry and Nt is the final number of fry. The feed

conversion ratio (FCR) was determined by weight of the feed fed to

the fry/live weight gained.

Determination of proximate, mineral and amino acid profiles of

earthworm and diets

The proximate composition of earthworm and formulated diets was

determined according to the AOAC (1993) method (Table 2). Dry

matter (moisture content) was determined by differential weighing of

dried and fresh samples. Crude protein was determined by the

macro-kjedahl method. Ash content was by drying, ashing at 500°C

in a muffle furnace and weighing. Ether extract or crude fat

determination was by ether extraction method. Crude fibre was

determined by acid digestion of residues from the ether extraction

and loss in weight on ignition. Five macro (Calcium, Potassium,

Sodium, Phosphorus and Magnesium) and four micro minerals

(Iron, Zinc, Copper and Manganese) were determined using Atomic

Absorption Spectrophotometer at International Institute of Tropical

Agriculture (IITA), Ibadan. The amino acid concentrations of the

earthworm and experimental diets were analyzed using the High

Performance Liquid Chromatography (Technichon TSM-1,

technosequential multisample analyzer) at the Department of

Zoology, University of Jos, Nigeria.

Statistical analysis

Statistical analysis of data was done using SPSS version 13. Data

were analysed using the one way analysis of variance (Steel and

Torrie, 1981); and mean differences compared using the Duncan’s

multiple range tests (p= 0.05).

RESULTS

The proximate composition of the experimental diets is

shown in Table 1.The nutrient values were similar and

reflected the pattern in the ingredients.

L. violaceous had a protein composition greater than

60%, a value lower than that of Danish fish meal (72%)

used in this study (Table 2).

Table 3 shows the amino acid profile of the earthworm

and formulated diets. All the essential amino acids were

represented and the values are comparable. Arginine had

the highest value while Threonine had the least value

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Table 1. Ingredient and proximate composition of the experimental diets.

Ingredient composition (%)

D0

D15

D25

D35

D50

Fishmeal (72% crude protein)

45.00

38.25

33.75

29.25

22.50

EW meal

0.00

6.75

11.25

15.75

22.50

SBM

30.00

33.00

33.50

40.00

40.00

FFS

15.00

13.00

11.50

9.30

9.00

FH

2.65

3.65

2.65

3.35

3.65

Corn Starch

7.00

5.00

5.00

2.00

2.00

Mineral/vitamin premix

0.25

0.25

0.25

0.25

0.25

Dicalcium phosphate

0.10

0.10

0.10

0.10

0.10

Total

100

100

100

100

100

Proximate composition

Dry matter

92.35

91.89

93.02

93.45

94.33

Crude protein

54.20

54.24

54.36

54.41

53.88

Crude fibre

2.10

1.89

3.43

3.21

3.03

Crude fat (EE)

7.94

8.06

7.96

7.69

7.49

Ash

13.83

11.42

12.72

11.52

11.18

NFE

18.48

11.42

12.72

11.52

11.18

Ca

0.11

0.88

0.79

0.77

0.63

P

0.11

0.11

0.99

0.93

0.82

SBM, Soybean meal; FFS, full fat soya; FH, fish hydrolysate; EW, earthworm; NFE, nitrogen free extract.

Table 2. Proximate composition and mineral profile of L.

violaceus.

Proximate composition

Mean±SD (N=10)

%Moisture content

6.95±1.55

%Ash

39.53±13.66

%Crude protein

60.46±14.30

%Crude fat

4.68±0.36

%Crude fibre

0.50±0.08

Mineral profile

%Ca

0.40±0.09

%Mg

0.12±0.18

%K

0.028±0.002

Na (ppm)

23.12±9.96

Mn (ppm)

21.23±6.74

Fe (ppm)

18.24±3.68

Cu (ppm)

8.05±2.02

Zn (ppm)

28.22±6.68

% P

0.51±1.10

among the essential amino acids. In terms of non

essential amino acids, Aspartic acid had the highest

value. The mineral profile of the earthworm indicated

Phosphorus as the dominant element (Table 2). Fish fed

on the treatment diets throughout the experiment and diet

had a significant effect on growth performance and feed

utilization (Table 4). Final weight, weight gained, daily

weight gained, specific growth rate(weight) were highest

in fish fed diets in which fish meal was substituted at

25%. A similar pattern was observed for length

measurements. Feed conversion ratio was highest in fish

fed diet D (35), indicating poor utilization. Fish fed diets

exceeding 25% earthworm meal substitution showed a

depressed growth performance and nutrient utilization.

Survival was similar in all the treatments (Table 4).

DISCUSSION

The percentage crude protein found in earthworm meal

compared favourably with fish meals produced by

menhaden, tuna and catfish (BOANR, 1993), which have

been used by other workers. The mineral profile of L.

violaceous is also consistent with those found in

literature. Dedeke et al. (2010b) observed that five

macrominerals (calcium, magnesium, potassium, sodium

and phosphorus) were well represented in five

earthworms examined (Hyperiodrilus africanus, Eudrilus

eugena, Libyodrilius vilaceous and Alma mansoni). The

present study showed that earthworm meal can be a

suitable substitute for fish meal in the diet of the African

catfish, C. gariepinus. Earthworm meal is a high protein

feedstuff and contains a balanced amino acid profile

similar to that found in fish meal (Hilton, 1983; Dedeke et

al., 2010a). Lysine and methionine which are limiting

amino acids in most feedstuffs were adequately present

in L. violaceous. However, there are contrasting results in

the literature on the nutritional effects of fish meal

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Table 3. Amino acid concentration(g/100g crude protein) in L. violaceus and formulated diets.

Amino acid

L.violaceus

(g/100 g protein)

Control diet

(g/100 g protein)

Diets containing varied levels of L. violaceus

(g/100 g protein)

Essential

D0

D15

D25

D35

D50

Lysine

5.50

5.02

6.01

5.90

6.05

6.51

Histidine

3.36

2.05

2.16

2.45

2.61

3.02

Arginine

8.01

5.58

6.12

6.50

7.02

6.95

Threonine

1.02

2.01

2.41

2.55

2.62

2.50

Valine

4.00

3.81

3.20

4.10

4.51

4.31

Methionine

2.30

2.80

3.00

3.20

3.20

2.99

Isoleucine

4.80

3.21

3.51

3.05

3.65

3.59

Leucine

6.71

5.01

4.91

5.79

6.21

6.56

Phenylalanine

4.40

4.30

4.62

4.46

5.03

5.51

Non-essential

Aspartic acid

10.68

10.54

8.97

9.65

11.15

12.00

Serine

4.03

2.40

3.20

3.07

2.99

3.26

Glutamic acid

11.80

12.03

11.92

13.00

13.18

13.11

Proline

2.56

2.09

2.56

2.36

2.31

2.18

Glycine

0.85

3.05

3.02

2.61

3.21

2.91

Alanine

3.50

3.00

3.31

3.56

4.02

3.80

Cystine

0.80

0.88

0.96

0.90

1.00

0.88

Tyrosine

3.18

3.04

2.92

3.31

3.32

3.18

Table 4. Growth performance and survival of Clarias gariepinus fingerlings fed with experimental diets.

Parameter

Diets

D(0)

D(15)

D(25)

D(35)

D(50)

Initial weight (g)

0.21±0.08a

0.19±0.07a

0.19±0.06a

0.21±0.07a

0.18±0.06a

Initial length (cm)

2.67±0.34a

2.74±0.35a

2.67±0.31a

2.80±0.25a

2.67±0.39a

Final weight (g)

2.48±1.09bc

2.89±1.07b

3.53±1.59a

1.60±0.74d

1.97±0.79cd

Final length (cm)

6.78±1.08b

7.08±0.96ab

7.45±0.98a

5.93±1.06c

6.18±0.75c

Weight gain (g)

2.26±1.09bc

2.65±1.07b

3.34±1.59a

1.39±0.72d

1.79±0.81cd

Daily weight gain (g/day)

0.06±0.03bc

0.07±0.03b

0.08±0.04a

0.04±0.02d

0.05±0.02cd

Specific growth rate (%/day)

2.63±0.61b

2.94±0.57b

3.11±0.58a

2.18±0.53d

2.59±0.61c

Length gain (cm)

4.05±0.92b

4.29±1.03ab

4.78±0.98a

3.13±1.07c

3.51±0.96c

Daily length gain (cm/day)

0.10±0.02b

0.11±0.03ab

0.12±0.03a

0.08±0.03c

0.09±0.02c

Specific growth rate (%/day)

0.99±0.16b

1.02±0.21ab

1.11±0.18a

0.80±0.21c

0.92±0.20b

Feed Conversion Ratio (kgDM/kg gain)

6.19b

4.42bc

3.83c

10.08a

5.95b

Survival rate (%)

62.0a

61.3a

70.0a

70.0a

67.0a

Means with the same superscript in the same row are not significantly different ( p>0.05).

substitution with earth worm meal. Tacon et al. (1983)

reported that trout fed frozen earthworms (Allobophora

longa and Lumbricus terrestis) grew as well or better than

fish fed a commercial trout pellet.

In contrast the frozen earthworm, Eisenia foelida fed to

trout was totally unpalatable and showed little or no

growth (Tacon et al., 1983), while a growth depression

was also observed in trout fed on worm meals (Hilton,

1983). The author observed that protein digestibility was

high and could not have been the cause of growth

depression. He attributed the poor dietary response to a

lack of some unidentified essential component in high

worm meal diets. Poor growth performance and nutrient

utilization beyond a certain level of inclusion of

earthworm meal as observed in this study has also been

documented by other workers .Sogbesan et al. (2007)

observed growth depression in H. longifilis fingerlings

when fed with earthworm meal beyond 25% substitution

level, while highest growth was found in fish fed control

diet. In other studies on fish meal substitution with other

protein sources, it has also been reported that there have

been depressed growths, when fish meal protein was

substituted beyond a certain level. Ng et al. (2001)

reported that African catfish fed meal worm (larvae of the

beetle, Tenebrio molitor) as a replacement of fish meal

up to 40% substitution showed comparative growth, while

catfish fed solely meal worms showed growth depression.

These have been attributed to a number of factors such

as poor nutrient digestibility, mineral deficiencies, amino

acid deficiencies and anti-nutritional factors (Storebakken

et al., 2000).

In other studies in which fish meal has been substituted

with other protein sources, a trend has been observed in

which beyond a certain level of inclusion, there are

growth depressions. Such studies include the use of

soybean meal (Zhou et al., 2005; Lim et al., 2011),

soybean and cotton seed meals (Monentcham et al.,

2010), and poultry by-product meal (Shapawi et al., 2007)

as substitutes for fish meal. The decline in food

conversion efficiency also observed beyond a certain

level could be due to decreased food intake and

digestibility of protein and energy (Storebakken et al.,

2000).

It is concluded that fish meal can be substituted by

earthworm meal in the diet of C. gariepinus up to 25%,

without adverse effects on growth and nutrient utilization.

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