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RESEARCH ARTICLE

GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF CATFISH *Clarias gariepinus* FINGERLINGS FED WITH RUMEN EPITHELIAL SCRAPPING (RESmeal) DIETS

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ABSTRACT

A 76 days study was carried out to evaluate the growth performance and nutrient utilization of African catfish fed diets containing Rumen Epithelial scraping meal (RESmeal). Four isonitrogeneous diets containing 32.04%, 32.15%, 32.32%, 32.38% crude protein were formulated. Fishmeal was partially replaced with RESmeal. Diet A being the control contain 100%, diet B has 25% replacement, diet C has 50% replacement and diet D with 75% replacement. The result obtained in this study, showed an excellent growth performances and status of experimental fish. The standard growth rate (SGR) was between 1.82–2.41; food conversion ratio (FCR) was from the range of 2.62 to 3.16; protein efficiency ratio (PER) was at 1.83 to 2.86. The hepatosomatic index (HSI) and condition factor (Cf) were between the range of 2.29 to 2.42 and 1.04 to 1.16 respectively. Fish survival was from the range of 32-48%. The apparent crude protein digestibility of diet D (81.46%) containing highest RESmeal dietary inclusion level, decrease significantly compared to other diets which are 85.00%, 86.67%, 86.05% respectively.

INTRODUCTION

Increasing concern about the sustainability of industrial fishing and the modality of using fish to grow more fish has intensified the search for alternative sources. Scarcity of fish in some part of the world (largely attributed to the effect of human activities which is believed to be unfavourable to the environment) has led to increase in fish meal prices which are naturally passed down the line to the farmer. And the ever increasing need for cheap sources of protein to meet the world's overpopulation problems underscores the necessity to increase fish production. China substantially increased imports of fish meal over the past decades to cover one million metric tons of fish meal per year, nearly one-sixth of annual production. Most of china's imported fish meal is used to make fish feeds. At the moment, fish meal is the most widely sought after fish feed ingredient (Hardy and Tacon, 2002). Unfortunately the increased cost and short supply of fish meal constitute an impediment. This situation has led to a major shortfall in the supply of fish to most homes and where it exists, it comes at a high cost. For example, a matured cat fish, *clarias gariepinus,* is sold in the Nigeria market between ₦500 - ₦600, while matured. Tilapia, *Oreochromis nitoticus,* is sold between ₦150 - ₦250 which is too expensive for most people to afford.

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In Nigeria, an estimated one million metric tons of fish is consumed annually. Out of this, 200,000 tons is source mainly from the catch in the wild, but is still insufficient to feed the nations teeming population (Muyiwa Lucas, 2008).Worldwide production of fish meal averages about 7.05 (mmt) per year has decrease tremendously as a result of simultaneous collapse or under performance of several key fishery industries due to increase in the price of fish meal (Hardy and Tacon, 2002). Tacon and Hardy, (2002) predicted that fishmeal use in aquafeeds will decrease from 2,190,000mmt in year 2000 to 1,550,000mmt in year 2010. Their prediction was based on the fact that prices for fishmeal will increase at the same time that market price for farmed fish and shrimp decreases, forcing the fish feed industry to replace portions of fish meal in aquafeeds with less expensive ingredients. The first part of their prediction has come true, fish meal prices have dramatically increased, causing aquafeed manufacturers to use higher amount of alternative protein source.

The aquaculture has the potential to utilize 70% of the total annual production of fish meal by 2020 (Tacon and Forster, 2002). As the demand for farmed raised fish increases so does the demand for wild caught fish as the protein source for aquaculture feeds. It is estimated that 14 million metric tons of aquaculture fish feed is produced each year. And the major component of aquaculture fish feed is fish meal (10% or 1.4mmt), which is obtained from wild harvest fish. Aquaculture is expected to reach 80mmt by the year 2030, which will demand over 8mmt of fish meal per year, hence the need for alternative protein source in aquaculture is eminent (Keith Wilda, 2004).

Many different feed ingredients have been tested in an effort to replace fish meal in the diet of farmed fish (such as Catfish, Tilapia, Salmond, trout etc). These include animal proteins, plant sources. Examples of animal protein used are feather meal, bone meal, worms, maggot meal, and presently Rumen epithelia cells (RES) meal used in this project. And those of plant source are soya bean meal, sesame seed, maize, wheat offal etc. Finding alternative protein sources for aquaculture feeds will reduce the need for wild harvested fish, improve water quality, and reduce the risk of contaminates in fish feed. (Ogunji, 2004). The use of alternative protein sources will improve the water quality in the production facility as well as improving discharge water quality. Fish meal base proteins are made up mostly of nitrogen. Uneaten or indigested feeds introduce large quantities of unnecessary nitrogen and phosphate into production facility and the environment. Plant based proteins feed have more available proteins easier to digest thus reducing unnecessary nitrogen. Plant based feeds also allow phosphates to be readily available, which lowers the phosphate discharge from the facility (Keith Wilda, 2004). RES meal is a product obtained from the rumen of herbivorous animals such as cow, goat, sheep etc. It is readily available as waste in abattoir, relatively cheap and affordable by fish farmers, which can be used as local substitute in the diet of farmed fish. RESmeal, an example of animal protein in combination with other plant protein source such as soyabeans meal, wheat offal, fishmeal etc, will provide good nutritional base in fish production.

MATERIALS AND METHODS

The procedure chosen for feed study have been in operation for the past 5-8years and have been proven as successful grown-out system. Rumen epithelial scraping (RES) was obtained from the rumen of cow as described below. The procedure chosen was the same as described by Ajani *et al.* (2004) and Adesola and Mustapha, (2000), in the diet formulation for tilapia using housefly maggots.

Four isonitrogenous diets were formulated with fish meal being replaced partially with RESmeal. Fishmeal was included in control, diet A, at a level 28% without any RESmeal. Inclusion level for diets B, C and D are 21:7%, 14:14% and 7:21% respectively. The four (4) diets are isonitrogenous with 32% protein with diet A serving as control; diet B has 25% replacement; diet C has 50% replacement and diet D with 75% replacement. Ash content was determined by using water insoluble ash procedure. It was by burning in a muffle furnace at 550-570^{0}C (FIIRO). Moisture content was determined by oven drying at 105^{0}C. The method used was based on Loss on dry at an oven (FIIRO). Crude protein was determined by the use of the Macro Kjeldahl digestion and distillation method (FIIRO). Fat content was estimated by continuous extraction with either light petroleum ether or n-haxane over a period of time in a soxhlet type of apparatus (FIIRO). Crude fibre is the organic residue left after subjecting the food stuff sample to acid and alkali-treatment which are to break down the inorganic components. It was determined by Ashing the fibre at 700^{o}C in a furnace for 1hour (FIIRO).

Table 1. Proximate composition of Fishmeal and RESmeal used for diet formulation (%)

Components	Fishmeal	RESmeal
Moisture	9.87	9.16
Crude protein	67.65	68.00
Crude fibre	0.44	4.31
Crude Ash	12.73	11.93
Crude fat	7.18	3.14
[1]Nitrogen free extract (NFE)	2.13	3.46
[2]Gross energy KJ/g	34.37	31.41

Table 2. Ingredient composition of experimental diets fed *clarias gariepinus* (%)

Ingredient	Diet A (control)	Diet B	Diet C	Diet D
Fishmeal	28.00	21.00	14.00	7.00
RESmeal	-	7.00	14.00	21.00
Soyabean	25.44	34.00	47.00	60.00
Wheat offal	26.66	12.31	8.00	5.00
White maize	17.90	23.69	15.00	5.00
Vit premix	1.00	1.00	1.00	1.00
Dicalcium phosphate	1.00	1.00	1.00	1.00
Total	**100g**	**100g**	**100g**	**100g**

Table 3. Weekly weight measurement

Week	Tank A (g)	Tank B (g)	Tank C (g)	Tank D (g)
Initial weight (g)	1.22	0.98	1.36	1.20
Week 1	1.90	1.76	1.72	1.88
Week 2	1.50	2.42	1.98	2.24
Week 3	2.54	2.48	2.76	2.34
Week 4	3.14	2.96	3.24	3.00
Week 5	3.46	3.34	3.32	3.24
Week 6	3.66	3.82	3.56	3.30
Week 7	3.92	4.30	3.94	3.56
Week 8	4.10	5.28	4.56	4.84
Week 9	4.62	5.86	4.82	4.32
Week 10	5.30	6.14	5.42	5.00

All growth data were subjected to statistical analysis using ANOVA.The significance of different between means was determine by Ducan's multiple range test (P<0.05) using minitab

Ingredient compositions of the experimental diets are shown in Table 2. The diets are all measured out accordingly in their various proportions. All dried diet components including RESmeal were thoroughly mixed together and a little amount of water was added. It was then pressed and made into pellets. The pellets were oven dried for 5hrs. The feeds were stored at room temperature until used. One hundred and forty fingerlings with initial average weight of 1.22g were acclimatized for one week. Thereafter, one hundred of them were stocked into the four experimental tanks, with 25 fingerlings in each of the tank containing 10litres of water. The experimental tanks were organized in a single row outside the Laboratory for convenience and to allow for natural conditions to act upon the set up. The artificial aeration was also provided with the aid of aerators to support the natural aeration. The experimental diets were assigned to each tanks spread uniformly within the tank. The fish were manually fed 5% of their body weight in two proportions per day at 9.00am and 3.00pm for 76days. The ration were well consumed, the uneaten ones are siphoned out every morning before giving fresh ones. The water was changed daily (in the morning) before giving the fresh feeds. And this was done to ensure the cleanliness of the water as well as to allow sufficient aeration in the water. Data were collected by sampling 20% of the initial population in each tank (25). From the experimental data obtained weekly, in the four tanks, weight gain, length gain, specific growth rate (SGR) and feed conversion ratio (FCR), protein efficiency ratio (PER), survival percentage (SP), condition factor (CF) and hepatosomatic Index (HSI) were all calculated as follows:

$$FCR = \frac{\text{Feed fed}}{\text{Live weight gain}}$$

$$SGR = \frac{(\ln W_2 - \ln W_1) \times 100}{T_2 - T_1 \text{ (day)}}$$

Where W_2 = final weight of fish, W_1 = Initial Weight of Fish, T_1 = begin of experimental (day) and T_2 = End of experiment (day)

$$PER = \frac{\text{Live weight gain (g)}}{\text{Protein Fed (g)}}$$

Protein to Energy ratio (/E ratio) was calculated as Mg protein/KJ gross energy.

$$\text{Survival (\%)} = \frac{F_2 \times 100}{F_1}$$

Where F_2 = number of fish at the end of experiment

F_1 –= number of fish at the beginning of the experiment.

All calculations were base on each of the tank per treatment.

$$\text{Condition factor (CF)} = \frac{W_2 \times 100}{L^3_2}$$

Where W_2 = final fish weight

L_2 = standard length

The apparent digestibility coefficient (ADCs) of RES, Crude Protein, Crude Fat, EE and energy were calculated as follows:

$$\text{ADC (\%)} = 100 - 100 \frac{\text{(\% DCP feed x CP)}}{\text{Food fed}}$$

All growth data were subjected to one-way analysis of variances (ANOVA). The significance of different between means was determine by Ducan's multiple range test ($P<0.05$) using minitab for windows (Version 11.21).

Rumen Epithelial Scraping Processing

The processing of the RES was done at the abattoir in Agege Local Government of Lagos State, Nigeria. This begins with the evacuation of waste material, which is mostly undigested garbage, from the rumen of the slaughtered cow, it was washed with water. The towel-like rumen is then boiled for 10minutes in a hot water tank. The stirring is done continuously with a long stick until the whole rumen is softened. It was then removed and allowed to cool for about 5minutes before scraping. The unwanted epithelial cell is then scraped out with the continuous addition of water while scraping out with the edge of an iron can made purposely for that. After the scraping, the epithelial cell was collected and dried under the sun for 6-7 days or oven-dry for 12hours (75-80^{o}C) to remove the moisture content. The dried epithelial cells was then pounded with mortar and pestle into powdered form, it was later sieved to remove the shaft before using it with other diets in feeding the fingerlings.

Collection of Catfish Fingerlings

Clarias garienpinus fingerlings were obtained from a reputable fish farm in Lagos. They were thereafter transferred to Biology Laboratory, Yaba College of Technology, Nigeria.

RESULTS

The ingredient composition of experimental diets is shown in Table 2. The proximate composition of RESmeal and fishmeal used for diet formulation was 68.00% and 67.65% respectively. The effects of RESmeal diet on growth performance and nutrient utilization of *Clarias gariepinus* is shown in Table 6. During the experiment, mortality rate was recorded; about 59% of the fingerlings were lost while 41% survive throughout the experiment. And this may be due to change of diets, stress and the length of acclimatization before introduction into the tanks. High mortality was recorded in the first one and half week of the start of the experiment. Highest weight gain and specific growth rate (SGR) were observed in catfish fed diet B, followed by fish fed diet, A, C and D respectively which did not show significant difference. Feed conversion (FCR) was most efficient in fish fed diet C compared to diet A, D and B. Although fish fed diet B (containing 21% fishmeal and 7% RESmeal) show the best growth performance, high protein efficiency ratio (PER) was recorded in diet B followed by C, A and D respectively. The C_f of fish fed diet A was higher in comparism to fish fed diet B, C and D while Hepatosomatic index (HSI) of the fish fed diet B is higher in comparism with the rest diets. The length of cat fish fed diets is shown in Table (4) with tank B showing a highest increase in length compare to the rest experimental tanks. Feed fed per week is shown in Table (5) in which tank B show the highest amount of feed fed. The total amount of feed fed was 497.20gms. Physico-chemical parameters of the water measured are pH, temperature and dissolved oxygen (D_O). It indicates that the pH value of water was 6.8-7.1 and then temperature range is between 25^{o}C-26^{o}C. The dissolved oxygen (Do) of the water measured shows the minimum Do to be 6.87mg/dm^{-3} and the maximum to be 12.80 mg/dm^{-3} (standard = 4-6mg/dm^{-3} minimum). In Table 7, the apparent digestibility coefficients (ADCs) for crude protein, crude lipids did not differ as such. Crude protein digestibility of diet D was decreased significantly in contrast to the rest diets. Gross energy digestibility was the highest in diet B, C and A in comparism to diet D.

DISCUSSION

The crude protein content of RESmeal used in this study (68.00) is high when compared with what was obtained when maggot meal was used in feeding Tilapia. It has been reported by Teotia and Miller, 1973; Spinelli *et al.,* 1979, that magmeal crude protein content ranges from 40 to 61.4%. The good growth performances obtained in each of the experimental group of this study confirmed the suitability of chosen nutritional composition for cat fish fingerlings and juvenile. The digestibility results indicate that the nutrient composition, especially ash and fibre content highly influence the utilization of RESmeal. However, there is a need to standardize the production of RESmeal so as to realize comparable nutrient composition of the feed stuff. The highest value of food fed (135.18g) recorded in Tank B indicate that as the weight of fish increases so is the amount of food consumed. FCR values < 1 have been reported, although, generally it ranges between 1.2 and 1.5 for fish fed well prepared diets (Da Silva and Aderson, 1995). Ogunji and Wirth, (2002) used fish meal diets and reported that FCR 1.19; SGR 3.39 at the dietary protein content of 33.32% indicated the most efficient utilization of feed by *Oreochromis niloticus* fingerlings (average initial weight 4.4g). As such the highest value of FCR (3.16) recorded in this study shows the efficient utilization of feed by *Clarias gariepinus*. However, weight gain, PER and SGR decreased with higher dietary inclusion (as in Diet D) of RESmeal. This may be due to a decrease in protein and energy level (Table 8). Protein is an essential nutrient that must be included at an appropriate level in a diet for growth and health of fish. Also adequate energy must be supplied so that dietary protein may be use for growth rather than metabolized protein for energy. It is therefore important to maintain a proper ratio of protein to energy in the diet (SRAC, 1998). According to SRAC, 1998, inadequate protein as well can cause decrease growth, and excessive energy can cause reduced feed intake and decrease in growth rate. The dietary apparent digestibility coefficients for crude protein and gross energy did not have significant different between fish fed diets A, B, C (Table 8). However, there is significant difference in crude protein, crude lipid and gross energy in diet D. This may be due to elevated ash concentration of RESmeal in the ingredient composition of experimental diets formulation (Table 2). Gully (1980) and Hajen *et al.,*

Table 4. Weekly Body Length

Week	Tank A (cm)	Tank B (cm)	Tank C (cm)	Tank D (cm)
Initial length (cm)	4.00	3.68	4.04	4.22
Week 1	4.76	5.48	5.37	5.44
Week 2	6.04	6.44	6.12	6.24
Week 3	6.50	6.50	6.70	6.48
Week 4	6.70	6.68	6.76	6.68
Week 5	6.76	6.70	6.86	6.70
Week 6	6.82	7.14	7.04	6.80
Week 7	7.10	7.62	7.20	6.98
Week 8	7.44	7.84	7.52	7.28
Week 9	7.52	7.92	7.76	7.54
Week 10	7.70	8.36	7.88	7.84

Table 5. Feed Fed per week

Week	Tank A (g)	Tank B (g)	Tank C (g)	Tank D (g)
1	10.71	8.61	11.90	10.50
2	13.30	13.86	12.04	14.80
3	15.31	14.82	13.86	11.76
4	13.34	15.19	14.49	10.24
5	13.74	15.54	14.18	12.60
6	10.90	13.19	11.76	11.34
7	13.72	14.98	13.79	12.46
8	14.35	18.48	15.96	13.44
9	16.7	20.51	20.24	15.12
Total	**121.54**	**135.18**	**128.22**	**112.26**

The fish were fed 5% of their body weight twice daily.

Table 6. Growth and Nutrient utilization of *Clarias gariepinus*fingerlings fed experimental diets.

Week	Diet A	Diet B	Diet C	Diet D
Initial weight (g)	1.22	0.98	1.36	1.20
Final weight (g)	5.30	6.14	5.42	5.00
Mean wt gain/week (g)	0.41	0.52	0.41	0.38
Weight gain (g)	4.08	5.16	4.06	3.80
SGR	1.93	2.41	1.82	1.88
FCR	2.98	2.62	3.16	2.95
PER	2.24	2.86	2.27	1.83
HSI	2.42	2.61	2.48	2.29
C_f	1.16	1.05	1.11	1.04
Survival (%)	40	48	44	32

Table 7. Proximate Nutritional value of experimental diets (%)

Proximate composition	Diet A	Diet B	Diet C	Diet D
Crude protein	18.23	18.02	17.89	20.78
Crude lipid	10.04	11.30	10.35	13.83
Crude ash	12.32	11.95	13.07	14.23
NFE	59.41	58.73	58.69	51.16
Gross energy (KJ/g)	64.78	64.59	64.12	59.89
P/E ratio	28.14	27.90	27.90	34.70

Values are means of duplicate determinations
P/E = Protein to energy ratio in mg protein KJ^{-1} gross energy

Table 8. Apparent digestibility coefficient (ADCs %) of crude protein, crude lipid and gross energy of *clarias gariepinus* fingerlings fed varying diets

Week	Diet A	Diet B	Diet C	Diet D
Crude protein	85.00	86.67	86.05	81.46
Crude lipid	91.74	91.64	91.93	87.68
Gross energy (KJ/g)	76.74	78.31	77.98	67.36

Table 9. Physico-chemical parameter of freshwater measured

Week	pH	Temperature (^{0}C)	Dissolved oxygen (mg/dm-^{3})
Initial day	6.80	25	**6.87**
Week 1	7.00	25	**10.20**
Week 2	7.20	26	**8.95**
Week 3	6.90	25	**10.20**
Week 4	7.10	26	**11.10**
Week 5	7.10	26	**7.60**
Week 6	7.00	26	**10.30**
Week 7	7.00	25	**9.70**
Week 8	7.10	26	**12.80**
Week 9	7.00	26	**10.75**
Week 10	7.00	25	**12.50**

The record was based on the daily measurement (average) per week.

(1993) have established an inverse relationship between ash content and digestibility of dietary components. The evident of the influence of this factor was seen among the fish group fed diet D, formulated with highest inclusion of RESmeal. It has been reported that highest ash content has a negative correlation with protein digestibility (Robiana *et al.,* 1997). Hence, it may be that RESmeal may have low digestibility which resulted in the reduction in growth performance of experimental fish fed diet D with full-fat RESmeal (21% inclusion) to low protein digestibility of the feed stuff among other reasons. Crude lipid digestibility did not differ in all feeding groups. This indicates that *clarias gariepinus* fingerlings effectively utilize the crude lipid supplied by RESmeal and fishmeal in the diets. Hanley (1987) studied the coefficient of digestibility for gross energy of several feed-stuffs used in Nile tilapia *Oreochromis niloticus*. For his results, it was apparent that the energy of the animals based feed-stuffs was more available to Nile tilapia that plant based feed stuffs.

The HSI and C_f in all the four feeding groups show no significant difference except higher HSI calculated in Diet B. The condition factor (C_f) is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fish. It shows the welfare of fish during the various stages of life cycle (Angelescu et al, 1956). Therefore, the condition of the experimental fish in this study is seemed comparable and adequate. According to Afuang *et al.,* (2003) who fed O. nilocticus (initial weights 15.5-17.0g) on varying amounts and extracts of Moringa *Moringa Olufera* leaf meals to replace fish meal reported that the HSI ranging from 1.5 to 2.7 correlated with body lipid incorporation and was obviously influenced by dietary nutrient intake and availability. Therefore, the HSI of 2.29 -2.61 found in this study conformed to the dietary group range.

Conclusion and Recommendation

Since this study is new, there is a need for more research on the suitability of RESmeal inclusion in fish feed. However, from the result obtained in this work it has shown an excellent growth performance and status of *clarias gariepinus*. This recommends the suitability of RESmeal in the diets of catfish. The experiment was carried out in artificial environment-that contributed to the rate of mortality recorded. if the experiment had been carried out in a fresh and natural environment, the result would have been, where all the natural biotic and abiotic factors will be available. Also, there is a need to standardize the production of RESmeal so as to realize comparable nutrient compositions of the feed stuff. The significant decreased in weight gain and crude protein in diet D with 21% RESmeal inclusion rate in contrast to the other diets raises a question that calls for more research. It is also important to determine the apparent digestibility coefficient (ADCs) of RESmeal as an alternative fish feed ingredient and the effect of crude protein content in the digestibility of formulated diets be verified. The availability of RESmeal is very important, and so there is a need to device the best processing and production method to ensure consistency in the quality of the product. The relevance of this project at this point in time where there is global concern about the high cost of fish coupled with the high demand for fish food worldwide cannot be overemphasized. High cost of fish food is affecting fish production worldwide.

The relevance can be seen under the following:

i. Availability of the feed
ii. Cost effective and economical
iii. Turning waste to wealth

This research work may serve as one of the purpose whereby local source of feeds which are cheap and readily available could be sourced for as a means of responding to the trend in fishing industry. It is cost effective and economical.

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