EFFECT OF DIFFERENT INCLUSION LEVELS OF SHRIMP MEAL WITH FISH MEAL IN *OREOCHROMIS NILOTICUS* DIET

NENE AMABERE JAMABO*, CHARITY DASIMEOKUMA

A feeding trial was conducted to evaluate the effect of inclusion of different levels of shrimp meal with fish meal on growth performance, feed utilization, water quality and cost implication of the diet *O. niloticus* fingerlings. A total of two hundred and four (204) fish with an initial weight of 2.93± 0.55g were stocked in twelve (12) tanks of dimension 1.8 × 1.3 × 0.36 m^3 for 12 weeks. Four treatment diets (D1, D2, D3 and D4) contained 100% shrimp meal, 70% shrimp meal and 30% fish meal, 50% shrimp meal and 50% fish meal, 30% shrimp meal and 70% fish meal respectively, were fed twice daily to satiation. Final weight gain was 4.65±1.72g, 3.89±0.96g, 3.58±0.65g, 3.73±0.80g for the treatments respectively. The highest mean weight gain (4.98±0.31g) and specific (4.57±0.69%) growth rates were in fish fed with 100% shrimp meal (D1) and lowest (3.59±0.15g, 17.7±0.17% respectively) in fish fed 50% shrimp meal and 50% fishmeal (D3). Protein efficiency ratio was highest in D1 (0.13±0.00) and lowest in D4 (0.04±0.00). Feed conversion ratio was lowest in treatment diet D1 (0.60±0.10) and highest in D4 (2.01±0.20). Survival rate was good in all the treatments having the highest (89.7±3.17%) in D2 and lowest (82.4±5.02%) in D1. Diet 1 had the best growth performance followed by D2, D4 and D3 respectively. Cost implication and water quality parameters showed no significant differences (p>0.05) among the diets. Results showed that Shrimp meal could replace fish meal by 100% without having any negative effect on the growth and tend to be uneconomically efficient at such inclusion level. When included at reduced levels, it gives a good growth performance and is economically efficient.

Keywords: Growth performance, survival, feed utilization and protein.

INTRODUCTION

The fast growth of the aquaculture industry experienced in the last two decades is as a result of the progressive intensification of production systems and use of quality fish feeds, which meet the nutritional requirement of cultured fish (FAO, 2013). Aquaculture, which is the farming of aquatic organisms such as fish, aquatic plants, crustaceans, mollusks, reptiles and amphibians in a confined environment or enclosures, enhances production and generates income. Fish farming which is an aspect of aquaculture, involves raising fish commercially in

ROM. J. BIOL. – ZOOL., VOLUME **65**, Nos. *1–2*, P. 107–116, BUCHAREST, 2020

tanks or enclosures usually for food. However, the greatest challenge facing aquaculture today in Nigeria is the high cost of feed ingredients and this has made feed industries and farmers to compromise quality for affordability (FAO, 2008). Feed represents a major part of the operational costs in fish farming.

Tilapia is a favourite aquaculture species in Africa and one of the most successful cultural finfish species in the world. They are fast growing, highly prolific, able to survive in poor water conditions, eat a wide range of food types and breed easily with no need for special hatchery technology (Erick *et al.*, 2014, Ebrahim and Abou-seif, 2009). *Oreochromis niloticus* is the most cultured freshwater species among the farmed tilapia and comprises 83% of the global tilapia production (El-Sayed, 2006 and FAO, 2013). They grow rapidly in relatively high temperatures, flourish on agricultural waste and have a good resistance to diseases. However, to ensure high yield and fast growth at least cost, a well balanced prepared feed is essential to successful tilapia culture. However, slight variations exist among tilapia species, nutrient requirements are primarily affected by the size of the fish (El-Sayed and Teshima, 1992).

Nutrition plays a critical role in intensive aquaculture because it influences not only the production cost but also fish growth, health and waste production. It represents over 50% of the operational costs which makes it the most expensive component in intensive aquaculture industry (Jamabo, 2017). Moreover, protein itself represents about 50% of feed cost in intensive culture. Protein is a major dietary nutrient and at such, it affects the way fish performs. It provides the essential and non-essential amino acids. Protein requirements for optimum growth of tilapia are dependent on dietary protein quality/source, fish size or age and the energy contents of the diets. It varies from fry to adults or on-growing; for fry and fingerlings; 35–40%, 30–35% for juveniles and on-growing has 28–30% (Munguti *et al.*, 2014). Fishmeal (FM) is one of the main protein sources in the conventional aquaculture sector due to its high protein content (60–80%) and it is highly palatable to fish (Lovell, 1984). It is generally added to animal diets in order to increase the efficiency of feed and growth through better feed palatability; it also enhances nutrient uptake, digestion and absorption (Mike and Chapman, 2006). However, the inconsistency of supply, growing demand and price among other problems, are limiting the use of fishmeal and putting greater pressure on the feed industry to find an economical alternative source of protein. Shrimp meal is an animal protein source and it is the undecomposed ground dried waste of shrimp. It is a by-product of the shrimp industry. It can contain whole shrimps and or shrimp parts such as the head or shells. It contains high levels of crude protein and due to its high protein content, it is considered as a good ingredient for fish feed. It also gives a reddish pigmentation to Nile tilapia muscles.

Increasing demand and rising costs of fish meal (FM), coupled with static landings of reduction fisheries, have made continued use of FM-rich aqua feed formulations environmentally and economically unsustainable. Numerous alternative protein sources have already been investigated by nutritionists, including products derived from plants, animals, and single-cell organisms. Good quality feed helps in the growth of the fish and makes the fish healthy (Iskandor *et al.*, 2017). Fishmeal has been traditionally used by aquaculturist because it is highly palatable to fish, enhances fish growth and contains high protein content. This study determines the rate of growth, feed utilization and economic viability of feeding *O. niloticus* with various inclusion of shrimp meal in the diet.

MATERIAL AND METHODS

Experimental Area/Design

The experiment was carried out at the Aquaculture section of the Demonstration Farm, Faculty of Agriculture, University of Port Harcourt. It was a twelve (12) weeks feeding trial experiment having four (4) treatments with three (3) replicates to determine the rate of growth and nutrient utilization of *Oreochromis niloticus* fed with different inclusion levels of shrimp meal. Fingerlings of *O. niloticus* were bought from a private fish in Port Harcourt, Rivers State, Nigeria.

Experimental diet

Four experimental diets was formulated with different inclusion levels of shrimp meal of 100% SM, 70% SM/30%FM, 50%SM/50% FM, and 30%SM/70%FM (designated as D1, D2, D3 and D4 respectively) was formulated on an equal nitrogen basis (Table 1). Feed ingredient was homogeneously ground to pass through a 200 mm sieve. The formulations were made by mixing the necessary ingredients into a homogenate, which was moistened before passing through a mechanically operated pelletize of Prostan GX 160 5.5hp. The resulting feed were sun-dried and stored at room temperature for feeding.

Fish and feeding

Juvenile of *O. niloticus* were obtained from the African Regional Aquaculture Center, Aluu, Rivers State, Nigeria. Prior to the start of the feeding trial, fish were acclimated to the experimental conditions and fed a commercial diet for 2 weeks. At the beginning of the feeding trial, healthy fish (initial weight 2.93 ± 0.55 g) were weighed and sorted into 1.80 × 1.3 × 0.36 m^3 plastic tanks, with 17 fish/tank. Three replicate groups of fish were used for each diet. Water quality parameters were monitored daily between 8:00 and 16:00 hours. During the feeding trial, temperature ranged from 25.0 to 30.0°C. Total ammonia nitrogen maintained was 0.6mg/l, and dissolved oxygen maintained was 6.1 mg/l. Fish were fed the experimental diets to satiation twice daily (between 07:30–08:30 and 16:00–17:00 hours) for 12 weeks. The amount of feed consumed by the fish in each tank was recorded daily, and rations were adjusted according to feed consumed the previous day. All the tanks were cleaned by scrubbing and siphoning of accumulated wastes, and water change rate was 30% every morning before feeding. Fish in the tanks were counted and weighed collectively every week.

Analysis of the component in diet

Moisture, ash, ether extract, crude protein, crude fiber and carbohydrates in diets were determined in triplicates using standard methods (AOAC, 2005). Moisture was determined by oven-drying at 105^0C until a constant weight was achieved. Crude protein (N×6.25) was measured using micro-Kjeldahl nitrogen determination method. Ash content was measured after placing the samples in a muffle furnace at 550^oC for 4 hours. Crude fibre was determined as the ash-free residues of a digestion process in alkaline and acidic solution.

Water quality parameters

Water quality parameters were measured weekly. The parameters measured were temperature, dissolved oxygen, pH and Ammonia and they were measured with thermometer, DO meter, pH meter and Ammonia reagents respectively.

Growth parameters

At the end of the trial, growth performance was calculated as follows:

Weight gain (WG) = Final body weight – Initial body weight

$$\text{Specific growth rate (SGR)} = \frac{\text{Logew2} - \text{Logew1}}{\text{T2} - \text{T1}}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed fed}}{\text{Weight gain by fish}}$$

$$\text{Survival Rate (SR)} = \frac{\text{Final number of fingerlings}}{\text{Initial number of fingerlings}} \times 100$$

Feed intake (g) = Weight of food consumed by fish within the experimental period

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Gain in fish weight (g)}}{\text{Protein intake (g)}}$$

Data Analysis

Data was analysed using the analysis of variance (ANOVA). The difference between the mean were compared by Duncan's multiple range test. Pearson's correlation was used to determine the relationship between weight and experimental periods.

RESULTS

The ingredients and proximate composition of the diets as determined is presented in the Table 1. The moisture contents were below 11%, ash content vary between 6.48 to 9.11. Ether extract values ranged between 4.5 and 5.1, while, crude protein was highest for Diet 4.

Table 2 represents the result for growth performance and feed utilization of *O. niloticus* fingerlings fed on different inclusion levels of shrimp meal diets. The result showed that D1 had the highest value of mean weight gain (3.39, specific growth rates, feed intake and protein efficiency ratio than D2, D3 and D4. No significant difference was observed among the treatment diets ($p>0.05$). Significant differences in feed conversion ratio (FCR) were observed for the treatment diets. FCR values were 0.60±0.10, 1.02±0.10, 1.90±0.35 and 2.01±0.20 for treatment diets D1, D2, D3 and D4 respectively. Survival rates ranged from 82.40 to 89.70%, no significant difference was observed between the treatments.

Water quality in the containers at was not significantly altered by diet. Temperature, dissolved oxygen, pH and ammonia ranged from 25.0 to 30.0C, 4.6 to 6.1 mg/l, 6.5 to 7.0 and 0.01 to 2.4 mg/l, respectively. Cost implication of the inclusion of shrimp meal in the diet of *O. niloticus* is presented in Table 3. The cost analysis of the four treatment diet shows that D1 (100% shrimp meal) was the most expensive (₦10,740) followed by D2 (₦9,165), D3 (₦8,115) and the cheapest was D4 (₦7,065). The cost of palm oil in each of the diet is of small quantity and is therefore negligible in the cost.

Table 1

Ingredients and proximate composition of the experimental diets (% dry weight)

Ingredients (%)	Diets (inclusion level of shrimp meal)			
	Diet 1 (100%)	**Diet 2 (70%)**	**Diet 3 (50%)**	**Diet 4 (30%)**
Shrimp meal	30.0	21.0	15.0	9.0
Fish meal	0.0	9.0	15.0	21.0
Soybean meal	18.0	18.0	18.0	18.0
Maize	50.0	50.0	50.0	50.0
Vitamin premix	0.5	0.5	0.5	0.5
Lysine	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1
Bone meal	0.2	0.2	0.2	0.2
Salt	0.2	0.2	0.2	0.2
Vitamin C	0.2	0.2	0.2	0.2
Palm Oil	0.2	0.2	0.2	0.2
Binder	0.4	0.4	0.4	0.4
Proximate composition				
Moisture	6.7	7.9	7.4	4.8
Ash	9.1	6.6	6.6	6.5
Ether extract	4.5	4.6	4.8	5.1
Crude protein	24.6	28.8	28.5	33.7
Crude fiber	22.1	20.4	12.9	9.4
Carbohydrate	27.0	25.6	33.4	34.6

Table 2

Growth parameters and feed utilization of *O. niloticus* fed with different inclusion levels of shrimp meal

Parameters	D1	D2	D3	D4	SD±
No of fish stocked	17	17	17	17	
Duration of experiment (days)	84	84	84	84	
Initial mean weight (g)	2.93 ± 1.46^{a}	2.93 ± 1.46^{a}	2.93 ± 1.46^{a}	2.93 ± 1.46^{a}	0.06
Final mean weight gain (g)	6.32 ± 0.06^{d}	4.82 ± 0.05^{c}	4.15 ± 0.07^{a}	4.44 ± 0.07^{b}	0.88
Mean weight gain (g)	3.39 ± 0.01^{d}	1.89 ± 0.01^{c}	1.22 ± 0.00^{a}	1.51 ± 0.01^{b}	0.88
Specific Growth Rate(%Day)	4.57 ± 0.69^{c}	3.45 ± 0.31^{b}	1.77 ± 0.17^{a}	1.90 ± 0.15^{a}	1.76
Total Feed Intake	22.23 ± 0.50^{c}	20.20 ± 0.25^{b}	17.40 ± 0.39^{a}	7.50 ± 0.29^{a}	2.41
Feed Conversion Ratio	0.60 ± 0.10^{a}	1.02 ± 0.10^{a}	1.90 ± 0.35^{b}	2.01 ± 0.20^{b}	0.91
Survival (%)	82.40 ± 5.02^{a}	89.70 ± 3.17^{a}	88.70 ± 2.85^{a}	82.80 ± 4.00^{a}	13.33
Protein Intake	24.50 ± 0.45^{a}	28.50 ± 0.70^{b}	28.40 ± 0.54^{b}	33.70 ± 0.35^{c}	3.44
Protein Efficiency Ratio	0.13 ± 0.00^{c}	0.07 ± 0.01^{b}	0.05 ± 0.00^{ab}	0.04 ± 0.00^{a}	0.40
Weight Gain (%)	115.7 ± 0.02^{b}	64.51 ± 0.01^{c}	41.64 ± 0.01^{a}	51.54 ± 0.01^{b}	29.78

Data on the same row carrying same superscripts are not significantly different from each other ($p>0.05$).

Table 3

Cost implication of utilizing the experimental diets

Ingredients (kg)	D1 (₦ & $)	D2 (₦ & $)	D3 (₦ & $)	D4 (₦ & $)
Shrimp meal	6,500, 18.06	4,550, 12.64	3,250, 9.03	1,950, 5.42
Fish meal	0	375, 1.04	625, 1.74	875, 2.43
Soybean	180, 0.50	180, 0.50	180, 0.50	180, 0.50
Maize	170, 0.47	170, 0.47	170, 0.47	170, 0.47
Vit. premix	650, 1.81	650, 1.81	650, 1.81	650, 1.81
Lysine	400, 1.11	400, 1.11	400, 1.11	400, 1.11
Methionine	1,000, 2.78	1,000, 2.78	1,000, 2.78	1,000, 2.78
Bone meal	60, 0.17	60, 0.17	60, 0.17	60, 0.17
Salt	100, 0.28	100, 0.28	100, 0.28	100, 0.28
Vitamin C	1,500, 4.17	1,500, 4.17	1,500, 4.17	1,500, 4.17
Binder (starch)	180, 0.50	180, 0.50	180, 0.50	180, 0.50
Total	10,740, 29.85	9,165, 25.47	8,115, 22.56	7,065, 19.64

₦ = Naira (Nigeria currency). $= US dollar

Table 4

Water quality parameters recorded in the experimental tanks

Parameters	Treatments diets			
	T_1	T_2	T_3	T_4
Temperature (^{0}C)	25.0 - 27.0	27.0 - 29.0	27.0 - 30.0	28.0 - 30.0
pH	6.5 - 7.0	6.8 - 8.0	7.0 - 7.5	6.8 - 7.0
DO (mg/l)	1.6 - 1.9	2.6 - 4.0	3.5 - 4.0	4.7 - 6.1
Ammonia (mg/l)	0.0 - 0.6	0.6 - 1.2	1.2 - 2.4	0.6 - 2.4

DISCUSSION

Shrimp meal which is rich in protein compares favourably with fish meal. This is in agreement with investigations of Cavalheiro *et al.* (2007). The present evaluation of *O. niloticus* fed with different inclusion levels of shrimp meal showed no significant differences among the diets ($p > 0.05$). Thus, no adverse effect was observed on the growth performance. This shows that shrimp meal could be included at different levels or better still replace fish meal without affecting the growth rate of Nile tilapia. This is in agreement with the study conducted by Cavalheiro, *et al*., (2007) who found out that silage shrimp head meal could completely replace fish meal in tilapia diets without having adverse effect on the growth. Jean *et al*. (2012) reported that shrimp shell meal could be used as a substitute for soybean meal up to 60% in a practical diet for tilapia fry. Leal *et al.* (2010) observed that shrimp meal can be compared with fish meal because of its high protein content of 53.09% which is close to that of fish meal. Plascencia-Jatomea *et al*. (2002) reported that 15% hydrolsed shrimp head meal could replace fish meal in the diet of Nile Tilapia. The feed conversion ratio (FCR) shows the efficiency of how fish can convert feed into body mass. It is usually influenced by various factors, some of which are: quality of feed given, the fish, pond water quality and feeding management. A number of study argued that a low FCR is an indicator of feed utilization efficiency of formulated feed i.e. it is 100% efficient whereas above 1 is not 100% efficient. This is due to the fact that less feed waste occurs when fish are fed manually in clear water. This means that Diet 1 which had the least FCR that is less than 1 was 100% efficient than the other diets. The feed conversion ratio (FCR) is a measure of effective utilization of feeds for the purpose of growth. The lower the FCR of a feed, the more efficient the feed is (Lovell, 1984; Agbebi *et al*., 2009).

The water quality parameters (temperature, DO, pH and ammonia) showed no significant difference among the diets ($p > 0.05$). The values recorded for water temperature are in the range of the requirement of Nile tilapia culture (25–32℃). The recommended DO for Nile tilapia is between 5.0 and 7.5mg/l. However, the DO values were quite low at some point in this study, low DO is said to affect the growth and feed conversion ratio. Survival and recovery are possible with short term exposure (less than 10mins) to DO concentrations as low as 0.8mg/l. Tilapia can survive in pH from 5–10 but grow best at pH 6–9. The value of the pH in this study is therefore in line with the recommended value in Nile tilapia diets. Ammonia has a more toxic form at high pH and less toxic form at low pH. The ammonia values in this study shows at some point was toxic to the fish and when it was noticed, the water was immediately changed. Shiau (2002) and El-Sayed (2006) reported that high levels of ammonia in the water are toxic for the fish. The high levels of ammonia may have caused high mortality during the experimental period. Tank culture system was used in the course of this study and an advantage of this is the fact that environmental conditions are easy to control and toxic levels can be easily detected and reduced.

An analysis of the cost implication of replacing fish meal with blood meal revealed that 100% blood meal inclusion was significantly cheaper compared to 100% fish meal diet (Aladetohun & Sogbesan, 2013). The cost implication of the inclusion of shrimp meal with fish meal in this study was not significantly different ($p > 0.05$). The treatment with the least cost was that containing 30% shrimp meal and 70% fish meal. This is in line with the findings of Nwanna (2003) that indicated that the best profit margin would be realized by replacing fish meal with

30% fermented shrimp head meal in the diet of *Clarias gariepinus*. From the cost analysis evaluation of the experimental diets D4 was economically efficient than the other diets.

Shrimp meal could be included at different levels to fish meal in the diet of Nile tilapia with no adverse effect on the growth performance. For the purpose of this study, the growth performance and cost implication were considered. Going by that, the treatment that was economically efficient and had a good growth performance, even though not the best performance, was that containing 30% shrimp meal and 70% fish meal (D4). Therefore, shrimp meal can be included in tilapia diets without having any negative effect on the growth performance and inclusion of shrimp meal (up to 30%) and fish meal (up to 70%) would be economically efficient.

Acknowledgements. The authors wish to thank the staff of the Aquaculture section of the Demonstration Farm, Faculty of Agriculture, University of Port Harcourt Choba, Rivers State, Nigeria.

REFERENCES

AGBEBI O.T., OTUBUSIN S.O., OGUNLEYE F.O., 2009, *Effect of different levels of substitution of fish meal with blood meal in pelleted feeds on catfish Clarias gariepinus (Burchell, 1882) cultured in net cages*. European Journal of Sciences Research, **31** (1): 6–10.

ALADETOHUN N.F., SOGBESAN O.A., 2013, *Utilization of blood meal as a protein ingredient from animal waste product in the diet of Oreochromis niloticus*. International Journal of Fisheries and Aquaculture, **5** (9): 234–237.

AOAC, 2005, *Official Methods of Analysis*. 18th ed. Association of Official Analytical Chemist. Maryland, USA.

CAVALHEIRO J.M.O., DE SOUZA E.O., BORA P.S., 2007, *Utilization of shrimp industry waste in the formulation of tilapia (Oreochromis niloticus Linnaeus) feed*. Bio Resource Technology, **98**: 602–606.

EBRAHIM M. S. M., ABOU-SEIF R. A., 2009, *Evaluation of growth, survival rate, feed utilization and economics of O. niloticus fed on diets containing alternative protein sources for fish meal*. *In*: Proceedings of the 2nd Global fisheries and aquaculture research conference, Cairo, October 2009, pp.: 609–620.

EL-SAYED A.F.M., 2006, *Tilapia culture*. Cambridge, USA. Edited by CABI publishing.

EL-SAYED A.F.M., TESHIMA S., 1992, *Protein and energy requirement of Nile tilapia, fry*. Aquaculture, **103**: 55–63.

ERICK O.O., JONATHAN M.M., YOSHITAKA S., ATSUSHI H., 2014, *Complete replacement of fish meal in the diet of Nile Tilapia (O. niloticus L.) grow-out with alternative protein sources. A review*. International Journal of Advance Research, **2** (8): 962–978.

FAO, 2013, *Food and Agriculture Organization. The state of food insecurity in the world. The multiple dimensions of food security*. Rome, 56 pp.

FAO, 2008, *Food and Agriculture Organization. State of World Aquaculture*. FAO Fisheries Technical Paper, Rome, 134 pp.

JEAN F., YI-THENG T., DIEGANE N., SHIN-SHYN S., 2012, *The effects of replacement of soybean meal by shrimp shell meal on the growth of hybrid tilapia (Oreochromis niloticus × Oreochromis aureus) reared under brackish water*. International Journal of Fisheries and Aquaculture, **4** (5): 85–91.

JAMABO N. A., 2017, *Understanding Aquaculture Business*. Publishers: Tynz Graphics Port Harcourt, Nigeria, 127 pp.

LEAL A.L.G., DE CASTRO P.F., DE LIMA J.P.V., DE SOUZA CORREIA E., DE SOUZA BEZERRA R., 2010, *Use of shrimp protein hydrolysate in Nile tilapia (Oreochromis niloticus) feeds*. Aquaculture International, **18**: 635–646.

LOVELL T.T., 1984, *Effect of size on feeding response of catfish in ponds*. Aquaculture magazine, **10**: 35–36.

MIKE R. D., CHAPMAN F. A., 2006, *The benefits of fish meal in aquaculture diets*. The Fish site.

MUNGUTI J. M., OGELLO E. O., LITI D., WAIDBACHER H., STRAIF M., ZOLLITSCH W., 2014, *Effects of Pure and Crude Papain on the utilization and digestibility of diets containing hydrolysed feather meal by Nile tilapia (Oreochromis niloticus L.).* International Journal of advanced research, **2** (6): 809–822.

NWANNA L. C., 2003, *Nutritional value and digestibility of fermented shrimp head waste meal by African catfish Clarias gariepinus*. Pakistan Journal of Nutrition, **2** (6): 339–345.

PLASCENCIA-JATOMEA M., OLVERA-NOVOA M.A., ARREDONDO-FIGUEROA J.L., HALL G.M., SHIRAI K., 2002, *Feasibility of fishmeal replacement by shrimp head silage protein hydrolysate in Nile tilapia (Oreochromis niloticus) diets.* Journal of Science Food and Agriculture, **82** (7): 753–759.

SHIAU S.Y., 2002, *Nutrient requirements and feeding of Finfish for aquaculture. Tilapia, Oreochromis spp. In:* Webster C.D. and Lim C. (eds.), CABI publishing, 27.

Received July 12, 2019

* *University of Port Harcourt, Department of Fisheries, Faculty of Agriculture, P.M.B.5323, Rivers State, Nigeria*
e-mail: nene.jamabo@uniport.edu.ng