OPEN ACCESS Freely available online

Journal of
Aquaculture Research & Development

Research Article

Partial Replacement of Plant Protein by Fish meal in the Diets of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758)

Egbal OA*, El-Nouman BA, Siham BM, Mona MA

School of Fisheries Science, Al-Neelain University, Sudan

ABSTRACT

Fishmeal is recognized by nutritionists as a high-quality, very digestible feed ingredient that is favored for addition to the diet of most farm animals, especially fish. In this study, plant protein was replaced by fish meal (FM) to determine the feasibility to the diets of juveniles of Nile tilapia fish *Oreochromis niloticus*. The experiment was conducted for 8 weeks in aquariums; each one was stocked with 15 fish of an average weight of 8.13 ± 1.3 g. The feeding trial was consisted of 4 treatments, first one without FM (control), the second, third and fourth a diet containing 4%, 8% and 12% FM respectively. The effect of each replacement level on the growth performance, feed utilization, and survival rate of the experimental fish was assessed. All the experimental diets were well accepted by the fish, and no mortality was observed during the experimental period. At the end of the experiment no different in survival rate, growth performance, across the dietary treatments ($P \geq 0.05$) but the difference was significant ($p \leq 0.05$) between control diet and the diet contain 12% FM. The percentage of the fish weight was 127.92 ± 3.57% for 12% FM diet, followed by 8% FM diet with 112.42 ± 3.34%, and then 4% FM diet with 103.29 ± 3.1%. The fish weight of the treatment without FM reached 80.44 ± 2.24%. The diet that contained 12% fishmeal is the best in terms of the rate of food conversion ratio (FCR) which recorded 2.60 ± 0.13, followed by 8% FM diet with 2.93 ± 0.16, and then 4% FM diet with 3.10 ± 0.17 and 3.78 ± 0.23for the diet without FM. The fish growth in the three treatments whose food contained FM was better than that of food did not contain it, despite containing the same protein content (35%). This indicates that fish meal improves the quality of protein, and the increase in growth was directly proportional to the increase in the percentage of FM in the diet.

Keyword: Nile Tilapia; Juveniles; Plant Protein; Fish meal; Growth performance

INTRODUCTION

Aquaculture is the fastest growing food producing sector globally. Aquaculture continues to grow more rapidly than all other animal food producing sectors, with an average annual growth rate for the world of 8.8% per year since 1970, compared with only 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period [1]. World aquaculture production sector is playing an important role in providing products which are very essential to human basic needs and also providing employment opportunities to many people worldwide [2].

Nile tilapia (*Oreochromis niloticus*) is one of the most commonly cultured fish species in fish farms. Nile tilapia (*Oreochromis niloticus*) is the second most chief farmed fish worldwide, and its production has expanded over the past decade because of its suitability for aquaculture, marketability, and stable market prices [3].

Tilapia is the common name given to three genera of fish in the family Cichlidae namely *Oreochromis*, Sarotherodon and Tilapia [4]. The genus *Oreochromis* includes Nile tilapia (*Oreochromis niloticus*), Mozambique tilapia, (*Oreochromis mossambicus*) and blue tilapia (*Oreochromis aureus*). The first trials of tilapia culture were recorded in Kenya in the 1920s [5]. Since then, tilapia culture has been established in many tropical and subtropical regions, and even in areas beyond their native ranges. Regionally, Tilapia is the most preferred cultured fish in East Africa but are the second most important cultured fish in the world after Carps [5,6]. Fish farming requires the provision of feed especially in intensive and semi-intensive systems and represents about 50-80% of the operational costs in an intensive system [7]. Special attention should be given to protein, the most expensive macro component of feed [8]. The dietary protein requirements of Tilapia based on the size/age, small tilapia have a higher dietary protein requirement and the requirement decreases as the fish grows bigger [9,10]. Protein

Correspondence to: Egbal OA, School of Fisheries Science, Al-Neelain University, Sudan, Tel: +249122149065; E-mail: egbalosman1@gmail.com; sharfi22222@hotmail.com

Received: 30 August, 2020, **Accepted:** October 07, 2020, **Published:** October 14, 2020

Citation: Egbal OA, El-Nouman BA, Siham BM, Mona MA (2020) Partial Replacement of Plant Protein by Fish meal in the Diets of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758). J Aquac Res Development 11: 10. doi: 10.35248/2155-9546.20.10.611

requirement of juvenile fishes is ranged from 35% to 55% for their optimal growth [11]. Any complete diet must contain some protein, but the nutritional value of the protein relates directly to its amino acid composition and digestibility. Fishmeal and any other feedstuff that contains protein can simply be thought of as a 'vehicle' for providing amino acids to the diet. Feeds containing fish meal outperform the diet that did not contain it can be traced back to the quality of the fish meal protein, which is not balanced in the necessary amino acids that meet the growth needs of fish [12]. Fish meal is rich in many important vitamins [13]. Fish meal is still generally the preferred protein source within compound aqua feeds for Tilapia because of its high nutritional quality and biological value to Tilapia. Several studies examining the effects of many ingredients on fish reproduction performance have obtained different results according to type of ingredients, composition of the diets and fish species [14-19].

Balancing nutrients in diets by using the minimum amount of fishmeal to meet specific amino acid requirements for fast growth and reproduction and reducing feed costs constitute one of the principal objectives in formulation of fish feeds. The objectives of this study to determining the optimum percentage of fish meal in diets of juveniles of Tilapia, and to filling the lack information of feeding at this stage of fish under local conditions in Sudan.

MATERIALS AND METHODS

Experimental fish and culture conditions

The study was conducted in the Wet Lab of the Faculty of Agricultural Technology and Fish Science, El-Neelain University for 8 weeks. The experiment consisted of four treatments conducted in four aquariums of equal size, each containing 72 liters of "tap water" water. Juveniles' fish were obtained from the college farm, and were adapted to the aquarium conditions and to the industrial food for a week. Then the fish were weighed and distributed to the experiment aquariums by 15 juveniles (mean weight 8.13 ± 1.3 g) per aquarium. The daily water temperature was recorded in all treatments in the morning. The aquariums were cleaned daily throughout the experiment period by removing the dirt and debris accumulated on the bottom, and replacing a third of the aquarium water with new water to reduce the concentration of excretory nitrogenous wastes of fish (ammonia). All experiment aquariums are ventilated with Aquarium Air Pumps and Air Stones.

Feed and Feeding

Fish were fed in 4 treatments with diets each containing 35% protein and differed in the percentage of Fish meal (Table 1), where one of them was left without fish meal (control) and the other three contained fish meal with ratio of 4%, 8%, 12% respectively. The Peanut seed, sesame seed, cotton seed, wheat bran, and Sorghum were used as plant protein feed. The feeds are manufactured on the fish farm, where the components of the various diets were individually ground, and then the calculated quantities and weighed using the "QE-400" scale (accuracy of a gram weight). The pellets were crushed into small particles (Crumbles) by an electric grill to match the grain size with the size of the fish used in the experiment. Fish were fed in all treatments in the beginning of the experiment at 4% of their body weight per day, but later the rate was increased to 6%, depending on the fluctuation in water temperature. The daily food ration was given in three doses. Analyzes of the different feeds used in the experiment were performed, where the moisture, ash, protein, fat, and carbohydrate ratios were identified (Table 2). All fish were weighed at the beginning of the experiment and then weekly to tracking the growth of fish and re-estimate the amount of food needed, according to the new weights of fish. At the end of the experiment, all fish were weighed, and then the percentage increase in fish weight, the daily growth rate, the food conversion ratio and the survival rate in the various treatments were calculated.

RESULTS

The results showed that the average weight of the fish in the control treatment, increased from 8.13 ± 1.3 g to 14.67 ± 1.3 g with an average weight 6.54 g at the end of the experiment. The average weight of fish for the diet 4% FM increased from 8.20 ± 1.3 g to 16.67 ± 1.6 g at an average 8.47 g. The average weight of fish for the diet 8% FM increased from 8.13 ± 1.3 g to 17.27 ± 1.4 g with an average 9.14 g. Whereas the weight of fish for the diet 12% FM increased from 8.13 ± 1.3 g to 18.53 ± 1.0 g with an average 10.40 g at the end of the experiment (Table 3).

The daily growth rate was 0.12 ± 0.01 g/day for the control diet, while it reached 0.15 ± 0.03 g/day for the diet 2, 0.16 ± 0.03 g/day for the diet 3 and 0.19 ± 0.06 g/day for the diet 4 (Figure 1). Accordingly, the percentage weight was 80.44 ± 2.24% for the control diet, 103.29 ± 3.1% for the diet 2, 112.42 ± 3.34% for the diet 3 and 127.95 ± 3.57% for the diet 4 (Figure 2). The food conversion ratio was 3.78 ± 0.23 for the control diet, 3.10 ± 0.17, 2.93 ± 0.16 and 2.60 ± 0.13 for the diets 2, 3, 4 respectively. The survival rate (%) for the four treatments it was 100% until the end of the experiment (Table 3).

The temperatures recorded daily in all aquariums were almost

Table 1: Components of the experimental diets (%).

Feed Ingredients	Treatments			
	I	II	III	IV
Peanut meal (42% protein)	34.56	32.24	29.92	27.60
Sesame meal (41.3% protein)	34.56	32.24	29.92	27.60
Cottonseed meal (26.90% protein)	17.18	16.12	14.96	13.80
Wheat bran (11.8% protein)	10.20	11.55	12.90	14.25
Sorghum (10.7% protein)	3.40	3.85	4.30	4.75
Fish meal (51.0% protein)	-	4.00	8.00	12.00
Total	100	100	100	100

Table 2: Proximate analysis of the ingredient feeds (%).

Feed stuff	Moisture	Crude protein	Crude fat	Ash	Carbohydrate
Peanut seed	5.7	41.95	7.95	6.20	38.20
Sesame seed	4.8	41.5	11.90	17.60	24.45
Cotton seed	7.0	26.90	7.80	4.65	53.65
Wheat bran	7.7	11.75	2.45	3.90	74.20
Sorghum	8.3	10.70	3.35	2.80	74.85
Fish meal	9.9	51.0	8.10	27.60	3.40

Table 3: Fish performance in 8-weeks.

Parameters	Diet 1 Control	Diet 2 4% FM	Diet 3 8% FM	Diet 4 12% FM
Initial weight(g)	8.13 ± 1.3	8.13 ± 1.3	8.13 ± 1.3	8.13 ± 1.3
Final weight (g)	14.67 ± 1.3	16.67 ± 1.6	17.27 ± 1.4	18.53 ± 1.0
Gain (g)	6.54 ± 0.2	8.47 ± 0.4	9.14 ± 0.3	10.40 ± 0.6
Gain (%)	80.44 ± 2.24	103.29 ± 3.1	112.42 ± 3.34	127.92 ± 3.57
Daily gain (g)	0.12 ± 0.01	0.15 ± 0.03	0.16 ± 0.03	0.19 ± 0.06
FCR	3.78 ± 0.23	3.10 ± 0.17	2.93 ± 0.16	2.60 ± 0.13
Survival (%)	100	100	100	100

Values are the mean ± S.D. of triplicate groups of each treatment

equal in one day, but they varied between successive days, with weekly average ranging between 22.3°C and 28.3°C (Figure 3).

DISCUSSION

Selection of feed ingredients is one of the most important factors for the formulation and commercial production of supplemental quality feed for any aquatic species [20]. Fish feed is among the most critically important factors influencing the ability of cultured fish to grow profitably in a fish farm [21]. From the study the fish were feed on the different type of the diets during the experiment period, were grew. The weight of the fish increased in all treatments that received food in varying proportions, this indicates that the fish accepted the food provided to them. The results of the study indicated that fish growth in the three treatments containing fish meal (4%, 8%, and 12%) was better than fish growth in the treatment without fish meal and was restricted to plant feed only (Figure 1). Wu GS, et al. [22] found that growth of hybrid tilapia (*O. niloticus* × *O. aureus*) offered diets devoid of FM was significantly lower ($P \leq 0.05$) than those fed diets containing FM because of poor palatability and lysine deficiency. This indicates the importance of fish food containing fish meal at this life stage, which does not find a way for natural food, and this is consistent with the findings of Nahla AA [23] who said that the growth of fingerlings of Nile tilapia increases if the fish meal is used within the diet. In the current study, the rate of growth is directly proportional to the increase in the percentage of fishmeal in the diet, the growth increased and reached 103.29 ± 3.1%, 112.42 ± 3.34%, and 127.92 ± 3.57% for the diets that contained fish meal 4%, 8%, and 12%, respectively, (Table 3). This means the juveniles and young fish still require fishmeal to grow at an optimal rate. The rate of fish growth in the various treatments that received food during the following weeks of the experiment remained consistent with the general trend that represented in the superiority of the diet containing fish meal 12%, followed by 8%, then 4%, and then the diet without fish meal (Figure 2). This is in agreement with the results of Soltan M, et al. [24], who found that growth and feed utilization were significantly affected when fishmeal replacement with plant protein mixture and with the results of Abdel-Tawwab M [25] who indicated that growth of Nile tilapia was improved significantly by increasing the dietary protein level from 35 to 45%.

From biological point of view, in this study the best diet contains 12% FM, followed by the diet that contains 8%, then the diet that contains 4%, and then the diet that was confined to vegetable feed only. In case of protein source (quality), growth is usually high when high quality source like fishmeal is used but on the other hand

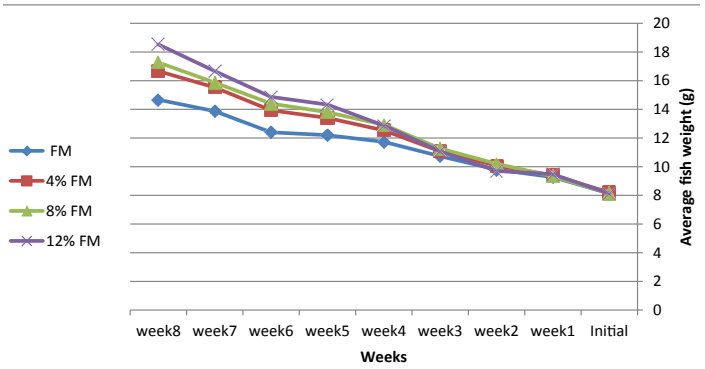

Figure 1: Changes in the weight (g) of juveniles fish fed different experimental diets.

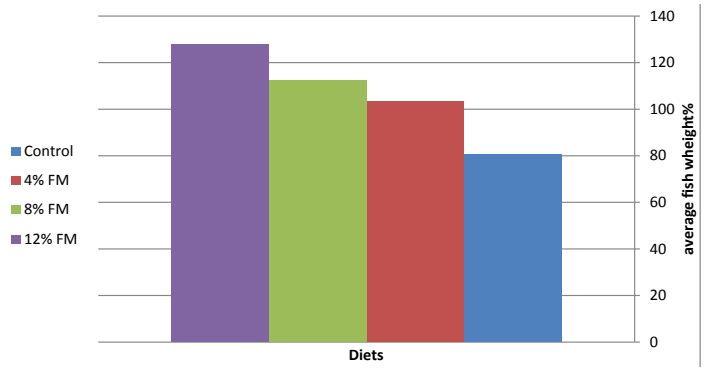

Figure 2: Final weight (%) of juveniles fish fed different experimental diets.

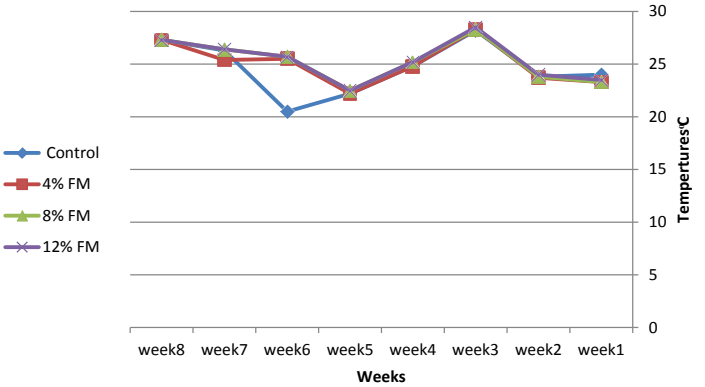

Figure 3: Temperature (°C) in the experimental aquariums during the experiment.

when low quality source such as plant protein is used, the reverse occurs [26]. This ranking is preference not only for growth rates but also in terms food conversion ratio (FCR) where the rate is graded from 2.6 ± 0.13 (as the best rate) to 2.93 ± 0.16, and 3.10 ± 0.17 for the fish feed on the diet contain 12%, 8%, 4% FM, respectively whereas the diet without fish meal recorded 3.78 ± 0.23 (Table 3). A low value of FCR is a good indicator of a high quality feed. FCR is related to dietary protein intake and its conversion into fish weight gain [20]. This result suggests that 12% replacement by fish meal could be used to feed Nile Tilapia fingerlings in order to obtain good feed utilization.

The survival rate is normally calculated at the end of the feeding trials to detect the impact of the formulated diets on the fish survivability. At the end of this experiment, all fishes in all treatments showed good survival. This indicates that the pelleted diet was highly palatable and well accepted by the fish. These rates

also remained in line with the significant fluctuation in water temperatures range between 22.3°C and 28.3°C (Figure 3), which necessitated a change in the daily feeding percentage of fish during the trial period.

CONCLUSION

The current study confirms the importance of protein quality for fish growth, because despite the containment of different treatments which it received the diets on one protein (35%), but they differed in their nutritional value of the fish, as evidenced by the different growth rates and rates of food conversion ratio. The study showed that the growth performance of Juveniles of Nile tilapia *Oreochromis niloticus* can be increased with higher content of fish meal in the diets. All The diets were highly palatable and well accepted by the fish and the diet contained 12% FM represent the best one. The growth of the Juveniles fish feed on the diet contained 12% FM increased significantly ($p < 0.05$) compared to the fish feed on the diet containing plant feed only.

REFERENCES

1. Tri NN. The utilization of soybean products in Tilapia feed–A review. 8th International Symposium on Tilapia in Aquaculture. 2008; 53-65.
2. FAO. Global Aquaculture Production Statistics for the year 2011. FAO, Fisheries and Aquaculture Department. 2013.
3. Dawood MA, Eweedah NM, Moustafa EM, Shahin MG. Synbiotic effects of *Aspergillus oryzae* and β-Glucan on growth and oxidative and immune responses of Nile Tilapia, *Oreochromis niloticus* Probiotics. Antimicro Pro. 2019; 1-12.
4. Santiago CB, Laron M. Growth and fry production of Nile tilapia *Oreochromis niloticus* (L) on different feeding schedules. Aqua Res. 2002; 33: 129 – 136.
5. El-Sayed AFM. Tilapia culture. CAB International, Wallingford, Oxfordshire UK. 2006; 256.
6. Dan NC, Little DC. Overwintering performance of Nile tilapia *Oreochromis niloticus* (L.) brood fish and seed at ambient temperature in Northern Vietnam. Aqua Res. 2000; 31: 485-493.
7. Oliveira-Cavalheiro J, Oliveira de Souza E, Bora P. Utilization of shrimp industry wastes in the formulation of tilapia *Oreochromis niloticus* (Linnaeus) feed. Biores Tech. 2007; 98: 602–606.
8. Lim C, Garcia JC, Yildirim-Aksoy M, Klesius PH, Shoemaker CA, Evans JJ. Growth response and resistance to *Streptococcus iniae* of Nile tilapia, *Oreochromis niloticus*, fed diets containing distiller's dried grains with soluble. J World Aqua Soc. 2007; 38: 231-237.
9. Abdel-Tawwab M, Ahmad MH. Effect of dietary protein regime during the growing period on growth performance, feed utilization and whole-body chemical composition of Nile Tilapia, *Oreochromis niloticus* (L.). Aqua Res. 2009; 40: 1532-1537.
10. Winfree R, Stickney RR. Effects of dietary protein and energy on growth, feed conversion efficiency and body composition of Tilapia (*Oreochromis aureus*) J Nutr 1981; 111: 1001-1012.
11. Ofojekwu PC, Onuoha PC, Ayuba VO. Substitute of cottonseed cake with palm kernel meal in diets for Nile Tilapia, *Oreochromis niloticus* (L.). J Aqua Sci. 2003; 18: 59-63.
12. Miles RD, Chapmen FA. The benefits of fish meal in aquaculture. FA 122 Document, Published by Dept. of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, Univ. of Florida, Gainesivlle, Fl. 2009.
13. NRC series. Nutrient requirements of domestic animals: Nutrient requirements of warm-water fishes. National Academy of Science, Washington D.C., USA. 1977.
14. El-Sayed AFM, Kawanna M. Effects of dietary protein and energy levels on spawning performance of Nile tilapia (*Oreochromis niloticus*) brood stock in a recycling system. Aqua. 2008; 280: 179–184.
15. Chen C, Sun B, Li X, Li P, Guan W, Bi Y, et al. N-3 essential fatty acids in Nile tilapia, *Oreochromis niloticus*: Quantification of optimum requirement of dietary linolenic acid in juvenile fish. Aqua. 2013; 416–417: 99–104.
16. Ghaedi A, Anamul KM, Hashim R. Effect of lipid levels on the reproductive performance of Snakehead murrel, *Channa striatus*. Aqua Res. 2016; 47: 983–991.
17. Masse D, Jean F, Abdoulaye, L, Saloum, J, Mariama, S, Diegane, N, et al. Effects of replacement of corn flour with different forms of *Boscia senegalensis* leaf meal on growth, feed efficiency and survival of *Oreochromis niloticus* FRY. Int J Fis Aqua Stu. 2020; 8: 153-156.
18. Zakeri M, Kochanian P, Marammazi, JG, Yavari V, Savari A, Haghi M. Effects of dietary n-3 HUFA concentrations on spawning performance and fatty acids composition of brood stock, eggs and larvae in yellowfin sea bream, Acanthopagrus latus. Aqua. 2011; 310: 388–394.
19. Zimba RD, Sussel FR, Batista de Oliveira KR, Segura JG, De Lima CG, Viegas EM. Reproductive performance of Lambaris fed with distillery dried grains. Boeletim Instituto de Pesca. 2017; 43: 20-34.
20. Koumi AR, Atse BC, Kouame LP. Utilization of soya protein as an alternative protein source in *Oreochromis niloticus* diet: Growth performance, feed utilization, proximate composition and organoleptic characteristics. A J Biotech. 2009; 8: 91-97.
21. Ochuko E, Peterson A. Factors affecting feed intake in cultured fish species: A review. Ani Res Int. 2017; 14: 2697-2709.
22. Wu GS, Chung WY, Lin SY, Chen SY, Huang CH. Effect of substituting de-hulled or fermented soybean meal for fish meal in diets on growth of hybrid tilapia, (*Oreochromis niloticus* × *Oreochromis aureus*). Journal of the Fisheries Society of Taiwan. 2004; 30: 291–297.
23. Nahla AA. Partial substitution of animal protein (Fish meal) by non-conventional ingredient in feeding of *Oreochromis niloticus* fingerlings. M.Sc. Thesis, Al-Neelain University, Sudan. 2008.
24. Soltan M, Hanafy MA, Wafa MI. Effect of Replacing Fish Meal by a Mixture of Different Plant Protein Sources in Nile Tilapia *Oreochromis niloticus* (L.) Diets. Global Veterinaria. 2008; 2: 157-164.
25. Abdel-Tawwab M. Interactive effects of dietary protein and live bakery yeast, Saccharomyces cerevisiae on growth performance of Nile tilapia, *Oreochromis niloticus* (L.) fry and their challenge against *Aeromonas hydrophila* infection. Aquacult Int. 2012; 20: 317-331.
26. Furuya W, Pezzato L, Barros M, Pezzato A, Furuya V. Use of ideal protein concept for precision formulation of amino acid levels in fish-meal-free diets for juvenile Nile tilapia *Oreochromis niloticus* (L.). Aqua Res. 2004; 35: 1110-1116.