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Optimum Crude Protein Requirement of the Fingerlings Nile Tilapia *(Oreochromis niloticus)*

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Abstract:
Fingerlings of Nile Tilapia (*Oreochromis niloticus*) were fed four isocaloric diets with different crude protein levels to determine the optimum protein requirement of the species. Eighty of apparently healthy tilapia (*Oreochromis niloticus*) fish, of average weight 10 g were divided into four groups, each of 20 fish. Four experimental diets were formulated with four levels of dietary protein 27, 30, 33 and 36% and constant digestible energy, 3000 kcal/kg diet. Significant differences ($P<0.05$) were recorded for the growth indices, weight gain and feed conversion and the highest values obtained for the fingerlings fed the 33% crude protein diet. Crude protein, fat and ash contents of tilapia's body were not significantly different among the fish fed the diets containing different protein levels. Protein retention, protein in gain and protein efficiency ratio of the fish fed diet containing 33% dietary protein were significantly ($P<0.05$) higher than other groups. It is therefore, concluded that 33% crude protein is optimal requirement in the diet of fingerlings Nile Tilapia (*Oreochromis niloticus*) with digestible energy 3000 kcal/kg diet.

Keywords:
Crude Protein, Growth Performance, Feed Conversion, Body Composition, Protein Utilization, Protein Efficiency Ratio, Nile Tilapia

1. Introduction

Tilapia is one of the most widely cultured fish in the world. Currently, farmed tilapia represents more than 75% of world tilapia production [1], and this contribution has been exponentially growing in recent years. Several factors have contributed to the rapid global growth of tilapia. Among these are: genetic improvement, ease of culture, highly adaptable to a wide range of environmental conditions [2]. Aquaculture is growing in Egypt and becoming an increasingly important source of fish available for human consumption. Tilapia is a highly popular aquaculture product because of its fast growth rate and ability to grow in extremely diverse and adverse conditions, so it is considered the most intensive cultivated freshwater fish in Egypt [3, 4]. Nutrition is the most expensive component in aquaculture, particularly intensive

culture, where it accounts for over 50% of operating costs. Protein is an important nutrient which provides amino acids required for synthesizing new tissue and/or replacing worn out tissues and also provides energy when other energy sources are limited. Dietary protein is, therefore, the most important nutrient considered when formulating fish feed to avoid any deficiency which may lead to poor growth and loss of weight. The protein component alone in fish diets represents about 50% of feed cost in intensive culture [5]. The nutrient requirements of tilapia depend on several factors, such as fish size, age, culture system and environmental conditions [6, 7]. Marty [8] reported that, the level of dietary protein producing maximum growth of *O. nitolicus* depends on the emergency diet and physiological state of the fish beside the level of food intake. Based on weight gain and body length, it could be suggested that 35% dietary protein is optimum for Nile tilapia using commercial ingredients [9]. Mohamed [10] revealed that a diet containing 32.68% protein fed at 10% feeding rate appears to be economical and suitable for *O. mossambicus* fingerlings. As an example, in Egypt, Khattab et al. [11] reported that the optimum dietary protein levels for growth was between 27 and 37% CP depending upon the culture location. In contrast, El-sayed and Kuwanna [12] found that increasing dietary protein from 30-40% CP produced significantly better growth for both female and male tilapia reared in mono-sex culture tanks. Many experiments have been conducted to determine the optimal protein in the diet for various fish species. Since, the protein requirements affected by and interact with many factors such as environmental conditions, specific physiology, energy and protein content of the diet as well as developmental stage of fish. So, the results of one experiment under a certain set of experimental conditions are not necessarily true for a different set of conditions [13]. The aim of the present study was to evaluate the effect of different protein levels on the growth performance, body composition and protein utilization of fingerlings Nile tilapia (*Oreochromis niloticus*) under the environmental condition of Egypt.

2. Materials and Methods

This experiment was conducted to test four different levels of protein for their ability to satisfy the needs of tilapia for optimal performance. The experiment lasted for 10 weeks, in addition to 2 weeks before starting used as an adaptation period to accustom the fish to the diets and the environmental conditions.

2.1. Fish and Management

Eighty (80 fingerlings) of apparently healthy Nile Tilapia (*Oreochromis niloticus*) fish, of average weight 10 g were purchased from fish hatchery were divided into four groups, each of 20 fish. The fish were stocked in clean glass aquaria; each was supplied by dechlorinated tap water, provided with continuous aeration and fluorescent lighting set at 12 h light: 12 h dark cycle. Water temperature was checked daily by using a thermometer to be ranging from 25 ℃ to 26 ℃, dissolved oxygen was measured at 3.9 mg/L by using oxygen meter and pH at 8.3 with pH meter.

2.2. Diets and Feeding

Four experimental diets were formulated with four levels of dietary protein 27, 30, 33 and 36% and constant digestible energy, 3000 kcal/kg diet as shown in Tab.1. For an adaptation period of 2 weeks, the fish were fed ad-libitum on the pelleted feeds under the arranged environmental conditions. After this period, the fish were fed twice daily at 9 am and 5 pm and the amount of feed consumed was weekly recorded.

In order to measure the body weight development in the different groups, the initial body weight at the start of the experiment and the final one at the end were recorded.

Table 1. *Ingredient content (%) and proximate composition (% dry weight basis) of experimental diet.*

Ingredients	% Inclusion			
	27%CP	**30%CP**	**33%CP**	**36%CP**
Yellow corn	43.31	36.51	29.71	22.93
Soybean meal	37.53	45.60	53.63	61.66
Fish meal	10.00	10.00	10.00	10.00
Corn oil	6.39	5.23	4.08	2.92
Ground limestone	1.68	1.61	1.56	1.51
Methionine	0.29	0.25	0.22	0.18
Premix	0.80	0.80	0.80	0.80
Proximate composition (%):				
Dry matter	91.09	91.09	91.09	91.09
Crude protein	27.00	30.00	33.00	36.00
Ether extract	9.57	8.31	7.06	5.80
Crude fiber	3.43	3.78	4.13	4.48
Calcium	1.29	1.29	1.29	1.29
Phosphorus	0.65	0.68	0.71	0.74
DE (Kcal/kg diet)*	3000	3000	3000	3000

* *DE: Digestible energy*

2.3. Chemical Analysis

Diets and fish samples were analyzed for moisture, crude protein, fat, fiber and ash according to the official methods of analysis [14]. The digestible energy content of the diets was calculated in Kcal/kg diet according to NRC [7].

2.4. Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) using the lines model of Statistical Analysis System [15], and differences ($P<0.05$) among treatments were tested using Duncan's multiple test [16].

3. Results and Discussion

3.1. Growth Performance of Tilapia Fish

The data on the growth performance of Nile tilapia (*Oreochromis niloticus)* fingerlings fed four different levels of protein (27%, 30%, 33% and 36%) is presented in Tab.2. The results showed significant differences among treatments in the growth indices; weight gain and feed conversion. The values recorded for fish fed 33% crude protein diet was significantly better and different from the other treatments. Further increases in the protein content of the diet did not produce any improvement in the growth performance of fish. Lowering the protein level, however, significantly ($P<0.05$) affected the growth performance of fish. The poorest feed conversion was observed at both lower protein (27% and 30%) and high protein level (36%). Dietary protein level significantly ($P<0.05$) affected body weight, weight gain, feed intake and feed conversion. The weight gain and feed conversion of the fish fed the diet containing 33% protein were significantly ($P<0.05$) higher than that of fish fed the diet of 36% protein, while no significant differences existed between other groups. It was found that as the protein level increased from 27 to 33%, the rate of gain was

increased, but increasing the level to 36% decreased the body gain. So, in spite of the recommendations previously [17,18] for protein levels, less than 30% and starting from 20%, this experiment indicated that the level should be more than 27% and up to 33% but no more and this coincides with that stated by Mohamed [10]. In support, Wilkinson [19] reported that, the growth rate of juvenile tilapia increased as dietary protein content was raised until a plateau reached at around 30-34%, further increased in dietary protein led to decline in growth rate thereafter. Weight gain improved as dietary protein level increased from 25 to 30 %, suggested that, the fish efficiently utilized the moderately high protein diets by converting them into body tissue protein [20]. Johnny [21] added range from 32-36% in fingerling feed and 28-32% in feed for larger than 40 grams body weight, the higher content was fed to small fish and gradually decreased with increasing size. On contrary, Nariman [22] revealed that, the best growth rate and food conversion ratio in Nile tilapia (*Oreochromis niloticus)* were obtained with 25% dietary protein level followed by 35% and 30% respectively, while the poorest growth rate and was recorded in the fish on the diet of 30% protein level. Also, the optimum growth of fry tilapia was obtained at 45% crude protein, while fingerling and advanced juvenile showed optimum growth performance with the 35% crude protein diet as reported by Mohsen et al [23]. Uwem [24] concluded that, a diet containing 40% protein would be adequate and suitable for tilapia growth and optimum performance. The considerable variations in the results recorded previously for optimum dietary protein requirements for maximum growth might be due to the variations in fish age and size, stocking density, protein quality, hygiene and environmental conditions or other unknown factors which mask the standardization of the parameters [13].

Table 2. *Performance of tilapia fish for different treatments.*

Parameters	Treatments			
	27%CP	**30%CP**	**33%CP**	**36%CP**
Initial body weight (g/fish)	10.30±0.02	10.05±0.01	10.10±0.05	10.03±0.03
Final body weight (g/fish)	44.50±1.30 ^{b}*	46.10±1.25 ^{b}	66.80±1.10^{a}	42.50±1.41 ^{b}
Weight gain (g/fish)	34.20±1.10 ^{b}	36.05±1.22 ^{b}	56.70±1.50 ^{a}	32.47±1.05 ^{b}
Feed intake (g/fish)	92.10±2.13 ^{b}	98.40±1.75 ^{b}	114.50±2.50 ^{a}	88.20±3.01 ^{c}
Feed conversion index	2.69±0.02 ^{b}	2.73±0.01 ^{b}	2.02±0.04 ^{a}	2.72±0.01 ^{b}

**Figures in the same row having the same superscripts are not significantly different (P<0.05)*

3.2. Body Composition of Tilapia Fish

Final dry matter, crude protein, fat and ash contents of fish tissues were not significantly affected by dietary protein (Tab.3). The dry matter of fish body was not affected significantly by dietary protein. This result was agreed with that reported with Wang et al. [25]. On contrary, the dry matter of fish tends to decrease with decreasing dietary protein [26]. Crude protein, fat and ash contents of tilapia in present study were not significantly different among the fish fed the diets containing different protein levels. These agreed with that found by Xie et al. [26] who reported that crude protein, crude fat and ash were not significantly affected by dietary protein levels when Nile Tilapia (*Oreochromis niloticus)* fed diets contained 15.8% to 35.6% protein levels. El-Saidy and Gaber [27] reported that, dietary protein levels (25-30%) did not affect whole body fat, protein and ash content of fish. This may be due to a number of factors including the diet formulation and ingredient composition. Ash content was unaffected by dietary protein levels and followed no particular trend. Similar result was presented by Khattab et al. [28] who reported that, ash content was

unaffected by protein level in Nile tilapia (*Oreochromis niloticus)* collected from fish ponds. On contrary, Wang et al. [25] reported that, both crude protein and lipid in fish body increased with increased dietary protein levels, while Millikin [29] reported that both fish body protein and lipid decreased with increased dietary protein.

Table. 3 *Body composition of Tilapia fish for different treatments.*

Parameters	Treatment				
	Initial	**27%CP**	**30%CP**	**33%CP**	**36%CP**
Dry matter %	25.9±1.15	32.1±1.10	32.20±1.10	31.9±1.20	30.5±1.41
Protein	4.15±1.15	20.01±1.10	20.35±1.22	20.29±1.03	19.70±1.05
Fat	6.10±0.10	6.81±0.25	6.71±0.01	6.51±0.30	6.50±0.01
Ash	3.99±0.12	5.62±0.01	5.50±0.18	5.90±0.05	5.94±0.06

3.3. Protein Parameters of Tilapia Fish

Protein efficiency ratio and protein utilization were commonly used as indicators of protein quantity, quality and amino acid balance in fish diet. The best protein deposition and protein efficiency ratio were observed at 33% protein level compared to other protein levels (Tab.4). Protein deposition, protein in gain and protein efficiency ratio of the fish fed diet containing 33% dietary protein were significantly ($P<0.05$) higher than other groups. According to Jauncey [30], after the optimum level, the excess protein was delaminated and excreted and energy for growth was utilized for this process. Thus, after the optimum protein level (i.e. 33% in the present study) there was a possible reduction in the dietary energy available for growth. Fagberno and Akegbejo-Samsons [31] also suggested that excess protein in relation to energy could reduce growth due to metabolic demands of nitrogen excretion, rather than for protein deposition. Results showed that protein efficiency ratio, protein utilization and protein intake were significantly affected by protein level in diets. This indicated that protein utilization decreased with increasing dietary protein levels in diets. These results may be due to the fact that major part of weight gain is related to the deposition of protein, and the protein accretion was a balance between protein anabolism and catabolism as reported by Uwem [24].

Table 4. *Protein utilization of Tilapia fish for different treatments.*

Parameters	Treatments			
	27%CP	**30%CP**	**33%CP**	**36%CP**
Protein intake (g/fish)	24.87±1.10 ^{c}*	29.52±1.50 ^{b}	37.79±2.05 ^{a}	31.75±2.01 ^{b}
Protein deposition (g/fish)	7.44±0.35 ^{b}	7.92±0.40 ^{b}	12.09±0.62 ^{a}	6.91±0.28 ^{b}
Protein utilization (%)	23.56±1.70 ^{a}	21.00±1.50 ^{a}	16.25±1.10 ^{b}	17.48±1.15 ^{b}
Protein in gain (g/kg)	6.48±0.49 ^{b}	7.34±0.35 ^{b}	11.50±0.79 ^{a}	6.40±0.60 ^{b}
Protein efficiency ratio	1.38±0.05 ^{ab}	1.22±0.08 ^{b}	1.50±0.02 ^{a}	1.02±0.01 ^{c}

**Figures in the same row having the same superscripts are not significantly different ($P<0.05$)*

4. Conclusions

Dietary protein level significantly influenced the growth of Nile tilapia (*Oreochromis niloticus)* and the best results were obtained with a dietary protein level of 33% in respect of weight gain, feed conversion ratio, protein efficiency ratio as well as survival. So, diet containing approximately 33% protein might be acceptable protein percentage for production of fingerlings Nile tilapia (*Oreochromis niloticus*) with digestible energy 3000 kcal/kg diet under the environmental condition of Egypt.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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