

Effect of Replacing Fish Meal in Fish Diet with Shrimp by-Product Meal on Growth Performance, Feed Utilization, Length-Weight Relationship and Condition Factors of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758)

Efecto de Reemplazar la Harina de pescado en la Dieta de Pescado por Harina de Subproducto de Camarón sobre el Rendimiento del Crecimiento, la Utilización del Alimento, la Relación Longitud-Peso y los Factores de Condición de la Tilapia del Nilo, *Oreochromis niloticus* (Linnaeus, 1758)

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ELSHAER, F. M.; AZAB, A. M. & EL-TABAKH, M. A. M. Effect of replacing fish meal in fish diet with shrimp by-product meal on growth performance, feed utilization, length-weight relationship and condition factors of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758). *Int. J. Morphol.*, 40(1):261-269, 2022.

SUMMARY: The present work aimed to study the effect of replacing fish meal (FM) in the fish diet with shrimp by-product meal (SBM) on the growth performance parameters of the Nile Tilapia, *Oreochromis niloticus*. A total of 200 specimens of monosex *O. niloticus* fries were obtained from a private fish farm at Kafr El-Sheikh Governorate. They were transported to the fish laboratory at the Animal House of Zoology Department, Faculty of Science, Al-Azhar University. After two weeks for acclimation, the fish were divided into 5 groups, 2 replicates for each group (20 fish in each replicate). The five experimental diets were: C: control group with 20 % fish meal (FM) and 0 % shrimp by-product meal (SM); T1, T2, T3, and T4 FM was replaced with SBM as 25 %, 50 %, 75 % and 100 %, respectively. Results indicated that the highest final length, growth in length, length gain, daily length gain and other growth performance parameters including the relationship between length and weight and condition factors of *O. niloticus* were recorded in T4 group (fed diet in which fish meal was completely replaced with shrimp by-product meal); while, their lowest values were recorded in control group. On the other hand, feed utilization parameters (feed intake, food conversion ratio, the maximum values of feed efficiency ratio and protein efficiency ratio) were recorded in T4 group and the minimum values were recorded in T3 group (fed diet in which 75 % of fish meal was replaced with shrimp by-product meal).

KEY WORDS: Fish diet; Fish meal; Nile Tilapia; *Oreochromis niloticus*; Shrimp by-product meal.

INTRODUCTION

The importance of fish as a food source is growing in tandem with rising demand, particularly for animal protein. Establishment fish farms have received a lot of attention. These farms may be able to help meet some of the demand for animal protein sources used by humans (El-Kalla *et al.*, 2001; Azab *et al.*, 2005). In intensive culture, fish feed is the most expensive operating cost component, accounting for more than half of all expenditures (El-Sayed, 1999, 2004). This cost is mostly determined by protein levels, ingredient source and type, and manufacturing processes (Glencross *et al.*, 2007).

Aquaculture produced 171 million tons of fish products worldwide, the most of which was for human consumption (Food and Agriculture Organization, 2018). Over the previous three decades, aquaculture production has risen about 12-folds, providing customers with a constant supply of high-quality seafood (Food and Agriculture Organization, 2016). The rising need for fish diets has come from the fast rise of aquaculture output. The supply of conventional fish diet components, such as fish meal (FM), has not risen in tandem with demand, necessitating the use of other protein sources (Naylor *et al.*, 2009).

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Many researchers have investigated the use of plant ingredients to substitute fish meal in fish diets (Jalili *et al.*, 2013; Jobling, 2015; Yusuf *et al.*, 2016; Solomon *et al.*, 2017; Adekoya *et al.*, 2018; Bos-Nyákné *et al.*, 2018; & Lazzarotto *et al.*, 2018). However, plant protein has low protein content, high fiber content, amino acid imbalance, poor palatability, and presence of anti-nutritional elements all restrict its usage (Tibbetts *et al.*, 2006).

Many other researchers looked into replacing fish meal in fish diets with animal ingredients, including poultry by-product meal in sea-bass, *Dicentrarchus labrax* diets (Srouf *et al.*, 2016), larvae meal in *Sparus aurata* diets (Piccolo *et al.*, 2017), insect meal in *Dicentrarchus labrax* diets (Reyes *et al.*, 2020), and zooplankton meal in *Dicentrarchus labrax* diets (Hassan *et al.*, 2020).

For Northern pink shrimp (NPS, *Pandalus borealis*) and spotted shrimp (SS, *Trachypena curvirostris*) collected in Tongyeong, Korea, the components and nutritional quality of processing by-products (heads, shells and tails) were studied (Heu *et al.*, 2003); and they discovered that these inedible portions of shrimp make up around half of the capture, and that these inedible pieces are eliminated during processing. They came to the conclusion that the rapid expansion of the fast-food sector has boosted shrimp consumption. As a result of unregulated dumping, increased production of inedible portions of shrimp (such as heads, shells and tails) is generating environmental concerns.

So, the focus of present study is to evaluate the effect of replacing fish meal in fish diet with shrimp by-product meal on growth performance metrics, feed consumption, food conversion ratio, feed utilization, length-weight relationship and condition factors of the Nile Tilapia (*Oreochromis niloticus*).

MATERIALS AND METHOD

Experimental fish: A total of 200 specimens of monosex Nile Tilapia (*Oreochromis niloticus*) fries, with a good

condition, were obtained from a private fish farm at Kafr El-Sheikh Governorate. All fingerling fish specimens were nearly similar in length (3.91 ± 0.37 cm) and in weight (2.26 ± 0.42 g). Fish were put in large plastic bags, each containing approximately 20 L of water and a lot of oxygen. They were transported to the fish laboratory at the Animal House of Zoology Department, Faculty of Science, Al-Azhar University. In the laboratory, fish were acclimatized for one week in well aerated large glass tanks (100x50x50 cm). Fish were fed daily on a commercial fish diet.

Experimental diets: The main ingredients of experimental fish diet were bought from fish diet factory at 6th of October City. But the shrimp by-product meal (SM) was prepared from the of shrimp head (cephalothorax) as a by-product of shrimp meat processing. These shrimp heads were dried and grind giving a dry powder of shrimp meal.

The analyzed proximate composition of the different ingredients, as well as the shrimp by-product meal, used in the control and different experimental diets were analyzed according to the standard methods of Association of Analytical Chemists (1990).

The composite composition revealed that the crude protein, crude lipids, crude fibers and ash in shrimp by-products (cephalothorax) of the Pacific white-legs shrimp, *Litopenaeus vannamei* were 53.9 ± 0.12 , 15.6 ± 0.43 , 17.3 ± 1.05 and 20.1 ± 0.24 , respectively. The composition and chemical analysis of the experimental diets were recorded and presented in Tables I and II.

Fish grouping. After acclimation, the fish were divided into 5 groups in 10 plastic aquaria (100 x 30 x 40 cm) with stocking density of 20 fish / aquarium (2 replicate aquaria were assigned for each experimental group). Water temperature range was 20-24°C. The five fish groups were fed by different five diets which prepared by replacing fish meal (FM) content in the diet by shrimp by-product meal (SM) as in Table II.

The experimental diets were formulated to contain approximately 30 % crude protein. Total shrimp by-product meal and fish meal (animal protein), Soybean meal (plant protein) were used as protein sources (Tables I and II). The experimental diets were also contained wheat, yellow corn and fish oil as energy sources. Vitamin and mineral premixes were added to each experimental diet.

Table I. The proximate composition of the different ingredients used in different experimental diets.

Ingredients	Protein	Lipids	Fibers	Ash
Yellow maize	7.7	3.2	2.3	5.32
Soybean	44.0	1.5	7.3	8.07
Fish meal (FM)	62.3	13.8	9.7	7.00
Shrimp bi-product meal (SM)	53.9	15.6	17.3	20.1
Wheat bran	15.0	4.0	11.0	5.79
Vitamins & Minerals.	--	--	--	--
Fish oil	--	100.0	--	--

Table II. Ingredients composition (%) and proximate analyses of the control and different experimental diets.

Ingredients (%):	C	T1	T2	T3	T4
Yellow maize	24	23	22	21	20
Soybean	22	22	22	22	22
Fish meal (FM)	20	15	10	5	0
Shrimp bi-product meal (SM)	0	6	12	18	24
Wheat bran	30	30	30	30	30
Minerals & vitamins	2	2	2	2	2
Fish oil	2	2	2	2	2
Total	100	100	100	100	100
Proximal composition (%):					
Dry matter	94.5	95.1	94.3	94.9	93.8
Crude protein	28.49	29.57	29.61	29.65	29.70
Crude lipid	7.06	7.31	7.53	7.74	7.95
Crude fibers	7.40	8.03	8.56	9.09	9.62
Ash	6.19	6.99	7.79	8.60	9.40

Fish were fed twice daily, six days a week at a fixed feeding rate of 5 % of the body fish weight (dry feed/ day). The feeding rate adjusted at weekly intervals, where 10 fish were randomly selected from each experimental group, weighed and the average fish weight was obtained; the weekly feed intake (g feed/fish /week) was calculated for each group. After removing the wastes (diet and excreta) 1/2 of the water volume for all aquaria was weekly replaced with de-chlorinated fresh tap water

Growth performance measurements: The experiment was conducted for 15 weeks (105 days). Length (L) and weight (W) of 10 randomly sampled fish from each treatment were weakly recorded as well as their initial length (LI) and initial weight (WI). Final length (LF) growth in length (GL), length gain (LG), daily length gain (DLG), final weight (WF), weight gain (WG), daily weight gain (DWG), growth in weight (GW), specific growth rate (SGR), feed intake (FI) and food conversion ratio (FCR) in *O. niloticus* were determined according to Recker (1975) and Castell & Tiews (1980) as following equations

- Length gain (cm/fish) = final length (LF) - initial length (LI)
- Daily length gain (m/fish/day) = LG (m)/ duration period (10 days)
- Growth in length (%) = {LG (cm) / LI (cm)} x 10
- Weight gain (g/fish) = WF (g)-WI (g)
- Daily weight gain (mg /fish/day) = WG (mg)/ duration period (days)
- Growth in weight (%) = {(WG (g) / WI (g)) x 10
- Specific growth rate (% / day) = (LnWF- Ln WI)* 100/ experimental day
- Total Feed intake (g feed/fish) = S {weekly W *(daily feeding rate *6)}
- Food conversion ratio = FI (g) / WG (g)

- Feed efficiency ratio (FER) = Weight gain (g) / Feed intake (g)
- Protein efficiency ratio (PER) = Total weight gain (g)/ Total protein intake (g)
- Total Protein intake (TPI) = feed intake (g) X Protein % in the diet/100.

Length-weight relationship:

Length-weight relationship of the two species was estimated by using the power equation of logarithmic modification according to the following equation:

$$\text{Log } W = a \pm b \log L \quad (\text{Lagler, 1956})$$

Where: W = Fish weight (g); L = Fish length (cm); a and b = Constants, whose values are estimated by the least square method.

Condition factors:

Condition factor (K) and relative condition factor (Kn) were calculated from the following equations:

$$K = W * 100 / L^3 \quad (\text{Hile, 1936})$$

$$Kn = W / W^{\wedge} \quad (\text{Le Cren, 1951})$$

Where: L = Fish length (cm); W = Fish weight (g); W[∧] = Calculated weight estimated from the length-weight relationship

Statistical analysis: The obtained results were statistically analyzed using SPSS (version 16) for one-way analysis of variance. Differences between individual treatments were tested with Duncan Multiple range test at probability level of 5 % when T-test was significant.

RESULTS

Effect of FM replacement with SBM on fish growth performance:

Final length (cm) and growth in length (%): Results in Table III showed that, Nile Tilapia, *Oreochromis niloticus*, fed on different feed rations exhibited great variations in body length. The highest average body length (12.05 ± 2.08 cm) was recorded in T4 (diet containing 0 % FM+24 % SM), representing the highest growth in length (208.1 ± 53.21 %). While, the lowest average body length (10.56 ± 1.83 cm) was recorded in C group (fed diet containing 20 % FM+0 % SM), representing also the lowest growth in length (170.0 ± 46.92 %).

Length gain (cm/fish): Results showed that the Nile Tilapia specimens exhibited greatly variation in length gain. The greatest average of length gain (8.14 ± 2.08 cm) was recorded in T4 group (fed on diet containing 0 % FM+24 % SM) and the lowest average of length gain (6.65 ± 1.83 cm) was recorded in C diet containing 20 % FM+0 % SBM; followed by (6.70 ± 1.95 cm) for T1 group fed on diet containing 15 % FM+6 % SM (Table III).

Daily length gain (m/fish/day): The highest average daily length gain of *O. niloticus* (774.8 ± 198.13 m/fish/day) was recorded in T4 and the lowest length gain (633.1 ± 174.73 m/fish/day) was recorded in C group (Table III).

The final length, growth in length, length gain and daily length gain had statistically significant differences ($P < 0.05$) in T2, T3 and T4 versus control group (Table III).

Final weight (g) and growth in weight (%): Results in Table IV showed that Nile Tilapia fed on different feed rations exhibited great variations in the total body weight. The highest average body weight (49.95 ± 24.87 g) was recorded in T4. While, the lowest average body weight (33.77 ± 16.67 g) was recorded in C. Also, the highest growth in weight (2110 ± 1100.3 %) was recorded in T4; while the lowest growth in weight (1394.5 ± 737.6 %) was recorded in C group.

Total weight gain (g/fish): The greatest total weight gain (47.7 ± 24.87 g) was recorded in T4, followed by T3 and the lowest weight gain (31.5 ± 16.67 g) was recorded in C group (Table IV).

Table III. Growth items in length (cm) of Nile Tilapia, *O. niloticus* fed on different feed rations at the end of the experimental period.

Growth items	Feed rations)Treatments(
	Control (C)	T ₁	T ₂	T ₃	T ₄
Initial length range (cm)	3.5 – 4.9	3.7 – 4.8	3.7 – 4.8	3.7 – 4.8	3.7 – 4.8
Initial length average (cm)	3.91±0.37	3.91± 0.37	3.91± 0.37	3.91± 0.37	3.91± 0.37
Final length range (cm)	6.90 – 16.38	6.96 – 16.67	7.44 – 17.60	7.57 – 16.92	7.77 – 17.81
Final length average (cm)	10.56±1.83	10.61±1.95 ^{NS}	11.48±2.00*	11.64±1.92*	12.05±2.08*
Growth in length average (%)	170.0±46.92	171.3±49.85 ^{NS}	193.6±51.15*	197.7±49.18*	208.1±53.21*
Length gain average (cm/fish)	6.65± 1.83	6.70±1.95 ^{NS}	7.57±2.00*	7.73±1.92*	8.14±2.08*
Daily length gain average (/fish/day)	633.1±174.7	638.0±185.7 ^{NS}	721.0±190.5*	736.0±183.1*	774.8±198.1*

C: 20 %FM+0 %SM; T1: 15 %FM+6 %SM; T2: 10 %FM+12 %SM; T3: 5 %FM+18 %SM and T4: 0 %FM+24 %SM – Multiple Comparisons versus Control Group (NS: nonsignificant; *: significant at $P < 0.05$).

Table IV. Growth performance parameters in weight of Nile Tilapia, *O. niloticus*, fed on different feed rations, at the end of the experimental period.

Growth items	Treatments				
	Control (C)	T ₁	T ₂	T ₃	T ₄
Initial weight (g)	2.26±0.42	2.26±0.42	2.26±0.42	2.26±0.42	2.26±0.42
Final weight (g)	33.77±16.67	37.60±18.38 ^{NS}	39.52±19.41 ^{NS}	41.31±20.10*	49.95±24.87*
Growth in weight (%)	1394.5±738	1564±813 ^{NS}	1649±859 ^{NS}	1728±890*	2110±1100*
Weight gain (g/fish)	31.5±16.67	35.3±18.38 ^{NS}	37.3±19.41 ^{NS}	39.1±20.10*	47.7±24.87*
Average daily weight gain (mg/fish/day)	300.1±158.8	336.6±175.0 ^{NS}	354.9±184.9 ^{NS}	371.9±191.5*	454.2±236.8*
Specific growth rate (%/day)	2.48± 0.38	2.58±0.38 ^{NS}	2.63±0.38 ^{NS}	2.67±0.39*	2.84±0.43*
Feed intake (g/fish)	53.38	58.16	62.36	67.22	73.24
Feed conversion ratio	1.694	1.646	1.674	1.721	1.536
FER	0.590	0.607	0.597	0.581	0.651
PI	15.208	17.198	18.465	19.931	21.752
PER	2.072	2.055	2.018	1.959	2.192

C: 20 %FM+0 %SM; T1: 15 %FM+6 %SM; T2: 10 %FM+12 %SM; T3: 5 %FM+18 %SM and T4: 0 %FM+24 %SM

Daily weight gain (mg/fish/day): Results showed that *O. niloticus* specimens fed on different feed rations exhibited great variations in daily weight gain (DWG). The highest average daily weight gain (454.2 ± 236.82 mg/fish/day) was recorded in T4 and the lowest daily weight gain (300.1 ± 158.75 mg/fish/day) was recorded in C group (Table IV).

Specific growth rate (% / day): The specific growth rate (SGR) of *O. niloticus* fed on different feed rations exhibited great variations. The highest specific growth rate (2.84 ± 0.43 %) was recorded in T4, and the lowest specific growth rate (2.48 ± 0.38 %) was recorded in C group (Table IV).

All growth performance parameters {FW, GW, WG, DWG and SGR} showed that they were statistically significant increase in T3 and T4 than that of control group; while no significant differences appeared for these parameters in T1 and T2 versus control group.

Feed utilization:

Total feed intake (FI, g/fish) and Food conversion ratio (FCR): Results in Table IV showed that, the highest average feed intake (73.24 g/fish) was recorded in T4 (diet containing 0 % FM+24 % SM) and the lowest average of feed intake (53.38 g/fish) was recorded in C (diet containing 20 % FM+0 % SBM). Accordingly, the best food conversion ratio (1.536) was recorded in T4, while the bad food conversion ratio (1.721) was recorded in T3.

Feed efficiency ratio (FER) and Protein efficiency ratio (PER): Results in Table IV showed that, the highest feed efficiency ratio (0.651) was recorded in T4 (fed diet containing 0 % FM+24 % SM) and the lowest average of feed efficiency ratio (0.581) was recorded in T3 (fed diet containing 5 % FM+18 % SM). Also, the maximum value of protein efficiency ratio (2.192) was recorded in T4, followed by C (2.072). But, the minimum value of protein efficiency ratio (1.959) was recorded in T3.

Length-weight relationship and condition factors:

Length-weight relationship: The effects of different feed rations (C, T1, T2, T3 and T4) on length-weight relationship of Nile tilapia, *O. niloticus* were graphically represented in Figure 1, and they represented by the following equations:

$$\begin{aligned} \text{Log W} &= - 1.5562 + 2.8 \text{ Log L} && \text{(C group)} \\ \text{Log W} &= - 1.5830 + 2.8315 \text{ Log L} && \text{(T1)} \\ \text{Log W} &= - 1.5828 + 2.8153 \text{ Log L} && \text{(T2)} \\ \text{Log W} &= - 1.5390 + 2.788 \text{ Log L} && \text{(T3)} \\ \text{Log W} &= - 1.6649 + 2.9294 \text{ Log L} && \text{(T4)} \end{aligned}$$

Results of length-weight relationship showed that the growth of all groups was negative allometric where the values of b-constant were less than the ideal value (3). It was found that the growth of T4 group was nearly ideal where its b-value was 2.929.

The correlation coefficient “R2” for both control group and all experimental groups was more than 0.95, showing a very good correlation between length and weight (Fig. 1).

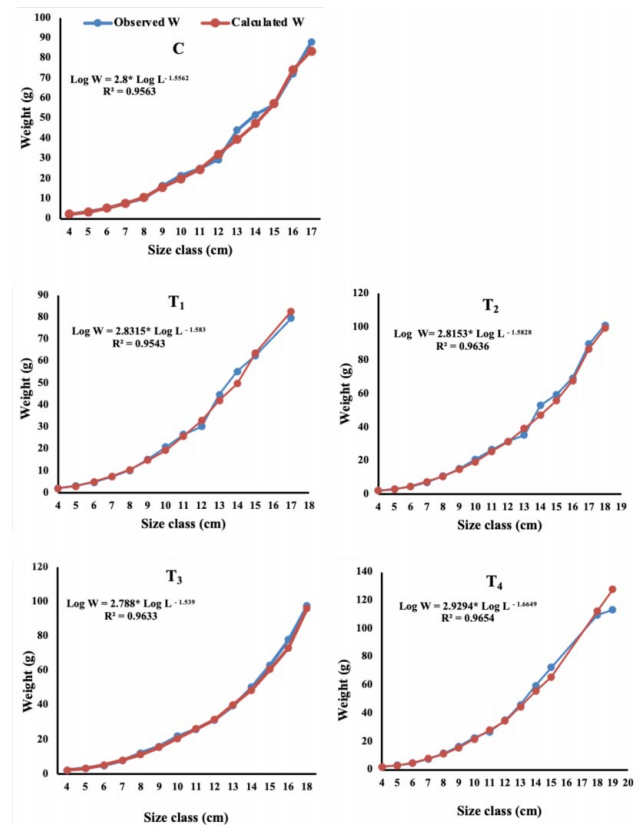


Fig. 1. Length-weight relationship in control and different experimental groups of Nile tilapia, during the experimental period

Condition factors: Results of the composite coefficient of condition (K) for the experimental groups of Nile tilapia, *O. niloticus* are given in Table V. Results revealed that this condition factor (K) is varied with the fish size in different feed rations. The highest value of the total condition factor (1.86 ± 0.135) was recorded for T4 group and the lowest value (1.79 ± 0.17) was recorded for the control group.

Results of the relative condition factor (Kn) for the experimental groups of Nile tilapia, *O. niloticus* is given in Table VI. Results revealed that the relative condition factor (Kn) is varied with the fish size in different feed rations.

Data revealed that, the composite coefficient “k” and the relative condition factor “kn” were statistically varied significantly ($P < 0.05$) with different experimental

groups. The gradual increases occurred in both “k” and “kn” and reached the highest significance for T4 (Tables V and VI).

Table V. Condition factor (K) of control and different experimental groups with different size classes of Nile tilapia, during the experimental period.

Size class (cm)	Control group C	Experimental groups			
		T1	T2	T3	T4
4	2.03 ± 0.32	1.98 ± 0.36	1.98 ± 0.36	1.98 ± 0.36	1.98 ± 0.36
5	2.1 ± 0.3	2.15 ± 0.25	2.05 ± 0.21	2.16 ± 0.23	2.08 ± 0.22
6	1.91 ± 0.38	1.79 ± 0.31	1.81 ± 0.35	1.86 ± 0.31	1.78 ± 0.34
7	1.9 ± 0.42	1.83 ± 0.43	1.75 ± 0.3	1.88 ± 0.45	1.85 ± 0.44
8	1.74 ± 0.45	1.79 ± 0.48	1.79 ± 0.41	2.01 ± 0.43	1.95 ± 0.39
9	1.84 ± 0.31	1.84 ± 0.27	1.77 ± 0.15	1.87 ± 0.19	1.96 ± 0.28
10	1.87 ± 0.32	1.89 ± 0.42	1.82 ± 0.34	1.86 ± 0.44	1.9 ± 0.37
11	1.75 ± 0.3	1.78 ± 0.32	1.73 ± 0.32	1.71 ± 0.3	1.73 ± 0.31
12	1.54 ± 0.22	1.57 ± 0.23	1.65 ± 0.26	1.68 ± 0.24	1.82 ± 0.41
13	1.83 ± 0.4	1.78 ± 0.43	1.45 ± 0.21	1.65 ± 0.27	1.85 ± 0.29
14	1.78 ± 0.17	1.85 ± 0.16	1.79 ± 0.35	1.68 ± 0.36	1.92 ± 0.36
15	1.6	1.61	1.67 ± 0.16	1.68 ± 0.06	1.96 ± 0.24
16	1.54 ± 0.1	--	1.59	1.69	--
17	1.65	1.55 ± 0.1	1.58	--	--
18	--	--	1.55	1.58 ± 0.07	1.72 ± 0.42
19	--	--	--	--	1.55
Total	1.79±0.170	1.80±0.163	1.73±0.158	1.81±0.166	1.86±0.135

Table VI. Relative condition factor (Kn) of control and different experimental groups with different size classes of Nile tilapia, during the experimental period.

Size class (cm)	Control group C	Experimental groups			
		T1	T1	T1	T1
4	1 ± 0.15	0.98 ± 0.17	1.01 ± 0.18	0.95 ± 0.17	1.02 ± 0.18
5	1.06 ± 0.15	1.09 ± 0.12	1.07 ± 0.11	1.06 ± 0.12	1.08 ± 0.11
6	1 ± 0.2	0.93 ± 0.16	0.97 ± 0.18	0.95 ± 0.15	0.94 ± 0.18
7	1.02 ± 0.22	0.98 ± 0.23	0.96 ± 0.16	1 ± 0.23	0.98 ± 0.23
8	0.95 ± 0.24	0.97 ± 0.26	1.01 ± 0.23	1.09 ± 0.23	1.04 ± 0.21
9	1.04 ± 0.17	1.02 ± 0.15	1.02 ± 0.09	1.04 ± 0.1	1.06 ± 0.15
10	1.07 ± 0.19	1.07 ± 0.24	1.07 ± 0.2	1.06 ± 0.25	1.04 ± 0.2
11	1.02 ± 0.17	1.02 ± 0.18	1.04 ± 0.19	0.99 ± 0.17	0.95 ± 0.17
12	0.91 ± 0.13	0.92 ± 0.13	1 ± 0.16	0.99 ± 0.14	1 ± 0.22
13	1.11 ± 0.24	1.05 ± 0.26	0.89 ± 0.13	0.98 ± 0.16	1.03 ± 0.16
14	1.09 ± 0.11	1.11 ± 0.09	1.12 ± 0.22	1.02 ± 0.22	1.07 ± 0.2
15	0.99	0.98	1.06 ± 0.1	1.04 ± 0.04	1.1 ± 0.13
16	0.97 ± 0.06	--	1.02	1.06	--
17	1.05	0.96 ± 0.06	1.03	--	--
18	--	--	1.01	1.01 ± 0.05	0.97 ± 0.24
19	--	--	--	--	0.88
Total	1.02 ± 0.055	1.01 ± 0.060	1.02 ± 0.054	1.02 ± 0.043	1.01 ± 0.062

DISCUSSION

The crude protein in shrimp by-products (cephalothorax) of the Pacific white-legs shrimp, *Litopenaeus vannamei*, was $53.90 \pm 12\%$ in the present

investigation, according to the composite composition. This is somewhat greater than the figure reported by Fernandes *et al.* (2013), who found that it would be $50.05 \pm 12\%$ crude

protein in dried shrimp cephalothorax of the same species. However, this finding is significantly greater than that of many previous researches (Heu *et al.*; Cavalheiro *et al.*, 2007; Ravichandran *et al.*, 2009). On the other hand, the protein content of *Penaeus indicus* ranged from 44.62 to 80.87 percent (Sambhu & Jayaprakash, 1994). They came to the conclusion that the elevated protein content in this species' smallest size groups might be due to enhanced protein synthesis during active development.

In the present study, T4 group (fed diet in which fish meal was completely replaced with shrimp by-product meal) had the highest averages for growth in length, length gain, and daily length gain, growth in weight, total weight gains, and daily weight gain, and specific growth rate of *O. niloticus*, while C group had the lowest averages (fed diet contains only fish meal). These findings are in line with the higher growth performance of sea bream, *Sparus aurata* fish fry fed copepods Mona *et al.* (2019), as well as the higher growth performance parameters of sea bass, *Dicentrarchus labrax*, fed a diet containing zooplankton meal rather than fish meal (Hassan *et al.*). This improved growth performance might be due to the greater protein levels found in shrimp, copepods, and zooplankton, where muscle growth is a result of protein synthesis (Liu & Xu, 2009).

One of the most fundamental characteristics of fish is the relationship between length and weight. The fish's weight increases in proportion to its length. Variations in the exponent "b" values of fish at different locations can be linked to differences in the habitat and location (Mekkawy *et al.*, 2007; Serajuddin *et al.*, 2013; Mabrouk, 2015; Ismail, 2018).

The present study showed that, the weight of *O. niloticus* increases at a rate that is larger than the cube of its length, indicating that the body weight changed fast as the body length increased. In addition, in all treatments, the actual and computed weights were almost identical. Many writers have found similar findings in various species (Khalaf-Allah, 2001; Farrag, 2008; Bahnasawy, 2009; Kumar *et al.*, 2013; Al-Zahaby, 2015; Ismail).

In the present study, the growth of *O. niloticus* is allometrically negative and has a low b value for T4 (completely fish meal replacing by shrimp by-product meal). This finding corresponds to the findings of the same experimental fish species (Bahnasawy; Al-Abssawy, 2010; Khalaf-Allah & Hassan, 2015; Ismail).

The present results showed that, the values of the composite coefficient of condition "k" varied greatly between *O. niloticus* size classes and treatments. These findings were verified by Al-Abssawy.

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ELSHAER, F. M.; AZAB, A. M. & EL-TABAKH, M. A. M. Efecto de reemplazar la harina de pescado en la dieta de pescado por harina de subproducto de camarón sobre el rendimiento del crecimiento, la utilización del alimento, la relación longitud-peso y los factores de condición de la tilapia del Nilo, *Oreochromis niloticus* (Linnaeus, 1758). *Int. J. Morphol.*, 40(1):261-269, 2022.

RESUMEN: El presente trabajo tuvo como objetivo estudiar el efecto de sustituir la harina de pescado (HP) en la dieta del pescado por harina de subproductos de camarón (HSC) sobre los parámetros de rendimiento de crecimiento de la Tilapia del Nilo, *Oreochromis niloticus*. Se obtuvieron un total de 200 especímenes de monosexo de *O. niloticus* de una piscifactoría privada en la gobernación de Kafr El-Sheikh. Fueron transportados al laboratorio de peces en el Departamento de Zoología de la Facultad de Ciencias, de la Universidad Al-Azhar. Después de dos semanas de aclimatación, los peces se dividieron en 5 grupos: Se realizaron dos repeticiones para cada grupo (20 peces en cada repetición). Las cinco dietas experimentales fueron: C: grupo control con 20 % de harina de pescado (HP) y 0 % de harina de subproductos de camarón (HSC); T1, T2, T3 y T4 FM se reemplazó con HSC con 25 %, 50 %, 75 % y 100 %, respectivamente. Los resultados indicaron que la longitud final más alta, el crecimiento en longitud, la ganancia de longitud, la ganancia de longitud diaria y otros parámetros de rendimiento del crecimiento, como además la relación entre la longitud y el peso, y los factores de condición de *O. niloticus*, se registraron en el grupo T4 (con una dieta reemplazada con harina de subproducto de camarón); mientras que, sus valores más bajos se registraron en el grupo control. Por otro lado, los parámetros de utilización del alimento (ingesta de alimento, índice de conversión de alimento, los valores máximos de índice de eficiencia alimenticia e índice de eficiencia proteica) se registraron en el grupo T4 y los valores mínimos se registraron en el grupo T3 (alimentación con dieta en la que el 75 % de la harina de pescado fue reemplazada por harina de subproductos de camarón).

PALABRAS CLAVE: Dieta de pescado; Alimento de pescado; Tilapia del Nilo; *Oreochromis niloticus*; Harina de subproductos de camarón.

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