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EFFECT OF VARYING PROTEIN, ENERGY AND PROTEIN TO ENERGY RATIO ON GROWTH, FEED EFFICENCY AND BODY COMPOSITION OF NILE TILAPIA, *OREOCHROMIS NILOTICUS*

BY

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ABSTRACT

A 8 week feeding trial was conducted on Nile tilapia, *Oreochromis niloticus* fingerlings with an average initial body weight of 15.30±0.32 g. Nine experimental diets of 20, 25 and 30% protein contents and within each level, three levels of metabolizable energy (ME) 300, 330 and 360 kcal ME/100 g representing nine P/E ratios ranged between 55.5 to 98.9 mg prot/kcal were tested. The obtained results indicated that:

- Increasing dietary protein content increased all growth parameters (body weight, weight gain, body length, condition factor and specific growth rate) but increasing dietary energy contents showed the opposite trend. At all nine P/E ratios the best growth parameters (body weight, body length, condition factor, weight gain and specific growth rate) were obtained with the diet containing 30% crude protein and 300 kcal ME/100 g (P/E ratio of 98.9 mg protein/kcal) but the diet contained 20% crude protein and 360 kcal ME/100 g (P/E ratio of 55.5) had the lowest one.
- It is also found that increasing protein level improved feed intake and feed conversion ratio but decreased protein efficiency ratio and dietary energy level had the opposite effect. Also, the diet contained P/E ratio of 98.9 mg protein/kcal improved feed intake and feed conversion ratio. Protein levels tested in the present study showed insignificant effect on most carcass characteristics. Although, energy level in the experimental diets had insignificant effect on carcass traits and proximate analysis of the experimental fish, it was found that, increasing dietary protein for tilapia decreased protein and fat contents in tilapia bodies.
- Generally, based on the present results the experimental diet contained P/E ratio of 98.9 considered the most suitable diet for Nile tilapia reared in tanks.

INTRODUCTION

The optimum protein level for Nile tilapia (*O. niloticus*) has been the aim of many research studies in order to increase farm profitability. A wide range of 25-56% dietary crude protein level has been reported to be the protein level inducing maximum weight gain (Winfree and Stickney, 1981, Jauncey, 1982; Shiau et al., 1987; Siddiqui et al 1988; El-Dahhar, 1994 and Wu et al., 1995). Variation in protein requirements is due to different reasons; fish size, feeding rates, environmental conditions, protein and energy quality and their concentration in the diet (Lovell, 1989). Jauncey and Ross (1982) found that optimum dietary protein level for fish was affected by balance between dietary protein and dietary energy, amino acid, composition, digestibility of

dietary protein, the physiological status of the fish and the level of food intake.

Fish require energy for growth, activity and reproduction. The rate of energy utilization is called metabolic rate. Factors affecting the metabolic rate in fish are temperature, species, age or body size, activity, physical condition, body functions and water chemistry parameters such as oxygen or carbon dioxide saturation, pH and salinity (Wilson 1977). Providing the exact amount of energy in the diet of fish is important, because if the useful energy is too high the consumption of protein and other nutrients may be restricted and growth is retarded. Furthermore excess of energy may produce fatty fish. This can be undesirable especially if it reduces the dress-out yield and decrease the durability of the frozen fish (Lovell, 1989). On the other hand, when the diet is deficient in energy, dietary protein will be used as an energy source (Cowey, 1980). The more protein is used for energy, the more ammonia is produced, and the more energy is lost as heat (Cho and Kaushik, 1985), consequently, less protein will be retained in the fish body. Therefore, the proper balance between dietary protein and energy is therefore essential in fish feed formulation. The aim of the present investigation is to find the optimum protein, energy and P/E ratio required for the best growth performance, feed utilization, carcass analysis and proximate analysis of Nile tilapia.

MATERIALS AND METHODS

The present study was carried out at the Laboratory of Aquaculture Research, Faculty of Agriculture at Moshtohor, Zagazig University (Banha branch). Eighteen rectangular aquaria 100×40×50 cm (200 liter for each) were used in this study, represent 9 treatments (2 replicates for each treatment), and each aquarium was stocked with 36 fish (15.30± 0.32g).

Formulation of the experimental diets are illustrated in Table (1). Fish were given the pelleted diets (3 mm in diameters) at a daily rate of 4% of total biomass during the experimental period 6 day/week (twice daily at 9.00 am and 3.00 pm) and the amount of feed was bi-weekly adjusted according to the changes in body weight throughout the experimental period (8 weeks).

Growth performance parameters were measured by using the following equations:

Condition factor (K) = $(W/L^3) \times 100$

Where, W = body weight in grams and L = body length in cm.

Specific growth rate (SGR) = $\frac{LnW2 - LnW1}{t} \times 100$

Where: Ln = the natural log; W_1 = initial weight; W_2 = the final weight in "grams" and t = period in days.

Weight gain (WG) = final weight (g) – initial weight (g)

Feed conversion ratio (FCR) = feed ingested (g)/weight gain (g)

Protein efficiency ratio (PER) = weight gain (g)/protein ingested (g)

At the end of the experiment, three fish were randomly taken from each aquarium and weighed and slaughtered. The weight of head, fins, viscera, bone, flesh, carcass and total by-products were recorded. All carcass components were measured according to Lovell (1981). Another three fish were also chosen at random from each aquarium and exposed to the chemical composition of whole fish body according to the methods of AOAC (1990).

The statistical analysis of data was carried out by applying the computer program, SAS (1996) by adopting the following model:-

$Y_{ijkl} = \mu + R_i + \alpha_j + B_k + (\alpha B)_{jk} + E_{ijkl}$,

Where:

Y_{ijkl} = the observation on the ijklth fish eaten the diet contained the kth energy level and jth protein level for the ith replicate; μ = overall mean, R_i = the effect of ith replicate; α_j = the effect of jth protein level; B_k = the effect of kth energy level; $(\alpha B)_{jk}$ = the effect of interaction between jth protein level and kth energy level and E_{ijkl} = random error assumed to be independently and randomly distributed (0, δ^2 e).

RESULTS AND DISCUSSION

Body weight, body length and condition factor:

As presented in Table (2) averages of initial body weight (BW) ranged between 15.22 to 15.50 g, body length (BL) 9.62 to 9.77 cm and condition factor (K) 1.64 to 1.72 with insignificant differences among the nine experimental groups, indicating the complete randomization of fish distribution among the nine treatments. At the experimental end it is obvious that, regardless dietary energy level, increasing dietary protein contents significantly (P<0.001) increased values of BW, BL and K. These results may indicate that, protein requirements for Nile tilapia reared in tanks lie above 25% crude protein and these results are in complete accordance with those reported by Cruz and Laudncia (1976). They showed that the dietary protein requirements of tilapia for fast growth at a size of 10-30 g lie between 25 to 30%. Viola and Zohar (1984) showed also that, increasing dietary protein level for hybrid tilapia (*O. niloticus* × *O. aureus*) from 25% to 30% or 35% increased significantly growth rate. Abdel-Hakim and Mustafa (2000) found that dietary protein requirements for Nile tilapia, *O. niloticus* reared in cages and depending only on artificial feeds lie between 28-30%. Also, Abdel-Hakim et al., (2001) demonstrated that, increasing dietary protein level from 25 to 30% significantly (P<0.05) increased fish BW, BL and K of Nile tilapia, *O. niloticus* reared in tanks. Recently, Wafa (2002) found that, BW and BL of hybrid tilapia (*O. niloticus* × *O. aureus*) reared in earthen ponds increased significantly (P<0.001) with increasing dietary crude protein from 25 to 30%.

Concerning to the effect of dietary energy level on average BW, BL and K, Table (2) show that, final BW, BL and K significantly decreased with

increasing dietary energy level from 300 to 330 and 360 kcal ME/100g. Results of BW, BL and K obtained in this study may be attributed to the depress in feed consumption related to the higher content of energy in fish diets. The present results are in accordance with those reviewed by Shiau and Haung (1990). They indicated that, excess energy may produce fatty fish, reduce feed consumption (reducing total protein intake) and inhibit proper utilization of other feedstuffs. Therefore, it is critical to obtain the proper protein to energy (P/E) ratio in a diet for the most economical production of tilapia.

The greatest final BW (34.23 g) and BL (13.56 cm) were achieved with the diet contained 30% protein and 300 kcal ME/100g. This diet presumably contained the most appropriate P/E ratio of 98.9 mg protein/kcal. Also the lower final BW (23.05 g) and BL (11.40 cm) were achieved with the diet contained 20% protein and 360 kcal ME/100g (P/E ratio of 55.5 mg protein/kcal). The differences between final BW, BL and K values attributed to the effect of P/E ratio were significant ($P<0.001$). Wafa (2002) found that, hybrid tilapia (*O. niloticus* × *O. aureus*) fed the diet contained 100 P/E ratio recorded the higher final BW, BL and K followed by those fed the 80 P/E ratio diet whereas fish fed the 120 P/E ratio diet showed the lowest values. Similar results were obtained with blue tilapia, *O. aureus,* (Winfree and Stickney, 1981), *O. niloticus* (Teshima et al., 1985; Siddiqui et al., 1988 and El-Sayed and Teshima, 1992), Tilapia zilli (El-Sayed, 1987), hybrid tilapia, *O. niloticus* × *O. aureus* (Shiau and Huang, 1990).

Weight gain:

During the whole experimental period (0-8 weeks) averages weight gain (WG) were 9.76, 10.90 and 12.74 g for the diets contained 20, 25 and 30% crude protein, respectively (Table 2). These results revealed that, increasing dietary protein level for tilapia (*O. niloticus*) significantly ($P<0.001$) increased WG. Wee and Tuan (1988), reached to a similar results with Nile tilapia. They found that, increasing dietary protein from 22 to 25% (in 7.5% increments) significantly improved the WG. Cisse (1996) came to the same conclusion that, tilapia fed on a 20% crude protein diet showed poorer WG compared to fish fed the 30% protein diet. Also, El-Dahhar (1994), found that WG of *O. niloticus* fry and fingerlings linearly increased with increasing diet crude protein contents. Wafa (2002) found that, increasing dietary crude protein from 25 to 30% significantly ($P<0.001$) increased WG of hybrid tilapia (*O. niloticus* × *O. aureus*). Table (2) also show that averages WG were 12.53, 11.19 and 9.77g for the diets contained 300, 330 and 360 kcal ME/100 g, respectively.

Generally, results of the present experiment indicated that, increasing dietary protein level for tilapia (*O. niloticus*) significantly ($P<0.001$) increased WG, but increasing dietary energy level significantly ($P<0.001$) decreased WG. Fish fed the diet contained the P/E ratio of 98.9 mg protein/kcal gained the higher WG compared to the other diets. These results are in complete accordance with those obtained by Wafa (2002), he found that hybrid tilapia (*O. niloticus* × *O. aureus*) fed 100 P/E ratio diet recorded the highest WG

followed by those fed the 80 P/E diets and fish fed the 120 P/E ratio diet showed the lowest WG.

Specific growth rate:

Specific growth rate (SGR) values were 0.83, 0.96 and 1.06 for fish fed diets contained 20, 25 and 30% crude protein, respectively (Table 2) and the differences were significant ($P<0.001$). These results indicated that, regardless of dietary energy level, SGR for tilapia increased with each increase in protein level. Abdel-Hakim and Mustafa (2000) indicated that SGR of Nile tilapia reared in cages improved almost significantly with each increase in the dietary protein level fed from 20 to 32% protein, and these results are in agreement with our results. Also, Abdel-Hakim et al., (2001) found that, SGR for Nile tilapia, *Oreochromis niloticus* reared in fiberglass tanks was improved when dietary protein level increased from 25 to 30%. Al-Hafedh (1999) found that, SGR of Nile tilapia was significantly increased as diet protein level increased from 25-45% (with increment of 5%). Also, Ogunji and Wirth (2000) with the same fish specie found that, SGR increased with increasing dietary protein level from 7.3 to 44.24%. Wafa (2002) found that, increasing dietary protein level from 25 to 30% significantly ($P<0.05$) increased SGR of hybrid tilapia (*O. niloticus* × *O. aureus*). On the other hand, Clark et al., (1990) found that SGR of Florida red tilapia did not differ significantly when fish fed diets contained 20, 25 or 30% crude protein.

Average SGR were 1.04, 0.97 and 0.83 for fish groups fed diets with the three energy levels, 300, 330 and 360 kcal ME/100 g, respectively (Table 2) and the differences were significant ($P<0.001$). It is obvious that, SGR in the present study decreased with increasing dietary energy content and this effect perhaps due to the decrease in feed consumption from diets with the higher energy content. Stickney and Wursts (1986) found that growth of blue tilapia fingerlings can be substantially improved when the diet contained 7.5-10% lipid. Also, Siddiqui et al., (1988) found that the best growth of young Nile tilapia (*O. niloticus*) was obtained by using 8% lipid than the other lipid levels i.e. 6, 9 and 11% when dietary lipids levels increased in diets from 5 to 12%.

The highest SGR value (1.43) was obtained with the diet contained P/E ratio 98.9 mg protein/kcal and the lowest SGR (0.73) was recorded for the diet contained P/E ratio of 55.5 mg protein/kcal (Table 2). Results obtained in the present study are relatively consistent with Jauncey (1982) who found that, the maximum growth of *S. mossambicus* was obtained with diets of P/E ratio of 116.6 mg protein/kcal. Mazid et al., (1979) obtained the maximum growth for tilapia zilli fed a diet contained 35% protein with a P/E ratio of 103 mg protein/kcal. Ross (1982) found that, the optimum protein-energy ratio was 78-90 mg protein/kcal for tilapia mossambicus fed 30-35% protein diets and 3836-3860 kcal ME/kg. Also, Siddiqui et al., (1988) found that, the best growth was obtained with P/E of 107 mg protein/kcal when Nile tilapia, *O. niloticus* fed diets different in P/E ratio (68, 107, 145 and 175 mg protein/kcal). Recently, Wafa (2002) found that, SGR of hybrid tilapia (*O. niloticus* × *O. aureus*) increased with increasing the P/E ratio from 80 to 100 being 1.14 and 1.16, respectively, then decreased to 1.07 with increasing the P/E ratio to 120 mg protein/kcal.

SGR values outlined above (Table 2) indicated that, increasing dietary protein level increased SGR but dietary energy level had the opposite effect, therefore we suggested that, diets for tilapia culture may have to be compounded on the basis of protein and energy considerations.

Feed intake:

Feed intake (FI) during the experimental period were 41.90, 43.71 and 45.29 g/fish for fish groups fed diets contained 20, 25 and 30% protein, respectively with significant differences ($P<0.001$) between these means (Table 3). These results indicated that, as protein content in tilapia fish diets increased, FI will be significantly ($P<0.001$) increased. These results are in agreement with those obtained by El-Dahhar (2000) who found that, feed consumption increased as dietary protein increased for tilapia fry. On the other hand, Cisse (1996), found that, a change in protein contents from 20 to 30% for tilapia fish did not have any significant effect on the quantity of feed consumed.

With regard to the effect of dietary energy content, results presented in Table (3) indicated that, increasing energy contents in tilapia diets significantly ($P<0.001$) decreased FI and this subsequently followed by decrease in all growth parameters such as BW, BL, K, SGR and WG (Table 2). El-Dahhar and Lovell (1995) described that, excess energy in tilapia diets may reduce feed consumption. Our results support those of Winfree and Stickney (1981) and Jauncey (1982) in that tilapia regulate their food consumption according to energy intake.

During the whole experimental period (0 to 8 week) it was observed that, the fish group fed the diet contained P/E ratio of 98.9 mg protein/kcal consumed the higher amount of feed (50.72 g/fish) whereas fish fed the diet contained P/E ratio of 69.2 mg protein/kcal consumed the lower amount of feed (41.30 g/fish). Wafa (2002) found that, feed hybrid tilapia (*O. niloticus* × *O. aureus*) increased with increasing P/E ratio from 80 to 100 mg prot/kcal and decreased when P/E ratio increased to 120 mg prot/kcal.

Feed conversion ratio:

Results of Table (3) indicated that, feed conversion ratio (FCR) was improved with increasing dietary protein level. Siddiqui et al., (1988), Cisse (1996) and Al-Hafedh (1999) came to the same results that FCR of Nile tilapia was improved with increasing dietary protein level. El-Dahhar (1994) found that, FCR was significantly improved with increasing dietary protein level for both *O. niloticus* fry and fingerlings and the significant improvement in FCR was achieved when dietary protein level increased from 17 to 30% for fry and 17 to 22 for fingerlings. Abdel-Hakim et al., (2001) concluded that, increasing protein level from 25 to 30% improved FCR of Nile tilapia *O. niloticus*. Wafa (2002) found also that, increasing dietary protein level from 25 to 30% significantly ($P<0.05$) increased SGR for hybrid tilapia (*O. niloticus* × *O. aureus*).

It could be seen that, decreasing dietary energy content from 360 to 330 and 300 kcal ME/100 g improved the FCR from 4.68 to 3.95 and 3.88, for the three dietary energy levels, respectively (Table 3).

The diet contained 98.9 mg protein/kcal showed the best improvement on FCR (2.68) and the diet contained P/E ratio of 55.5 mg protein/kcal was the

worst on FCR (5.42). These results mean that, the diet with P/E ratio of 98.9 mg protein/kcal considered as the most suitable diet tested in the present study for tilapia fish. Wafa (2002) found that, hybrid tilapia (*O. niloticus* × *O. aureus*) fed the diet with P/E ratio of 100 showed the best FCR (3.22) followed by those fed the diet contained 80 mg protein/kcal ME (3.27) while fish fed the diet contained 120 P/E ratio recorded the poorest ($P<0.05$) FCR values (3.44).

Protein efficiency ratio:

As described in Table (3), averages PER were significantly ($P<0.001$) different and being 1.09, 0.97 and 0.91 for fish fed the diets contained 20, 25 and 30% crude protein, respectively. Shiau and Huang (1989) came to the same result that PER for tilapia (*O. niloticus* × *O. aureus*) fed purified diets containing 0 to 56% protein (in 8% increments). Siddiqui et al., (1988) found that, PER decreased with increasing diet protein level from 20 to 50% for Nile tilapia. Also, El-Ebiary (1994) found that, increasing dietary protein level up to 35% and feeding rate up to 4% decreased the values of nutrients (protein and energy) utilization in Nile tilapia and its hybrid. Also, Wafa (2002) found that, hybrid tilapia (*O. niloticus* × *O. aureus*) fed the diet contained 25% crude protein recorded the best ($P<0.05$) PER value (1.19) while those fed the diet contained 30% crude protein showed the poorest one (1.03). On the other hand, Abdelhamied et al., (1997) and Twibell and Brown (1998) found that, PER was unaffected by increasing dietary protein from 25 to 35% for *O. niloticus*.

PER for fish fed diets contained 300, 330 and 360 kcal ME/100g diet decreased from 1.08, 1.02 to 0.88, respectively and the differences between these values were significant ($P<0.001$). PER values were improved for fish fed the diet contained P/E ratio of 98.9 and that of 61.4 mg protein/kcal. Wafa (2002) found that, hybrid tilapia (*O. niloticus* × *O. aureus*) fed diets contained 80 or 100 mg protein/kcal recorded the same (best) PER (1.14) whereas, those fed the diet contained 120 mg protein/kcal showed the poorest ($P<0.05$) PER (1.04).

Carcass analysis

As shown in Table (4) protein levels in the tested diets had insignificant effect on the percentages of dress-out, by-products, head, viscera and bone while the percentages of flesh were significantly decreased with increasing dietary protein. The three energy levels (300, 330 and 360 kcal ME/100 g diet) tested in the present study had insignificant effect on all carcass characteristics of Nile tilapia (Table 4). Abdel-Hakim et al., (2001) found that, increasing dietary protein level from 25 to 30% for Nile tilapia decreased dressing percentage from, 49.44 to 48.06, flesh from 37.23 to 35.68%, viscera from 9.62 to 9.28% but the percentage of by-products increased from 59.70 to 60.94%. For channel catfish (*Ictalurus punctatus*), Li et al., (2000) found that, fillet yield was higher for fish fed the 36% protein diet than fish fed the 24% protein diet.

With respect to the effect of P/E ratio on carcass traits it is clear that the diet contained P/E energy of 69.2 mg protein/kcal released the higher percentages of dress-out (49.38%); flesh (35.85%) and viscera (11.10%) and the lower percentages of by-products (53.31%); head (27.87%) and bone

(9.78%). Also, the diet contained P/E energy of 91.7 mg protein/kcal produced the higher percentages of by-products (61.30%) and the lower percentages of flesh (28.30%). Li et al., (2000) found that, carcass yield of channel catfish (*Ictalurus punctatus*) fed the diet contained E/P ratios of 11.7, 10.2, 9.0 and 8.1 kj/g did not significantly different.

Proximate analysis of Nile tilapia (Whole fish):

As shown in Table (5) moisture content in fish bodies were 70.51, 71.72 and 71.62% and the differences between these percentages were not significant and the same trend was also observed for ash percentages 13.49, 14.24 and 13.01% for the three protein levels 20, 25 and 30%, respectively. It is observed also that, increasing dietary protein level from 20 or 25 and 30% significantly decreased protein contents in whole fish bodies from 56.43 to 53.60 and 48.43%, and fat decreased also in a significant order from 32.49 to 30.60 and 24.79%, respectively.

In general, fish fed the high protein diet gained the highest crude lipid content in their bodies which can only be explained by an imbalance in the diet. Similar results were obtained by Abdel-Hakim et al., (2001) who found that, increasing dietary protein level from 25 to 30%, decreased the percentages of protein from 55.58 to 52.24%. Also, Al-Hafedh (1999) found no significant influence of dietary protein level (25 to 45%) on body protein content of Nile tilapia but the lipid content decreased with increasing protein level and no clear trends in ash content were observed.

Table (5) show that, percentage of moisture were, 71.88, 71.05 and 70.92%; protein 54.91, 53.11 and 50.44%, fat 28.73. 29.8 and 29.36% and ash, 14.41, 13.48 and 12.85% for fish fed the diets contained 300, 330 and 360 kcal ME/100g, respectively and the differences between these means are not significant. It could be seen that, increasing energy contents in fish diets decreased moisture, protein and ash and increase the percentage of fat in fish bodies and these results were supported by Buckely and Groves (1979) and Shiau and Huang (1990). They found that, body lipid increased as dietary energy increased while the moisture content decreased. Similar results were also reported with Mozambique tilapia (El-Dahhar and Lovell, 1995).

As described in Table (5) it is observed that moisture and ash contents ranged between 70.30 to 73.00% and 12.00 to 16.12%, respectively with insignificant effect of P/E ratio on moisture and ash content of tilapia bodies. Protein content in whole fish bodies ranged between 47.18 to 59.88% and fat ranged between 24.09 to 34.04%. The diet contained 81.7 mg protein/kcal gained the higher content of protein and ash in fish bodies but the diet contained P/E ratio of 69.2 mg protein/kcal gained the higher percentage of fat in fish bodies. Also, the diet contained P/E ratio of 84.5 mg protein/kcal gained the lower percentages of protein and fat in whole fish. Wafa (2002) found that, hybrid tilapia (*O. niloticus* × *O. aureus*) fed the diet contained P/E ratio of 120 achieved the highest moisture and protein ($P<0.05$) contents and the lowest fat ($P<0.05$) and ash percentages, while fish fed the diet with lower P/E ratio (80) recorded the highest fat ($P<0.05$) content and the lowest protein percentages and fish fed the diet with P/E ratio of 100 had the highest ash ($P<0.05$) content and the lowest moisture percentage.

Table (1): Composition and proximate analysis of the experimental diets.

Ingredients	1	2	3	4	5	6	7	8	9
Fish meal (64.5% CP)	16.0	16.7	18.2	27.6	28.8	29.7	35.0	35.0	35.0
Soy bean meal (40.3% CP)	10.0	11.0	11.0	11.0	11.0	11.0	15.3	16.3	17.5
Yellow corn	30.0	30.0	28.0	28.0	25.0	19.5	22.0	18.3	18.7
Wheat flour	19.2	19.0	20.3	20.0	20.0	20.0	16.2	14.0	8.0
Corn oil	5.0	10.0	15.0	5.0	10.0	15.0	5.0	10.0	15.0
Bran	16.5	10.0	4.2	5.1	1.9	1.5	3.2	3.1	2.5
Bone meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
[1]Vitamin & mineral mixture	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ascorbic acid	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sum	100	100	100	100	100	100	100	100	100
Protein	20.01	20.02	20.00	25.04	25.02	25.03	30.07	30.07	30.00
[2]ME (kcal/100 g)	289.16	325.85	360.98	306.48	336.80	361.21	304.26	328.27	355.00
P/E ratio mg/kcal	69.2	61.4	55.5	81.7	74.3	69.3	98.9	91.7	84.5
Proximate analysis (based on dry matter)									
Moisture%	4.93	5.55	4.58	4.80	5.60	4.91	5.19	5.50	5.46
Protein%	21.55	21.27	21.08	25.32	26.70	26.30	31.25	32.04	30.51
Fat%	5.80	9.83	14.80	6.00	9.94	14.72	6.10	9.525	14.40
Ash%	9.29	9.32	9.44	11.32	11.67	11.69	12.20	12.75	13.48

[1] Each Kg vitamin & mineral mixture premix contained Vitamin D_3, 0.8 million IU; A, 4.8 million IU; E, 4 g; K, 0.8 g; B_1, 0.4 g; Riboflavin, 1.6 g; B_6, 0.6 g, B_{12}, 4 mg; Pantothenic acid, 4 g; Nicotinic acid, 8 g; Folic acid, 0.4 g Biotin,20 mg , Mn, 22 g; Zn, 22 g; Fe, 12 g; Cu, 4 g; I, 0.4 g, Selenium, 0.4 g and Co, 4.8 mg,

[2] Estimated based on values of the diet ingredients (NRC, 1993)

Table (2): Least squares means and standard errors for the effect of dietary protein and energy levels on growth parameters of Nile tilapia *(Oreochromis niloticus).*

Item	No. of fish	Body weight (g)		Body length (cm)		Condition factor (K)		Weight gain (g)	Specific growth rate
		Initial	Final	Initial	Final	Initial	Final		
Protein levels (P)									
20% (P1)	108	15.35±0.18 a	24.52±0.60 c	9.70±0.05 a	11.58±0.16 b	1.68±0.02 a	1.56±0.02 a	9.76±0.02 c	0.83±0.002 c
25% (P2)	108	15.40±0.18 a	26.38±0.60 b	9.73±0.05 a	11.89±0.16 b	1.68±0.02 a	1.54±0.02 a	10.99±0.02 b	0.96±0.002 b
30% (P3)	108	15.33±0.18 a	28.07±0.60 a	9.63±0.05 a	12.32±0.16 a	1.71±0.02 a	1.54±0.02 a	12.74±0.02 a	1.06±0.002 a
Energy levels (E)									
300 kcal ME/100g (E1)	108	15.35±0.18 a	27.88±0.60 a	9.65±0.05 a	12.30±0.16 a	1.71±0.02 a	1.58±0.02 a	12.53±0.02 a	1.04±0.002 a
330 kcalME/100g (E2)	108	15.37±0.18 a	26.63±0.60 b	9.71±0.05 a	11.91±0.16 b	1.68±0.02 a	1.53±0.02 b	11.19±0.02 b	0.97±0.002 b
360 kcalME/100g (E3)	108	15.33±0.18 a	24.47±0.60 c	9.70±0.05 a	11.58±0.16 c	1.69±0.02 a	1.53±0.02 b	9.77±0.02 c	0.83±0.002 c
P×E (mg prot./ Kcal ME)									
P1×E1 (69.2)	36	15.36±0.32 a	24.35±1.04 b	9.65±0.08 a	11.49±0.28 b	1.71±0.03 a	1.63±0.03 a	9.00±0.04 h	0.81±0.003 h
P1×E2 (61.4)	36	15.33±0.32 a	26.17±1.04 bc	9.76±0.08 a	11.85±0.28 bc	1.64±0.03 a	1.54±0.03 ab	10.64±0.04 c	0.94±0.003 c
P1×E3 (55.5)	36	15.37±0.32 a	23.05±1.04 c	9.69±0.08 a	11.40±0.28 c	1.68±0.03 a	1.51±0.03 b	9.66±0.04 f	0.73±0.003 l
P2×E1 (81.7)	36	15.39±0.32 a	25.05±1.04 b	9.68±0.08 a	11.84±0.28 b	1.70±0.03 a	1.51±0.03 ab	9.66±0.04 f	0.88±0.003 f
P2×E2 (74.3)	36	15.31±0.32 a	28.00±1.04 bc	9.75±0.08 a	12.03±0.28 bc	1.66±0.03 a	1.55±0.03 ab	12.69±0.04 b	1.07±0.003 b
P2×E3 (69.3)	36	15.50±0.32 a	26.09±1.04 bc	9.77±0.08 a	11.79±0.28 bc	1.66±0.03 a	1.57±0.03 ab	10.61±0.04 d	0.93±0.003 d
P3×E1 (98.9)	36	15.31±0.32 a	34.23±1.04 a	9.64±0.08 a	13.56±0.28 a	1.71±0.03 a	1.59±0.03 ab	18.93±0.04 a	1.43±0.003 a
P3×E2 (91.7)	36	15.47±0.32 a	25.73±1.04 bc	9.62±0.08 a	11.86±0.28 bc	1.72±0.03 a	1.52±0.03 b	10.26±0.04 e	0.91±0.003 e
P3×E3 (84.5)	36	15.22±0.32 a	24.25±1.04 bc	9.65±0.08 a	11.55±0.28 bc	1.71±0.03 a	1.52±0.03 b	9.05±0.04 g	0.84±0.003 g

+ Means with the same letter in each column are not significantly different.

Table (3): Least squares means and standard errors for the effect of dietary protein and energy levels on feed utilization of Nile tilapia *(Oreochromis niloticus).*

Item	No.++	Feed intake (g/fish)	Feed conversion ratio	Protein efficiency ratio
Protein levels (P)				
20% (P1)	6	41.90±0.07 c	4.65±0.004 a	1.09±0.004 a
25% (P2)	6	43.71±0.07 b	4.02±0.004 b	0.97±0.004 b
30% (P3)	6	45.29±0.07 a	3.84±0.004 c	0.91±0.004 c
Energy levels (E)				
300 kcal ME/100g (E1)	6	44.79±0.07 a	3.88±0.004 c	1.08±0.004 a
330 kcalME/100g (E2)	6	44.18±0.07 b	3.95±0.004 b	1.02±0.004 b
360 kcalME/100g (E3)	6	41.29±0.07 c	4.68±0.004 a	0.88±0.004 c
P×E (mg prot./ Kcal ME)				
P1×E1 (69.2)	2	41.30±0.13 c	4.57±0.008 ab	1.08±0.006 a
P1×E2 (61.4)	2	42.81±0.13 bc	3.94±0.008 ab	1.23±0.006 a
P1×E3 (55.5)	2	41.60±0.13 c	5.42±0.008 a	0.92±0.006 b
P2×E1 (81.7)	2	42.35±0.13 bc	4.37±0.008 ab	0.91±0.006 b
P2×E2 (74.3)	2	45.90±0.13 ab	3.63±0.008 b	1.01±0.006 a
P2×E3 (69.3)	2	42.88±0.13 bc	4.04±0.008 ab	0.98±0.006 a
P3×E1 (98.9)	2	50.72±0.13 a	2.68±0.008 c	1.27±0.006 a
P3×E2 (91.7)	2	43.82±0.13 b	4.27±0.008 ab	0.77±0.006 b
P3×E3 (84.5)	2	41.31±0.13 c	4.57±0.008 ab	0.73±0.006 b

+ Means with the same letter in each column are not significantly different.

++ Feed intake, feed conversion ratio and protein efficiency ratio were calculated from the total biomass of two replicates for each treatment.

Table (4): Least squares means and standard errors for the effect of dietary protein and energy levels on carcass analysis of Nile tilapia *(Oreochromis niloticus).*

Item	No. Of fish	Dress-out %	By-products	Flesh%	Head%	Viscera%	Bone%
		Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Protein levels (P)							
20% (P1)	18	46.48±0.74 a	57.59±1.07 a	33.48±0.79 a	34.50±2.05 a	10.21±0.53 a	11.07±0.37 a
25% (P2)	18	44.45±0.74 a	59.90±1.07 a	31.17±0.79 b	34.10±2.05 a	9.20±0.53 a	11.77±0.37 a
30% (P3)	18	45.67±0.74 a	60.11±1.07 a	30.46±0.79 b	34.42±2.05 a	9.47±0.53 a	12.33±0.37 a
Energy levels (E)							
300 kcal ME/100g (E1)	18	46.48±0.74 a	57.63±1.07 a	32.93±0.79 a	32.20±2.05 a	9.25±0.53 a	11.14±0.37 a
330 kcalME/100g (E2)	18	45.78±0.74 a	59.86±1.07 a	31.52±0.79 a	36.98±2.05 a	9.08±0.53 a	12.24±0.37 a
360 kcalME/100g (E3)	18	44.35±0.74 a	60.11±1.07 a	30.65±0.79 a	33.84±2.05 a	10.55±0.53 a	11.80±0.37 a
P×E (mg prot./ Kcal ME)							
P1×E1 (69.2)	6	49.38±1.28 a	53.31±1.85 b	35.85±1.36 a	27.87±3.55 b	11.10±0.92 a	9.78±0.64 b
P1×E2 (61.4)	6	47.22±1.28 ab	59.84±1.85 a	33.44±1.36 ab	42.29±3.55 a	8.78±0.92 a	11.46±0.64 ab
P1×E3 (55.5)	6	42.85±1.28 c	59.64±1.85 a	31.13±1.36 b	33.34±3.55 ab	10.75±0.92 a	11.98±0.64 ab
P2×E1 (81.7)	6	42.81±1.28 c	60.90±1.85 a	30.77±1.36 b	34.51±3.55 ab	8.47±0.92 a	12.10±0.64 a
P2×E2 (74.3)	6	46.12±1.28 ab	58.45±1.85 ab	32.82±1.36 ab	33.12±3.55 ab	9.23±0.92 a	11.70±0.64 ab
P2×E3 (69.3)	6	44.43±1.28 bc	60.35±1.85 a	29.91±1.36 bc	34.68±3.55 ab	9.90±0.92 a	11.51±0.64 ab
P3×E1 (98.9)	6	47.23±1.28 ab	58.70±1.85 ab	32.18±1.36 ab	34.22±3.55 ab	8.18±0.92 a	11.53±0.64 ab
P3×E2 (91.7)	6	44.00±1.28 bc	61.30±1.85 a	28.30±1.36 c	35.53±3.55 ab	9.22±0.92 a	13.55±0.64 a
P3×E3 (84.5)	6	45.78±1.28 abc	60.31±1.85 a	33.89±1.36 ab	33.51±3.55 ab	11.00±0.92 a	11.90±0.64 ab

+ Means with the same letter in each column are not significantly different.

Table (5): Least squares means and standard errors for the effect of dietary protein and energy levels on proximate analysis of whole fish.

Item	No. of fish	Moisture%	Protein%	Fat%	Ash%
Protein levels (P)					
20% (P1)	18	70.51±0.54 a	56.43±1.79 a	32.49±0.84 a	13.49±0.59 a
25% (P2)	18	71.72±0.54 a	53.60±1.79 a	30.60±0.84 a	14.24±0.59 a
30% (P3)	18	71.62±0.54 a	48.43±1.79 b	24.79±0.84 b	13.01±0.59 a
Energy levels (E)					
300 kcal ME/100g (E1)	18	71.88±0.54 a	54.91±1.79 a	28.73±0.84 a	14.41±0.59 a
330 kcalME/100g (E2)	18	71.05±0.54 a	53.11±1.79 a	29.36±0.84 a	13.48±0.59 a
360 kcalME/100g (E3)	18	70.92±0.54 a	50.44±1.79 a	29.80±0.84 a	12.85±0.59 a
P×E (mg prot./ Kcal ME)					
P1×E1 (69.2)	6	70.47±0.63 a	57.36±3.11 a	34.04±1.45 a	12.86±1.02 b
P1×E2 (61.4)	6	70.75±0.63 a	57.02±3.11 a	32.38±1.45 ab	14.68±1.02 ab
P1×E3 (55.5)	6	70.30±0.63 a	54.89±3.11 a	31.06±1.45 b	12.92±1.02 b
P2×E1 (81.7)	6	72.16±0.63 a	59.88±3.11 a	27.04±1.45 bc	16.12±1.02 a
P2×E2 (74.3)	6	71.58±0.63 a	51.68±3.11 ab	31.83±1.45 b	12.96±1.02 b
P2×E3 (69.3)	6	71.42±0.63 a	49.24±3.11 b	32.92±1.45 ab	13.62±1.02 b
P3×E1 (98.9)	6	73.00±0.63 a	47.49±3.11 b	25.09±1.45 c	14.42±1.02 ab
P3×E2 (91.7)	6	70.82±0.63 a	50.62±3.11 ab	24.20±1.45 c	12.78±1.02 b
P3×E3 (84.5)	6	71.05±0.63 a	47.18±3.11 b	24.09±1.45 c	12.00±1.02 b

+ Means with the same letter in each column are not significantly different.

The present study has certainly not assessed all the nutritional requirements that must be considered to improve the growth performance of *O. niloticus* but it has shown some important factors that must be taken into consideration when developing experiments in which the effects of natural productivity are added to those of the feeds that are given.

REFERENCES

Abdel-Hakim, N. F. and S. T., Mustafa (2000): Performance of Nile tilapia (*Oreochromis niloticus*) raised in cages as affected with stocking density and dietary protein level. Egyptian Journal of Aquatic Biology and Fisheries, 4:95.

Abdel-Hakim, N. F.; M. S. Hussein, M. N. Bakeer, and M. A. Soltan (2001): Effect of protein level and stocking density on growth performance of Nile tilapia (*Oreochromis niloticus*) cultured in tanks. Egyptian J. Nutrition and feed, 4 (Special Issue) : 763-780.

Abdelhamied, A. M.; F. F. Khalil and M. E. Elbarbary (1997): Effect of different dietary protein levels supplemented with graded level of flavomycin on growth performance of Nile tilapia fry and their utilization of different nutrients. Egypt. J. Aquat. Biol. and Fish, 1:93.

Al-Hafedh, Y. S. A. (1999): Effects of dietary protein on growth and body composition of Nile tilapia, *Oreochromis niloticus* L. Aquaculture Resources, 30:385-393.

AOAC (1990): Official Methods of Analysis. Association of official Analytical chemists. Washington, D. C.

Buckely, J. T. and Groves, T. D. D. (1979): Influence of feed on body composition of finfish. In J. E. Halver and K. Tiews, (1978). Fish Feed Technology. Hamburg, 20-23 June 1978, Vol. II. Heenemann. Barlin pp. 334-343.

Cho, C.Y.; and S. J. Kaushik (1985): Effect of protein intake on metabolism and net energy values of fish diets. In: C. B., Cowey, A. M. Mackie and J. G. Bell (Editors), Nutrition and Feeding in Fish. Academic Press, London, pp, 96-117.

Cisse, A. (1996): Effects of the varying protein-energy levels on food consumption, growth and body composition of *Sarotherodon melanotheron* (Rüppel, 1852). P 193-197. In R.S.V. Pullin, J. Lazard, M. Legendre, J. B. Amon Kothias and D. Pauly (eds.). The third international Symposium on tilapia in Aquaculture. ICLARM Conf. Proc. 41, 575 p.

Clark, A. E.; W. O. Watanabe, B. L. Olla, and R. I. Wicklund (1990): Growth, feed conversion and protein utilization of Florida red tilapia fed isocaloric diets with different protein levels in seawater pools. Aquaculture, 88:75-85.

Cowey, C. B. (1980): Protein and amino acid requirements in fish. In H. J.Oslage and K. Rohr (Editors), Proc. Eur. Aquacult. Assoc. Symp. Protein

Metabolism and Nutrition, EAAP Publication no. 27, pp. 729-774. mp. Fin fish. Nutr. and feed technol., Hamburg. FLFC/78/symp. R 16.

Cruz, E.M. and I. L. Laudncia (1976): Preliminary study on the protein requirements of Nile tilapia (tilapia nilotica) fingerlings. IFP. Tech. Rept. No, 10, 2nd half cy, Up. Diliman, PP.117, Quezon City, Philippines

El-Dahhar, A. A. (1994): Protein requirements of fry and fingerlings of Nile Tilapia (*Oreochromis niloticus*) fed at varying protein level in Egypt. J. Agric. Sci. Mansoura Univ. 19 (1): 117- 128.

El-Dahhar, A. A. (2000): Developing a feeding guide for Nile tilapia *Oreochromis niloticus* based on dietary protein levels fed. Conference of Social and Agricultural Development of Sinai, El-Arish-North Sinai, 16-19 May, Egypt, 127-138.

El-Dahhar, A. A. and R. T. Lovell (1995): Effect of protein to energy ratio in purified diets on growth performance, feed utilization and body composition of Mozambique tilapia, *Oreochromis mossambicus* (peters). Aquaculture, 26: 451-457.

El-Ebiary, E. H. A. (1994): Studies on fish production: Relationship between nutrition and reproduction of tilapia sp. Ph.D. Thesis, Fac. of Agric., Alex. University.

El-Sayed, A. M. (1987). Protein and energy requirements of *Tilapia Zilli* Ph.D. Thesis., Michigan State University East lansing MI, USA, 147 PP.

El-Sayed, A. M. and S. Teshima (1992): Protein and energy requirements of Nile Tilapia *Oreochromus niloticus* fry. Aquaculture, 103: 55-63.

Jauncey, K. (1982): The effects of varying dietary protein level on the growth, feed conversion, protein utilization and body composition of juvenile tilapia (*Sarotherdon mossambicus*). Aquaculture, 27: 43-54.

Jauncey, K. and Ross, B. (1982): A Guide to tilapia feeds and feeding. Univ. Stirling, Stirling, UK, 111 pp.

Li, M. H. Bosworth, B. G. and Robinson, E. H. (2000): Effect of dietary protein concentration on growth and processing yield of channel catfish, *Ictalurus punctatus*. J. World Aquacult. Soc., 31:592-598.

Lovell, R. T. (1981): Laboratory manual for fish feed analysis and fish nutrition studies. Auburn Univ., Alabama.

Lovell, R. T. (1989): Nutrition and feeding of fish. Van Nostrand Reinhold, New York, NY, 260 pp.

Mazid, M. A.; Y., Tanaka, T., Katayama, M. Asadur Rahmafl, K. L. Simpson, and C. O. Chichester (1979): Growth response of *Tilapia zilii* fingerlings fed isocaloric diets with variable protein levels. Aquaculture 18: 115-122.

NRC. (1993): Nutrient requirements of fish, 114 pp. National Research Council Washington, DC.

Ogunji, J. O. and Wirth, M. (2000): Effect of dietary protein content on growth, food conversion and body composition of tilapia *Oreochromis niloticus* fingerlings fed fish meal diet. J. Aquac. Trop. 15:381-389.

Ross, B. (1982): Protein requirements of sub-adult *Sarotherodon mossambicus*. In K., Jauncey, and B. Ross (Ed.) pp. 111 (Review) a guide to tilapia feeds and feeding, Stirling, University of Stirling, Institute of Aquaculture,

SAS (1996): SAS Procedure Guide "version 6.12 Ed" . SAS Institute Inc., Cary, NC, USA.

Shiau, S. Y. and S. L. Huang (1989): Optimal dietary protein level for hybrid tilapia (*Oreochromis niloticus* × *O. aureus*) reared in sea water. Aquaculture, 81: 119-127.

Shiau S.Y. and S. L. Huang (1990): Influence of varying energy levels with two protein concentration in diets for hybrid tilapia (*Oreochromis niloticus* × *O. aureus*) reared in seawater. Aquaculture, 91: 143-152

Shiau S.Y.; J. L. Chuang, and C. L. Sun (1987): Inclusion of soybean meal in tilapia (*Oreochromis niloticus* × *O. aureus*) diets at two protein levels. Aquaculture, 65: 251-261

Siddiqui, A. Q.; M. S. Howlader and, A. A. Adam (1988). Effects of dietary protein level on growth, feed conversion and utilization in fry and young Nile tilapia*, Oreochromis niloticus.* Aquaculture, 70: 63-73.

Stickney, R. R. and W. A. Wursts (1986): Growth response of blue tilapia to selected levels of dietary menhaden and catfish oils. Progressive fish culturist, 48: 107.

Teshima, S.; A. Kanazawa, and Y. Uchiyama (1985): Optimum protein levels in casein gelatin diets for tilapia nilotica. Mem. Fac. Fish Kagoshima Univ., 34: 45-52.

Twibell, R. G. and P. B. Brown. (1998): Optimal dietary protein concentration for hybrid tilapia, *Oreochromis niloticus* × *O. aureus* fed all-plant diets. Journal of the world aquaculture Society, 29: 9-16.

Viola, S. and G. Zohar (1984):Nutrition studies with market size hybrids of tilapia in intensive culture. Bamidgeh, 36:3

Wafa, M. E. (2002): Nutrient requirements of Nile tilapia. Ph.D. Thesis, Fac. Agric. Moshtohor, Zagazig University (Banha branch).

Wee, K. L. and N. A. Tuan (1988): Effects of dietary protein level on growth and reproduction in Nile tilapia (*Oreochromis niloticus*), p. 401-410. In R. S. V. Pullin, T. Bhukaswan, K. Tonguthai and J. L. Maclean (eds.).

Wilson, R. P. (1977): Energy relationship in catfish. In: Regional Research project S-83 catfish production". Alabama Agricultural Experiment station. Univ. of Auburn. Alabama.

Winfree, R. A. and R. R. Stickney (1981): Effect of dietary protein and energy on growth, feed conversion efficiency and body composition of *Tilapia aurea*. J. Nutr., 111: 1001- 1012.

Wu, Y. V.; R. Rosati, D. J. Sessa, and P. Brown (1995): Utilization of corn gluten feed by Nile tilapia. The progressive fish-culturist 57: 305-309.

الملخص العربى

تأثير محتوى العليقة من البروتين والطاقة ونسبة البروتين إلى الطاقة على النمو والكفاءة الغذائية ومكونات الجسم لأسماك البلطى النيلى

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أجريت هذه الدراسة (والتى أستغرقت ثمانية أسابيع) على أصبعيات أسماك البلطى النيلى التى كان متوسط وزنها ١٥٫٣٠±٠٫٣٢ جم وقد استخدمت فى هذه الدراسة ثلاثة مستويات من البروتين ٢٠، ٢٥، ٣٠% بروتين وتحت كل مستوى من هذه المستويات إستخدمت ثلاث مستويات من الطاقة ٣٠٠، ٣٣٠، ٣٦٠ كيلو كالورى (طاقة ممثلة)/١٠٠ جم عليقة وبالتالى تكونت تسع علائق أحتوت كل منها على نسبة من البروتين إلى الطاقة تراوحت بين ٥٫٥٥ – ٩٨٫٩ مجم بروتين/كيلو كالورى (طاقة ممثلة). وكان من أهم النتائج المتحصل عليها مايلى:

- أدت زيادة نسبة البروتين فى العليقة إلى زيادة كل مقاييس النمو (وزن الجسم، طول الجسم، معامل الحالة ، الزيادة فى الوزن وكذلك معدل النمو) فى حين أن زيادة محتوى العليقة من الطاقة قد أدى إلى نقص كل مقاييس النمو السابق ذكرها. وقد أظهرت النتائج أن العليقة المحتوية على ٣٠% بروتين ، ٣٠٠ كيلوكالورى/١٠٠ جرام (نسبة البروتين إلى الطاقة ٩٨٫٩ مجم بروتين/كيلو كالورى) قد سجلت أفضل مقاييس للنمو فى حين أن العليقه المحتوية على ٢٠% بروتين ، ٣٦٠ كيلوكالورى/١٠٠ جرام (نسبة البروتين إلى الطاقة ٥٫٥٥ مجم بروتين/كيلو كالورى طاقة ممثلة) قد سجلت أضعف مقاييس للنمو.
- أدت زيادة نسبة البروتين فى العليقة إلى زيادة كمية الغذاء المأكول وكذلك معدل تحويل الغذاء ونقص فى كفاءة تحويل البروتين بينما أدت زيادة الطاقة فى العليقة إلى نتائج عكسية لزيادة البروتين. كما أن العليقة المحتوية على ٣٠% بروتين ، ٣٠٠ كيلوكالورى/١٠٠ جرام (نسبة البروتين إلى الطاقة ٩٨٫٩ مجم بروتين/كيلو كالورى) قد سجلت أعلى كمية من الغذاء المأكول وكذلك أعلى معدل لتحويل الغذاء.
- لم يكن لمستوى البروتين فى العليقة أى تأثير معنوى على معظم مكونات الذبيحة إلا أن زيادة مستوى البروتين فى العليقة قد أدى إلى نقص نسبة البروتين والدهن فى جسم الأسماك. كذلك وجد أن مستوى الطاقة فى العليقة لم يكن له تأثير معنوى على كلاً من مكونات الذبيحة وكذلك التحليل الكيميائى لجسم السمكة.
- إعتماداً على النتائج السابقة يمكن القول بأن العليقة المحتوية على ٣٠% بروتين ، ٣٠٠ كيلوكالورى طاقة ممثله/١٠٠ جرام (نسبة البروتين إلى الطاقة ٩٨٫٩ مجم بروتين/كيلو كالورى) قد سجلت أفضل مقاييس للنمو وكذلك كفاءة إستخدام الغذاء.