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Effect of Dietary Protein and Energy Levels on Growth Performance, Feed Utilization and Body Composition of Striped mullet (*Mugil cephalus*)

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ABSTRACT

A (2 x 4) factorial design was conducted to determine the effect of dietary protein and energy levels on growth performance, survival and feed utilization of striped mullet *Mugil cephalus* fry (1.62 ± 0.03 g initial body weight). Eight practical diets were formulated to contain two levels of metabolizable energy ME (210 and 250 Kcal/100 g diet) each with four protein levels (16, 20, 24 and 28%). Each diet was fed in triplicate groups of 10 fish twice daily to apparent satiation for 10 weeks. The results showed that growth was significantly affected by dietary protein and energy levels (P < 0.05). Final body weight, weight gain and specific growth rate (SGR) increased significantly (P < 0.05) with increasing protein level in the diet. Fish maintained at diets containing 28 % protein were significantly the higher in FBW, WG and SGR values compared to other treatments. Results indicated also that there were no considerable differences in FBW, WG and SGR with different levels of energy. The best value of feed conversion ratio (FCR) (P < 0.05) was found with fish maintained at diet containing 28% protein level and 250 Kcal/100 g diet (1.64). Survival rate increased significantly (P < 0.05) with increasing dietary energy level. Also, fish fed diet containing 20, 24 or 28 % crude protein were the highest significantly (P < 0.05) values of survival rate while the lowest (P < 0.05) was the fish fed diet containing 16% crude protein. Fish moisture and protein body contents of striped mullet did not differ significantly (P < 0.05) among treatments at both energy levels while lipid content increased significantly (P < 0.05) with increasing energy level in the diet from 210 to 250 kcal/100 g diet. The results did not show any significant effect of dietary crude protein on fish lipid content. However, the highest protein content concentration (P < 0.05) was found with fish fed at 28% crude protein. Values of feed utilization parameters not affected significantly (P < 0.05) by increasing energy level in the diet. In addition, protein efficiency ratio PER improved significantly (P < 0.05) by decreasing dietary protein level. Also, protein productive value (PPV%)decreased significantly (P < 0.05) with increasing dietary protein level. Highest significantly (P < 0.05) value of energy retention ER% was obtained with fish maintained at 28 % crude protein in diet. Therefore, the result of the present work suggest that the diet containing 28% crude protein and ME of 250 Kcal/100g is the optimal for striped mullet *Mugil cephalus* fry for maximum growth and feed efficiency during nursing period.

Keywords: Striped mullet; *Mugil cephalus*; Protein and energy levels; Growth performance; Feed utilization.

INTRODUCTION

Mullet (*Mugilidae)* represent some of the most promising fish species for commercial aquaculture (Benetti, 1985). They are good candidates for both mono and polyculture and have strong market demand and good price in many countries especially in Egypt (El-Dahhar, 2000a).

The cost of the fish production depends mainly on the cost of feed which constitute most of the economical expenses, and dietary protein is the most important factor affecting growth performance of fish and feed cost (Lovell, 1989). Therefore, it is important from a nutritional and economical point of view to improve protein utilization for tissue synthesis rather than for energy use. Also, dietary lipid, as a non-protein energy source, may also influence growth and protein utilization of fish. (Kim *et al.,* 2010).

Much of the nutritional research with fish species has focused on minimizing crude protein in the diet for mullet (Papaparaskeva and Alexis 1986; El-Dahhar, 2000b). Most of these researches tended to reduce the cost of fish feed. El-Dahhar (2000a) found that 26% dietary crude protein level is the optimal level for maximum growth and feed utilization for striped mullet (*Mugil cephalus*) larvae of 0.2g initial body weight .While Papaparaskeva and Alexis (1986) found that 24% dietary crude protein level was required for maximum growth for young grey mullet (*M. capito)* of 2.5 g initial body weight. Alexis and Papaparaskeva (1986) found that the dietary protein content of 15% resulted in sufficient growth equal to 26, 37 and 50% dietary crude protein levels for grey mullet of 12.5 initial BW. In addition, there is increased interest in devising methods for improving protein utilization, the optimum protein level of the diet can be lowered if the energy level is increased due to protein sparing action of energy nutrients (Aksnes *et al.,* 1996).

On the other side, treating the diet by heat and pressure improve the diet quality and make the best nutritional use of the raw materials. It can sterilizing the diet and give the opportunity to use raw materials with different quality (De- Silva and Anderson, 1995).

The purposes of the present study are to determine the effect of different dietary protein and energy levels on survival, growth performance, feed utilization and body composition of striped mullet *Mugil cephalus* advanced fry.

MATERIALS AND METHODS

This experiment was carried out at the fish production laboratory, Faculty of Agriculture (Saba Bacha), Alexandria University, Egypt to determine the effect of different dietary protein and energy levels on survival, growth performance and feed efficiency of striped mullet *Mugil cephalus* advanced fry in glass aquaria.

The Experimental Fish

Striped mullet *Mugil cephalus* advanced fry used in this study were obtained from privet fish hatchery in Kafr El-Shikh government. Advanced fry with an initial body weight of 1.62 ± 0.03 g were acclimatized in tanks of 1 m^3 capacity to laboratory conditions and artificial diets for two weeks. Water was exchanged daily by freshly stocked dechlorinated tap water. Fish were divided randomly to 8 groups in three replicates of 10 fish for each group per aquarium. Glass aquaria of dimensions 100 x 34 x 50 cm were filled with 100 L of water and supplemented with continuous aeration. Nearly half of the water was exchanged daily by freshly stocked dechlorinated tap water and aquaria were cleaned every day before feeding. Average water temperature ranged from 24 to 26 °C. Fish were fed twice daily at 9.00 and 14.00h to apparent satiation, six days a week. Fish were weighed at the beginning of the experiment and then biweekly for 10 weeks.

Diet formulation and preparation

Eight experimental diets were used in this study containing both animal and plant proteins sources. The composition and chemical analysis of the experimental diet are presented in Table 1. Diets were formulated from commercial ingredients of fish meal, wheat flour, wheat bran, soybean meal, yellow corn, Bone meal, vitamins and minerals mixture. Fish oil, emulsified with equal amount of water using 0.7% phosphatediyl choline (lecithin) according to El-Dahhar and El-Shazly (1993) was added to the diets. Vitamins and minerals mixture were added to the diets after heat treatment. Mixtures were homogenized in a food grinder mixer attachment model NFGA (Kitchen Aid St. Goseph, MI 49085 USA). Boiling water was then blended into the mixture at the ratio of 50% for pelleting. The diets were pelleted using meat grinder of

Table 1. ***Composition and proximate analysis of diets used in the present experiment.***

Ingredients	Metabolizable energy (ME) kcal/100g							
	210				250			
	Protein%							
	16	20	24	28	16	20	24	28
Wheat flour	21.5	15.5	11.5	5	21	14.5	10	5
Wheat bran	45.5	42.5	39	36	38	34.5	31	28
Soybean meal	7	14	21	28	8	16	23	30
Yellow corn	19.5	18	15	14	21	19	16.5	14
Fish meal	3.5	7	10.5	14	4	8	11.5	15
Fish oil	0	0	0	0	5	5	5	5
Bone meal	2	2	2	2	2	2	2	2
Vit. & Min mix.*	1	1	1	1	1	1	1	1
Total	100	100	100	100	100	100	100	100
Proximate analysis%								
Moisture	9.47	9.11	8.93	9.08	9.50	8.91	8.87	9.16
Crude protein	15.57	19.80	23.72	27.49	15.38	19.71	23.53	27.62
Crude lipid	10.59	10.46	11.08	11.73	14.77	16.07	16.25	16.88
Ash	5.70	5.93	6.60	7.78	5.09	5.89	7.28	7.40
Metabolizable energy (ME) kcal/100g	210.04	210.04	210.08	210.33	250.59	250.56	250.86	250.44

Content/kg of Vitamin & minerals mixture (P- Fizer, Cairo, Egypt). Vitamin A, 4.8 MIU; Vitamin D, 0.8 MIU; Vitamin E, 4.0 g; Vitamin K, 0.8 g; Vitamin B_1, 0.4 g; Vitamin B_2, 1.6 g; Vitamin B_6, 0.6 g; Vitamin B_7, 20.0 mg; Vitamin B_{12}, 4.0 g; Folic acid, 0.4 g; Nicotinic acid, 8.0 g; Pantothenic acid, 4.0 g; Colin chloride, 200 g; Zinc, 22 g; Cooper, 4.0 g; Iodine, 0.4 g; Iron, 12.0 g; Manganese, 22.0 g; Selenium, 0.04 g.

Kitchen Aid with a 1.5 mm diameter and kept dry until they were used. With a maximum pressure of 1.2 kg /cm² G, an autoclave was used to heat treat the diets for 15 minuets after adding boiling water. Gross energy was calculated from Macdonald's Tables as crude protein, crude fat and carbohydrate to be 5.8, 9.3 and 4.1kcal/g respectively (Macdonald *et al.* 1973).

Experimental design

A (2 x 4) factorial design was used in this experiment with two levels of metabolizable energy ME (210 and 250 Kcal/100 g diet) and four levels of protein (16, 20, 24 and 28% based on the feedstuff values reported by NRC (1993).The high energy level in the diets was obtained by adding 5% fish oil to the test diets.

Analytical methods

Samples of twenty fish at start and three from each aquarium at the end of the experiment were taken randomly and were frozen for body composition analysis. Frozen samples were dried at 70°C for 72 h and passed through a meat grinder into one composite homogenate per aquarium. Chemical analysis of homogenized fish and experimental diets were carried out according to the methods of Association of Official Analytical Chemists AOAC (1990) for protein (macro-keldahl method), fat (ether extract method) and moisture (oven drying). The analysis of variance (ANOVA) and Duncan's multiple range tests were made according to Snedecor and Cochran (1981).

RESULTS

Data of Table 2 show that final body weight (FBW), weight gain (WG), survival percent, feed conversion ratio (FCR) and specific growth rate (SGR%/day) of striped mullet *Mugil cephalus* were significantly ($P < 0.05$) improved with increasing protein level in the diet. Fish maintained on diets containing 28 % protein diet exhibited significantly the greatest FBW, WG and SGR having the values of (4.32 g, 2.68g and 1.49 respectively) compared to other treatments. This treatment followed by the treatment of fish fed 24% protein diet and finally the least ($P < 0.05$) FBW, WG and SGR was recorded with the fish fed at 16 or 20% protein diet without any significant differences between the last two treatments. Results indicated also that there were no considerable differences in FBW, WG and SGR among fish given diets with different levels of energy (210 or 250 Kcal/100g). Survival rate at the end of the experiment showed that there were significant differences ($P < 0.05$) among treatments. In addition, fish fed 210 kcal/100 g diet had significant lower ($P < 0.05$) survival rate compared with the fish fed 250 kcal/100g diet. Fish fed diet containing

Table (2). ***Means ± standard error (SE) of final body weight (FBW), weight gain (WG), survival rate %, feed conversion ratio (FCR) and specific growth rate (SGR%/day) of Striped mullet Mugil cephalus fed at different dietary protein and energy levels.***

Diet No.	Energy level Kcal/100g	Protein levels %	**Final BW g M ± SE**	**Gain g M ± SE**	**Survival% M ± SE**	**FCR M ± SE**	**SGR M ± SE**
T1	210	16	3.55 ± 0.02d	1.93 ± 0.02 d	65.0 ± 4.0 d	2.13 ± 0.02 a	1.21 ± 0.01d
T2		20	3.63 ± 0.05d	1.98 ± 0.02 d	75.0 ± 5.0bc	2.07 ± 0.01a	1.22 ± 0.01d
T3		24	3.79 ± 0.04c	2.17 ± 0.02 c	70.0 ± 6.0 c	1.94 ± 0.1b	1.31 ± 0.02 c
T4		28	4.21± 0.03 b	2.55 ± 0.04 b	75.0 ± 5.0bc	1.71 ± 0.13c	1.44 ± 0.02 b
T5	250	16	3.65 ± 0.03d	2.02 ± 0.01 d	70.0 ± 4.0 c	2.06 ± .05a	1.24 ± 0.01d
T6		20	3.60 ± 0.04 d	1.94 ± 0.02 d	80.0 ± 7.0ab	2.14 ± 0.06a	1.20 ± 0.03 d
T7		24	3.75 ± 0.06c	2.11± 0.03 c	85.0 ± 6.0 a	2.00 ± 0.2 b	1.29 ± 0.02 c
T8		28	4.43 ± 0.05a	2.80 ± 0.02 a	85.0 ± 5.0 a	1.58 ± 0.11d	1.55 ± 0.03 a
Pooled means							
	210		3.79 ± 0.11m	2.16 ± 0.03 m	71.3 ± 3.3 n	1.96 ± 0.03 m	1.29 ± 0.01 m
	250		3.86 ± 0.08 m	2.22 ± 0.02 m	80.0 ± 4.3m	1.94 ± 0.05 m	1.32 ± 0.01 m
		16	3.60 ± 0.09 z	1.98 ± 0.03 z	67.5 ± 2.5 y	2.09 ± 0.10 x	1.22 ± 0.02 z
		20	3.61± 0.04 z	1.96 ± 0.02 z	77.5 ± 3.0 x	2.10 ± 0.1 x	1.21 ± 0.01z
		24	3.77 ± 0.03 y	2.14 ± 0.03 y	77.5 ±3.50 x	1.97 ± 0.03 y	1.30 ± 0.1 y
		28	4.32 ± 0.22 x	2.68 ± 0.06 x	80.0 ± 2.50x	1.64 ± 0.06 z	1.49 ± 0.05 x

16% crude protein and 210 Kcal/100g diet recorded the lowest ($P < 0.05$) value survival rate, while the highest values were obtained when fish given diets containing 20, 24 and 28 % crude protein with 250 Kcal/100g diet. Differences among these groups were not significant.

Data of feed conversion ratio FCR of fish showed that increasing the protein content in the diet from 16 to 28 % improved FCR significantly ($P < 0.05$). The best value of FCR was found with fish maintained at diet containing 28% protein level (1.64). While the worst FCR was found with fish maintained at diet containing 16 and 20 % crude protein levels values (2.09 and 2.10 respectively). However, results indicated that there were no considerable differences in FCR among fish given diets with the two different levels of energy.

Results of body composition of striped mullet are presented in Table 3. Moisture content of mullet in the end of experiment showed no significant differences ($P<0.05$) among treatments, it ranged between 68.97 and 71.17 %. Concerning lipid contents of the fish, results showed that lipid contents of fish increased significantly ($P < 0.05$) as energy level of the diets increased. The fish fed diets containing 250 kcal/100 g diet exhibited a lipid contents of 14.23, 14.62, 14.48 and 14.46% and they were significantly ($P < 0.05$) higher than those of fish fed 210 kcal/100 g diet which exhibited lipid contents of 13.81, 13.48, 13.57 and 13.82 % for the fish fed diets containing 16, 20, 24 and 28% protein level, respectively. However, irrespective of energy levels, the results did not show any significant effect of crude protein on lipid content of fish. On the other hand, results showed that protein contents of the fish increased significantly ($P < 0.05$) as protein level of the diets increased. The highest protein content was found with fish fed at 28% crude protein (15.89%), while the least protein content($P < 0.05$) was found with fish receiving a diet containing 16 or 20% crude protein (14.39 and 14.56% respectively). However, results did not show any significant ($P < 0.05$) effect of energy level on protein content of fish.

Values of protein efficiency ratio (PER), protein productive value (PPV %), and energy retention (ER %) of striped mullet *Mugil cephalus* are shown in Table 4. Data indicated that PER (Gain/protein fed) improved significantly ($P < 0.05$) by decreasing dietary protein level in the diet. The group of fish which received 16% crude protein gave better PER, than group fed on 20 or 24% crude protein while the least group were those fed 28% crude protein, values were 2.95,

Table (3). Mean ± Standard error of moisture, protein and lipid contents in the carcass of Striped mullet *Mugil cephalus* fed at different dietary protein and energy levels.

Diet No.	Energy level Kcal /100g	Protein levels %	Moisture % M ± SE	Protein % M ± SE	Lipid % M ± SE
	Initial		70.26 ± 1.24	14.29± 0.56	15.07 ± 1.32
T1	210	16	71.04 ± 2.5	14.34± 0.41d	13.81± 0.42 b
T2		20	71.17 ± 3.12	14.51± 0.35cd	13.48± 0.38 b
T3		24	70.62 ± 2.14	15.23± 0.71 b	13.57 ± 0.87 b
T4		28	69.98 ± 3.21	15.86± 0.56 a	13.82 ± 0.56 b
T5	250	16	70.29± 3.42	14.44± 0.48cd	14.23± 0.56 a
T6		20	70.18 ± 2.51	14.60± 0.70 c	14.62 ± 0.36 a
T7		24	68.97 ± 2.10	15.15 ± 0.24 b	14.48 ± 0.22 a
T8		28	69.16 ± 3.13	15.92± 0.18 a	14.46 ± 0.19 a
Pooled means					
	210		70.70 ± 2.53	14.98± 0.04 m	13.67 ± 0.23 n
	250		69.65 ± 3.71	15.03± 0.02 m	14.44 ± 0.25 m
		16	70.66 ± 1.34	14.39±0.02 z	14.21± 0.42 x
		20	70.68± 0.94	14.56±0.03 z	13.85 ± 0.84 x
			69.79 ± 2.43	15.19±0.04 y	14.02 ± 0.67 x
			69.57 ± 02.24	15.89±0.07 x	14.14 ± 0.64 x

- Means in each column followed by different letters are significantly different (P <0.05).

2.37, 2.11 and 2.17 respectively. Also, results show that PPV% (100 gained protein/protein fed) decreased significantly (P < 0.05) with increasing dietary protein levels. The best values of PPV% (P < 0.05) were obtained

Table (4). ***Means ± standard error of protein efficiency ratio (PER), protein productive value (PPV%) and energy retention (ER%) of Striped mullet Mugil cephalus fed at different dietary protein and energy levels.***

Diet No.	Energy level Kcal/100g	Protein levels %	PER M ± SE	PPV % M ± SE	ER % M ± SE
T1	210	16	2.93± 0. 07 a	42.11±2.3 a	28.19±0.54cd
T2		20	2.41± 0.08 b	35.65±1.62 bc	29.49±0.47bc
T3		24	2.14 ± 0.06 d	34.21±1.37 c	31.84±0.65 b
T4		28	2.09 ± 0.03 d	35.49±2.10 bc	38.26±1.24 a
T5	250	16	2.98 ± 0.05 a	44.08±2.47 a	26.60±0.63 d
T6		20	2.34 ± 0.03 b	34.91±1.61 bc	27.01±0.82 cd
T7		24	2.08 ± 0.04 d	32.73±1.32 c	28.66±1.01 cd
T8		28	2.25 ± 0.04 c	38.28±2.11 b	37.82±1.25 a
Pooled means					
	210		2.39± 0.24 m	36.86±3.14 m	32.19±2.71m
	250		2.41± 0.56 m	37.50±2.67 m	30.09±3.51m
		16	2.95 ± 0.04 x	43.09±1.02 x	27.39±1.44y
		20	2.37 ± 0.04 y	35.28±0.23 y	28.25±1.36y
		24	2.11 ± 0.03 z	33.47±0.94 y	30.25±2.45y
		28	2.17 ± 0.04 z	36.88±1.14 y	38.04±0.37x

Means in each column followed by different letters are significantly different (P < 0.05).
Protein efficiency ratio (PER) = gain/protein intake.
Protein productive value (PPV) = protein increment (100) / protein intake.
Energy retention percent (ER %) = energy increment (100) / energy intake.

with fish maintained at 16% crude protein with both energy levels (210 or 250 Kcal/100g). Values were 42.11 and 44.08% respectively. However, irrespective of energy level, results did not show any significant ($P < 0.05$) effect of energy level on PPV%. With respect to energy retention (ER %) results show that ER% was insignificantly affected by different energy levels in the diet, but with increasing dietary protein level ER% increased. Fish fed 28% protein with the two energy levels were significantly ($P < 0.05$) higher in their ER% than those fed the other diets (16, 20 and 24% crude protein with the two energy levels).

DISCUSSION

The results of the present work indicate that the diet containing 28% protein and energy level of 250 Kcal/100g is optimal for striped mullet *Mugil cephalus* advanced fry (1.62 g). This result is nearly similar reported by El-Dahhar (2000 a). He found that 26% dietary crude protein is the dietary crude protein needed for maximum growth and feed efficiency of striped mullet *Mugil cephalus* larvae 0.2 g fed at incremental dietary crude protein levels from 14 to 38%. El-Dahhar (2000 a) started his experiment with the wild salinity (brackish water) in which the larvae caught from (about 7 ppt), while in the present study fish were maintained at fresh water. The difference in water salinity may affect the growth of mullet fish. However, no data have been reported regarding larval growth in varying salinities during their rearing period. Some authors indicated that mullet fish prefer brackish water areas of subtropics (Gosline and Brock 1965; Nash and Shehadeh 1980). On the other side, these results are lower than those observed by El-Sayed and Teshima (1992) in previous study for *Liza ramada* reared in fresh water which required about 35 to 40% dietary crude protein for optimum growth. Moreover, the results obtained by Mabrouk (1991) on striped mullet *Mugil cephalus* fingerlings indicated that fingerlings reared in fresh water required 40% dietary crude protein level for optimum growth and best performance. These results are in agreement with that reported by Vallet *et al.* (1970) for grey mullet *Mugil capito* 0.8 and 3 g initial BW and for grey mullet 2.5 g initial BW by Paparaskeva – Papoutsoglou and Alexis (1986). Amer (2000) and El-Dahhar *et al.* (2006) indicated that 24% dietary crude protein was the best level for striped mullet fingerlings maintained under polyculture system. They concluded that, this wide range of protein required for best growth seems likely, that striped mullet utilizes protein for body growth more efficiently than *Liza ramada*.

Moreover, the decrease in dietary crude protein level for striped mullet in the previous study could be reflect the positive effect occurred when striped mullet polycultured with Nile tilapia fingerlings. However, variation in protein requirements in the previous studies is due to different reasons: fish size, feeding rates, environmental conditions, protein and energy quality and balance between dietary protein and dietary energy in the diet (Lovell, 1989).

In the present study, growth characteristics data of all dietary groups over the whole experimental period demonstrate that performance of striped mullet *Mugil cephalus* maintained at diet containing 250 kcal ME /100g was superior to the other treatments. These results confirm with what finding by El-Dahhar (2000b). He stated that mullet larvae get increasing dietary ME from 225 to 250 kcal / 100g diet exhibited significant increase in all growth measurements and improved feed conversion ratio FCR (P <0.01). The improvement of fish growth and feed utilization by increasing energy level in fish diet may be due to the protein-sparing effect by dietary lipid reported in some fish species (De Silva *et al.*, 1991; Lee *et al.*, 2002). Variations may be observed within studies concerning fish protein requirements. These variations may be due to the following two aspects besides fish species. One is experimental dietary P/E level. The other is the difference in dietary ingredients (Ai *et al.*, 2004). Therefore, the optimal dietary P/E ratio varied for the same physiological fuel values (Catacutan and Coloso, 1995; Webster *et al.*, 1995; Tibaldi *et al.*, 1996), which probably affects the accuracy of optimal dietary P/E ratio.

Survival rate at the end of the present experiment showed that there were significant differences (P < 0.05) among treatments (Table 2). In addition, survival rate improved significantly (P < 0.05) with increasing both of energy level in fish diet from 210 to 250 kcal/100g diet and dietary crude protein level from 16 to 28% .The improvement in fish survival rate may be due to the energy nutrient sparing action, that the fish can utilize dietary protein more efficiently if the energy level is increased without using the dietary protein as a source of energy (Jantrarotai *et al.*, 1998 and El-Dahhar, 2000 b). Cho and Kaushik (1990) noted that fish appear to adjust feed intake in order to satisfy digestible energy requirements. This results are nearly similar with what El-Dahhar (2000 b) are found for striped mullet larvae 0.2g. He indicated that striped mullet maintained at 26% dietary crude protein and 245 kcal ME / 100g in diet possessed superior growth characteristics, feed efficiency and survival rate.

In the present study fish oil was added to fish diets to achieve the dietary energy level of 250 Kcal/100g. El-Dahhar (2000a) concluded that striped mullet *M. cephalus* utilize energy with a low ratio of carbohydrate to lipid more efficiently and this resulted in a protein sparing effect. Also, Jantrarotai *et al.*, 1998 and Degani *et al.*, 1989) reported that Clarias catfish use lipid as a source of energy more efficiently than carbohydrate. Using fish oil as a source of energy in the present work which is rich in its content of (n_3 highly unsaturated fatty acid) improved fish performance. (Ng *et al.*, 2004) stated that fish oil is very important for feed utilization and fish health. Moreover, El-Tawil and Amer (2010) stated that fish oil in fish diets enhance feed utilization and all growth parameters. El-Dahhar, (2000b) in previous study reported that increasing the amount of energy in the form of lipid (about 15%) decreased dietary crude protein needed for maximum survival and growth from 26% to 22%. But the practice of increasing dietary lipid levels should be carefully considered as it may affect carcass quality, flavor, and storage characteristics, as a result of increased lipid deposition (Cowey 1993; Hillestad and Johnsen 1994).

Data of feed conversion ratio FCR (Table 2) in the present study showed that increasing the protein content in the diet from 16 to 28 % improved FCR significantly ($P < 0.05$). Similar results were obtained by Amer (2000) on striped mullet *Mugil cephalus* fingerlings under a polyculture system. He found that, total weight gain and feed conversion ratio FCR were better with the diet containing 24% crude protein than diet containing 12, 16 or 20% crude protein. Also, this agrees with results obtained by Paparaskeva *et al*. (1986) with young grey mullet *Mugil capito* (2.5g) who found that feed conversion ratio decreased with increasing dietary protein level up to 24% and there were no considerable differences in FCR among fish given diets with different levels of energy.

The data on carcass composition in the present study showed that carcass lipid content increased significantly ($P < 0.05$) with increasing dietary energy level. These results were in agreement with those reported in previous studies (El-Sayed and Teshima, 1992; Catacutan and Coloso, 1995; El-Zaeem *et al*., 2009). However, irrespective of energy levels, the results did not show any significant effect of crude protein on lipid content of fish. On the other hand, results showed that protein contents of the fish increased significantly ($P < 0.05$) as protein level of the diets increased. El-Sayed (1991) explained the positive correlation between dietary protein and body protein. He stated that, with high protein level in the diet, dietary fat was used as fuel while dietary protein was spared for growth.

The present study indicated also that PER, PPV% improved significantly ($P < 0.05$) by decreasing dietary protein level in the diet. The best values of PPV% ($P < 0.05$) were obtained with fish maintained at 16% crude protein with both ME levels (210 or 250 Kcal/100g). This agrees with results of Nile tilapia obtained by El-Zaeem *et al*. (2009) they found that fish fed diet contained 18% crude protein were higher significantly ($P < 0.05$) in PER and PR% (protein increment (100) / protein intake) than those maintained at 26% crude protein with two ME levels (244 or 260 Kcal/100g). In previous studies with other fish species, increasing dietary lipid level improved PER, PPV% and ER%, suggesting an obvious protein sparing effect of lipid (De Silva *et al.*, 1991; Vergara *et al.*, 1996; Company *et al.*, 1999; Nankervis *et al.*, 2000; Morais *et al.*, 2001). Also, Kim *et al.* (2010) stated that increasing dietary lipid level from 7 to 14% can improve growth and protein utilization irrespective of protein levels (40, 45, and 50%). Results show also that ER% was insignificantly affected by different energy levels in the diet, but with increasing dietary protein level ER% increased. Similar results were found by El-Zaeem *et al.* (2009) where ER% increased with increasing dietary protein level. Lee *et al.* (2000, 2003) reported that increasing dietary lipid from 7 to 16% at 30, 40, and 50% dietary protein levels did not appear to improve feed efficiency or show a clear protein-sparing effect.

Therefore, the result of the present work suggest that the diet containing 28% crude protein and ME of 250 Kcal/100g is the optimal for striped mullet *Mugil cephalus* advanced fry (1.62g) for maximum growth, survival and feed efficiency.

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تاثير مستويات مختلفة من البروتين والطاقة على النمو و كفاءة الاستفادة من الغذاء وتركيب الجسم لأسماك البوري

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اجريت هذه التجربة بمعمل إنتاج الأسماك بكلية الزراعة (سابا باشا) جامعة الإسكندرية لدراسة تأثير مستويات مختلفة من البروتين والطاقة على النمو والحيوية وكفاءة الاستفادة من الغذاء لصغار أسماك البوري ذات وزن ابتدائى(١,٦٢ جم) ، تم تكوين ثمان علائق تجريبية (أربع مستويات من البروتين ١٦و ٢٠ و٢٤ و ٢٨% كل منهم بمستويين من الطاقة ٢١٠ و ٢٥٠ كيلو كالورى طاقة ميتابوليزمية /١٠٠ جرام غذاء) وذلك لتغذية الأسماك عليهم مرتين يوميا حتي الاشباع في ثلاث مكررات لكل معاملة لمدة عشرة أسابيع ، وقد أوضحت النتائج في نهاية التجربة زيادة كل من الوزن النهائى للأسماك والوزن المكتسب ومعدل النمو النوعي زيادة معنوية بزيادة مستوي البروتين في الغذاء حيث وجد أن الأسماك التى تغذت على مستوي بروتين ٢٨% كانت الأعلى معنويا بالنسبة لكل القياسات السابقة مقارنة بباقى المعاملات بينما لم يكن هناك اي فرق معنوي بين مستويي الطاقة في الغذاء لتلك القياسات. كذلك أوضحت النتائج أن أفضل معدل لتحويل الغذاء كان في المعاملة التي تغذت فيها الأسماك على مستوي بروتين ٢٨% مع مستوي طاقة ٢٥٠ كيلو كالورى / ١٠٠ جرام غذاء. كما زادت معدلات حيوية أسماك البوري معنويا مع زيادة مستوي الطاقة والبروتين في الغذاء . أوضحت النتائج أيضا أن محتوي جسم الأسماك من الرطوبة والبروتين لم يتأثر معنويا بالمعاملات بينما زاد محتوي جسم الاسماك من الدهون معنويا مع زيادة مستوي الطاقة في الغذاء في حين لم يؤثر مستوي بروتين الغذاء على محتوي جسم الاسماك من الدهون. و بالنسبة لمعدل كفاءة البروتين وقيم إنتاجية البروتين فقد تحسنت معنويا مع إنخفاض مستوى البروتين في الغذاء، كما ان أعلى مستوي معنوي للطاقة المحتجزة في جسم الأسماك وجد في الأسماك التى تغذت على مستوي بروتين ٢٨%. مما سبق وتحت ظروف التجربة الحالية يتضح أن معدل بروتين الغذاء ٢٨% مع مستوي طاقة ميتابوليزمية ٢٥٠ كيلو كالورى / ١٠٠ جرام غذاء هو المستوي الأمثل لصغار أسماك البوري

ذات الوزن الابتدائي ١,٦٢ جم لتحقيق أفضل نمو وأداء للأسماك وكفاءة الاستفادة من الغذاء.