4. RESULTS AND DISCUSSION

4.1. First Experiment:

4.1.1. Effect of dietary protein and energy levels on growth performance of Nile tilapia of small initial size (22.87 g):

4.1.1.1. Body weight:

The effect of dietary protein and energy levels on body weight (BW) of Nile tilapia fish of small initial size (22.87 g) is shown in Table (3) and analysis of variance for the same factors are illustrated in Table (4). At the start of the experiment, the initial BW of fish within all treatment groups was nearly similar (ranged between 22.40 and 23.23 g). At the end of the experiment (180 days), fish of treatment PL2EL2 (25% CP and 3000 kcal ME/kg) showed the highest final BW (126.33 g), while those of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) recorded the lowest one (92.40 g) as presented in Table (3). The previous results are in good agreement with those reported by **Samra (2002)** who reported that the best final BW of Nile tilapia (*Oreochromis niloticus*) with initial size of about 15 g was recorded with the diet contained 30% CP and 3000 kcal/kg.

Data in Table (3) cleared that fish fed the diet with 30% CP (PL3) showed the highest final BW (117.07 g) followed by those fed the 25% dietary CP level (PL2) being 114.37 g, with no significant differences in BW between the two levels of CP. The lowest ($P<0.05$) final BW was achieved by fish fed the 20% CP

Table (3): Least square means and standard errors for the effect of different dietary protein and energy levels on body weight (g) of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Initial body weight		Final body weight	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	23.05±0.23	91	97.66±4.72 b
25% CP (PL2)	96	22.63±0.23	90	114.37±4.71 a
30% CP (PL3)	96	22.95±0.23	87	117.70±4.83 a
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	22.72±0.23	89	112.33±4.37 a
3000 kcal ME /kg (EL2)	96	22.99±0.23	90	114.51±4.35 a
3500 kcal ME /kg (EL3)	96	22.91±0.23	89	102.20±4.32 b
PL×EL				
PL1×EL1	32	22.72±0.39	30	92.40±3.35 d
PL1×EL2	32	23.23±0.39	31	96.40±3.54 d
PL1×EL3	32	23.20±0.39	30	104.22±3.35 cd
PL2×EL1	32	22.40±0.39	30	119.70±5.35 abc
PL2×EL2	32	22.55±0.39	30	126.33±5.35 a
PL2×EL3	32	22.95±0.39	30	97.14±4.35 d
PL3×EL1	32	23.05±0.39	29	124.90±4.37 ab
PL3×EL2	32	23.20±0.39	29	120.81±4.37 abc
PL3×EL3	32	22.59±0.39	29	105.53±4.37 cd

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$)different

Table (4): Analysis of variance for the effect of different dietary protein and energy levels on body weight of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Initial body weight		Final body weight	
	df	F-ratio	df	F-ratio
Protein level (PL)	2	0.389	2	16.5 **
Energy level (EL)	2	0.931	2	6.17 *
PL×EL	4	0.693	4	6.2 *
Remainder df	279		259	
Remainder MS		4.8727		599.479

* = $P<0.05$ ** = $P < 0.01$

dietary level (PL1) being 97.66 g. These results are in accordance with those reported by **Samra (2002)** who indicated that final BW of Nile tilapia (initial weight of about 15 g) increased significantly ($P<0.05$) with increasing the dietary CP from 20 to 25 and 30%. Similarly, **Cruz and Laudncia (1977)** reported that dietary protein requirements of tilapia for fast growth at a size of 10-30 g lay between 20 and 30%. **Viola and Zohar (1984)** found that increasing dietary protein level of hybrid tilapia (*O. niloticus* × *O. aureus*) from 25 to 30 or 35% increased significantly growth rate. Also, **Abdel-Hakim et al., (2001 b)** concluded that increasing dietary protein level from 25 to 30% increased ($P<0.05$) fish body weight of Nile tilapia (*O. niloticus*)

With regard to the effect of dietary energy level on live BW of Nile tilapia, results in Table (3) indicated that the best final BW (114.51 g) was recorded with fish fed the diet contained 3000 kcal ME/kg, followed by that of fish fed the 2500 kcal ME/kg energy level being 112.33 g, the differences between the two levels of energy were not significant. Whereas, fish fed the diet with 3500 kcal ME/kg achieved the lowest ($P<0.05$) final BW (102.20 g). Similar results were achieved by **Samra (2002)** who found that the highest final BW of Nile tilapia (15 g, initial weight) was obtained with fish fed the dietary 3000 kcal ME/kg energy level. Increasing the energy level to 3300 or 3600 kcal/kg diet, significantly decreased final BW. **Shiau and Haung (1990)** indicated that excess of dietary energy may reduce feed intake which in turn reduce protein intake and inhibit proper utilization of other feed nutrients. Also, increasing dietary energy produce fatty fish.

4.1.1.2. Weight gain

Results of weight gain (WG) of Nile tilapia as affected by dietary protein and energy levels and their interactions are presented in Table (5). Analysis of variance for the same factors is shown in Table (6). Fish fed the diet contained 25% CP and 3000 kcal ME/kg (treatment PL2EL2) recorded the highest WG (103.78 g) and those fed the diet with 20% CP and 2500 kcal ME/kg (treatment PL1EL1) showed the lowest one (69.68 g), Table (5). In this connection **Samra (2002)** reported that Nile tilapia fish (15 g, initial weight) fed on diet contained 30% CP and 3000 kcal/kg recorded the highest WG.

Data in Table (5) indicated that WG of Nile tilapia fish showed the same trend observed with final BW, as the highest WG (94.15 g) was achieved by fish fed the 30% (PL3) dietary CP level, followed by that of fish fed diets with 25% CP (PL2) being 91.69 g, the difference in WG between the two dietary CP levels were not significant. The lowest WG ($P<0.05$) was recorded by fish of treatment PL1 (20% dietary CP level) being 74.67 g. In other words, increasing dietary CP improved WG of Nile tilapia. **Wee and Tuan (1988)** came to the same conclusion that increasing dietary CP from 22 to 25% significantly improved daily WG of Nile tilapia. Similarly **El-Dahhar (1994)** found that WG of Nile tilapia (*O. niloticus*) fry and fingerlings increased linearly with increasing dietary CP contents. Also, **Cisse (1996)** reported that tilapia fed a 20% CP diet showed

Table (5): Least square means and standard errors for the effect of different dietary protein and energy levels on weight gain (g) of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Weight gain	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	91	74.67±2.57 b
25% CP (PL2)	90	91.69±2.58 a
30% CP (PL3)	87	94.15±2.63 a
Energy level (EL)		
2500 kcal ME /kg (EL1)	89	89.66±4.39 a
3000 kcal ME /kg (EL2)	90	91.53±4.36 a
3500 kcal ME /kg (EL3)	89	79.31±4.39 b
PL×EL		
PL1×EL1	30	69.68±4.38 c
PL1×EL2	31	73.17±4.35 c
PL1×EL3	30	81.02±4.38 b
PL2×EL1	30	97.30±4.38 ab
PL2×EL2	30	103.78±4.38 a
PL2×EL3	30	74.19±4.38 c
PL3×EL1	29	101.85±4.40 a
PL3×EL2	29	97.61±4.40 ab
PL3×EL3	29	82.94±4.40 b

a, b and c means in the same column with different superscripts are significantly (P<0.05)different

Table (6): Analysis of variance for the effect of different dietary protein and energy levels on weight gain of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Weight gain	
	df	F-ratio
Protein level (PL)	2	16.86 **
Energy level (EL)	2	6.23 *
PL×EL	4	6.21 *
Remainder df	259	
Remainder MS		601.3

* = P<0.05 ** = P<0.01

poorer WG compared to those fed 30% CP diet. In 2002, **Samra** claimed that WG of Nile tilapia (15 g initial weight) increased significantly (P<0.05) with increasing dietary CP from 20 to 25 and 30%.

Values of WG of fish presented in Table (5) cleared that fish fed the 3000 kcal ME/kg energy level (EL2) achieved the highest (91.53 g) WG followed by those fed 2500 kcal ME/kg diet (89.66 g), with no significant differences in WG values, while fish fed 3500 kcal ME/kg dietary energy level (EL3) showed the lowest (P<0.05) WG values (79.31 g), indicating the same trend observed with final BW. In agreement with the previous results, **Samra (2002)** concluded that Nile tilapia fed the diet with 3000 kcal/kg showed the best WG and increasing the dietary energy level to 3300 or 3600 kcal/kg significantly decreased WG. **El-Saidy and Gaber (2002)** found that WG of Nile tilapia fed 10-12% lipid diets was higher than that of fish fed 14% dietary lipid.

4.1.1.3. Body length:

The effect of dietary protein and energy levels and their interactions on body length (BL) of Nile tilapia is shown in Table (7). Analysis of variance for results obtained are illustrated in Table (8). Averages of BL at the start of the experiment ranged between 11.23 and 12.17 cm, with no significant differences among treatment groups. At the termination of the experiment, fish of treatment PL3EL1 (30% CP and 2500 kcal ME/kg) recorded the longest final BL (19.27 cm) and those of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) achieved the shortest one being 17.49 cm as illustrated in Table (7). However, Table (7): Least square means and standard errors for the effect of different dietary protein and energy levels on body length (cm) of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Initial body length		Final body length	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	12.13±0.09	91	17.87±0.26 b
25% CP (PL2)	96	11.77±0.09	90	18.71±0.16a
30% CP (PL3)	96	11.91±0. 09	87	18.86±0.36 a
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	11.76±0. 09	89	18.64±0.28 a
3000 kcal/kg ME (EL2)	96	11.96±0. 09	90	18.67±0.16a
3500 kcal ME/kg (EL3)	96	12.09±0. 09	89	18.12±0.27 b
PL×EL				
PL1×EL1	32	12.06±0.16	30	17.49±0.28b
PL1×EL2	32	12.17±0.16	31	17.63±0.26 b
PL1×EL3	32	12.17±0.16	30	18.48±0. 28 ab
PL2×EL1	32	11.23±0.16	30	19.15±0. 28 a
PL2×EL2	32	11.99±0.16	30	19.22±0. 28 a
PL2×EL3	32	12.10±0.16	30	17.76±0. 28b
PL3×EL1	32	12.00±0.16	29	19.27±0. 28 a
PL3×EL2	32	11.73±0.16	29	19.17±0. 28 a
PL3×EL3	32	12.00±0.16	29	18.13±0. 28ab

a and b means in the same column with different superscripts are significantly ($P<0.05$)different

Table (8): Analysis of variance for the effect of different dietary protein and energy levels on body length of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Initial body length		Final body length	
	df	F-ratio	df	F-ratio
Protein level (PL)	2	1.44	2	11.05 **
Energy level (EL)	2	0.57	2	3.51 *
PL×EL	4	0.47	4	6.97 *
Remainder df	279		259	
Remainder MS		0.7978		2.2955

* = $P<0.05$ ** = $P<0.01$

Samra (2002) reported that the longest BL was recorded with Nile tilapia fed the diet contained 30% CP and 3000 kcal/kg and the shortest one was shown by fish fed 20% dietary CP level with 3600 kcal/kg diet.

The longest final BL (18.86 cm) was recorded by fish fed the diet contained 30% CP, followed by that of fish fed 25% dietary CP level being 18.71 cm. Whereas, the shortest BL (17.87 cm) was achieved by fish of treatment PL1 (20% CP) as presented in Table (7). Analysis of variance (Table 8) cleared that PL had significant ($P<0.01$) effect on the final BL of fish, the differences in final BL of fish fed the PL1 (20% CP) level and each of fish fed either 25% CP or 30% CP (PL2 or PL3) were significant ($P<0.05$). While, no significant differences were detected in BL of fish fed on PL2 and those fed on PL3. Similar results were reported by **Abdel-Hakim *et al.* (2001 b).** They found that Nile tilapia fed on 30% dietary CP level showed significantly ($P<0.05$) higher BL than those fed the 25% CP diet. Also, **Samra (2002)** concluded that BL of Nile tilapia fed the diet contained 30% CP was significantly ($P<0.05$) higher than that of fish fed either the 20% or 25% CP level.

Results in Table (7) showed that the longest final BL was recorded by fish fed 3000 and 2500 kcal ME/kg diet (EL2 and EL1 energy levels) being 18.67 and 18.64 cm, respectively, and the shortest ($P<0.05$) final BL (18.12 cm) was shown by fish fed the 3500 kcal ME/kg energy level (EL3). The differences in final BL of fish due to energy level effect were significant ($P<0.05$), Table (8). In accordance with the previous results, **Samra (2002)** reported that increasing the dietary energy level from 3000 to

3300 and 3600 kcal/kg decreased ($P<0.05$) BL of Nile tilapia and this effect may be attributed to the decline in feed consumption related to the higher dietary energy contents. **Shiau and Haung (1990)** also suggested that excess of dietary energy may reduce feed consumption.

4.1.1.4. Condition factor:

Results of condition factor (K) values of Nile tilapia fish as affected by dietary protein and energy levels and their interactions are illustrated in Table (9). Statistical analysis for the same factors is shown in Table (10). Averages of initial K values ranged between 1.70 and 1.82 with no significant differences between all treatments at the start of the experiment. The highest final K value (2.03) at the end of the experiment was recorded by fish of treatment PL2EL3 (25% CP and 3500 kcal ME/kg), whereas the lowest value (1.90) was achieved by fish of treatments PL1EL1 (20% CP and 2500 Kcal ME/kg) and PL2EL2 (25% CP and 3000 kcal ME/kg), Table (9).

Data in Table (9) showed that PL had little effect on final K values, it varied between 1.93 for fish fed PL3 (30% CP) and 1.95 (fish fed PL1, 20% CP), the differences between K among CP levels values were not significant. Similar results were found by **Samra (2002)**. Who indicated that the differences in K values of Nile tilapia (15 g, initial weight) due to CP level (20, 25 and 30%) effect were not significant.

Fish fed EL3 (3500 kcal ME/kg) showed slightly higher K value (1.95) than those fed either EL2 or EL1, being 1.93 and 1.94, respectively, with no significant differences among the

Table (9): Least square means and standard errors for the effect of different dietary protein and energy levels on condition factor of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Initial condition factor		Final condition factor	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	1.71±0.08	91	1.95±0.04
25% CP (PL2)	96	1.81±0.08	90	1.94±0.05
30% CP (PL3)	96	1.79±0.08	87	1.93±0.07
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	1.77±0.05	89	1.94±0.06
3000 kcal ME/kg (EL2)	96	1.76±0.05	90	1.93±0.07
3500 kcal ME/kg (EL3)	96	1.78±0.05	89	1.95±0.05
PL×EL				
PL1×EL1	32	1.71±0.06	30	1.90±0.05
PL1×EL2	32	1.70±0.06	31	2.00±0.04
PL1×EL3	32	1.73±0.06	30	1.96±0.05
PL2×EL1	32	1.80±0.06	30	1.93±0.05
PL2×EL2	32	1.81±0.06	30	1.90±0.05
PL2×EL3	32	1.82±0.06	30	2.03±0.05
PL3×EL1	32	1.80±0.06	29	2.02±0.07
PL3×EL2	32	1.77±0.06	29	1.91±0.07
PL3×EL3	32	1.79±0.06	29	1.93±0.07

Table (10): Analysis of variance for the effect of different dietary protein and energy levels on condition factor of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Initial condition factor		Final condition factor	
	df	F-ratio	df	F-ratio
Protein level (PL)	2	0.232	2	0.661
Energy level (EL)	2	0.341	2	0.812
PL×EL	4	0.413	4	0.372
Remainder df	279		259	
Remainder MS		0.033		0.064

three energy levels in K values (Table 9). However, **Samra (2002)** reported that increasing the dietary energy level from 3000 to either 3300 or 3500 kcal/kg significantly ($P<0.05$) decreased K values of Nile tilapia.

4.1.1.5. Specific growth rate:

Averages of specific growth rate (SGR) of Nile tilapia as affected by dietary protein and energy levels and their interactions are presented in Table (11) and the analysis of variance for these averages are shown in Table (12). The highest SGR value (0.98) was achieved by fish of treatment PL2EL1 (25% CP and 2500 Kcal ME/kg) and the lowest value (0.78) was obtained by fish of treatment PL3EL3 (30% CP and 3500 kcal ME/kg) as illustrated in Table (11).

As presented in Table (11), SGR values increased with increasing the PL from 20 to 25%, being 0.84 and 0.96, respectively, while it decreased to reach 0.88 with increasing the PL to 30%. Analysis of variance (Table 12) revealed that PL exerted significant ($P<0.05$) effect on SGR values. The differences in SGR values between PL2 (25% CP) and each of PL1 and PL3 were significant, while those between PL1 and PL3 were not significant. In accordance with the previous results, **El-Dahhar (1994)** reported that the best growth of tilapia fry (1.0 g) was achieved with 30% dietary CP. **Hafedh (1999)** revealed that growth rate of Nile tilapia was significantly increased as dietary CP level increased from 25 to 45% (with 5% increments). Also, **Ogunji and Wirth (2000)** reported that SGR of Nile tilapia increased with increasing CP in the diet from 7.3 to 44.2%.

Table (11): Least square means and standard errors for the effect of different dietary protein and energy levels on specific growth rate of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Specific growth rate	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	91	0.84±0.15 b
25% CP (PL2)	90	0.96±0.17 a
30% CP (PL3)	87	0.88±0.19 b
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	0.98±0.12 a
3000 kcal ME /kg (EL2)	90	0.88±0.11 b
3500 kcal ME/kg (EL3)	89	0.81±0.12 b
PL×EL		
PL1×EL1	30	0.85±0.12 c
PL1×EL2	31	0.83±0.10 cd
PL1×EL3	30	0.84±0.12 c
PL2×EL1	30	0.98±0.12 a
PL2×EL2	30	0.95±0.12 ab
PL2×EL3	30	0.80±0.12 d
PL3×EL1	29	0.96±0.13 ab
PL3×EL2	29	0.90±0.13 bc
PL3×EL3	29	0.78±0.13 d

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$)different

Table (12): Analysis of variance for the effect of different dietary protein and energy levels on specific growth rate of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Specific growth rate	
	df	F-ratio
Protein level (PL)	2	6.16 *
Energy level (EL)	2	18.24 **
PL×EL	4	3.32 *
Remainder df	259	
Remainder MS		0.0143

* = $P<0.05$ ** = $P<0.01$

Abdel-Hakim *et al.* (2001 b) found that SGR for Nile tilapia (*O. niloticus*) was improved when the dietary CP increased from 25 to 30%. **Samra (2002)** came to the same conclusion using three levels of dietary CP (20, 25 and 30%) in diets of growing rearing Nile tilapia. However, **Tacon and Cowey (1985)** concluded that SGR was positively correlated to the dietary CP content.

Results in Table (11) showed that fish fed the lower EL (2500 kcal ME/kg) had the highest SGR value (0.98) and these fed the higher EL (3500 kcal ME/kg) had the lowest value (0.81). The differences in SGR values between EL1 and each of EL2 and EL3 were significant ($P<0.05$), while those between the formentioned two levels were not significant. In full agreement with the previous results, **Samra (2002)** reported that SGR of Nile tilapia significantly decreased with increasing the dietary energy level from 3000 to 3300 and 3600 kcal/kg and the effect perhaps due to decrease of feed consumption from higher energy content diets. However, **Sddiqui *et al.* (1988)** found that the best growth of young Nile tilapia (*O. nilotius*) was obtained with the diet contained 8% lipid compared with that of fish fed either 6, 9 or 11% dietary lipid content. **Hanely (1991)** reported that tilapia fish are able to store significant quantities of lipids in the carcass and viscera, but not able to utilize this energy to improve growth.

4.1.2. Effect of dietary protein and energy levels on feed utilization of Nile tilapia of small initial size (22.87 g):

4.1.2.1. Means of feed, protein and energy intakes:

Results in table (13) showed that feed intake increased with increasing the PL from 20 to 25%, then slightly decreased with increasing the PL to 30%. Values of protein and energy intakes

Table (13): Means of feed, protein and energy intakes of Nile tilapia (initial weight 22.87 g) reared for 180 days as affected by different dietary protein and energy levels.

Items	No.	Feed intake (g)	Protein intake (g)	Energy intake (kcal ME)
		Means	Means	Means
Protein level (PL)				
20% CP (PL1)	91	192.83	39.01	580.38
25% CP (PL2)	90	222.63	54.96	664.10
30% CP (PL3)	87	220.33	65.59	668.01
Energy level (EL)				
2500 kcal ME/kg (EL1)	89	205.07	51.63	518.28
3000 kcal ME /kg (EL2)	90	212.80	53.80	645.82
3500 kcal ME/kg (EL3)	89	214.87	54.13	748.39
PL×EL				
PL1×EL1	30	179.81	36.53	454.75
PL1×EL2	31	200.33	39.66	593.87
PL1×EL3	30	198.42	40.83	692.51
PL2×EL1	30	234.81	58.12	589.79
PL2×EL2	30	219.51	54,19	658.06
PL2×EL3	30	213.62	52.57	744.46
PL3×EL1	29	200.63	60.23	510.32
PL3×EL2	29	227.83	37.55	685.52
PL3×EL3	29	232.61	68.99	808.20

increased with each increase in PL from 20 to 25 and 30%. Values of feed nutrients intake were 192.83, 222.63 and 220.33 g feed, 39.01, 54.96 and 65.59 g CP and 580.38, 664.10 and 668.01 kcal ME for fish fed diets with 20, 25 and 30% CP, respectively.

Values of feed, protein and energy intakes increased with increasing the EL from 2500 to 3000 and 3500 kcal ME/kg, being 205.07, 212.80 and 214.87 g feed, 51.63, 53.80 and 54.13 g CP and 518.28, 645.82 and 748.39 kcal ME for fish fed EL1, EL2 and EL3 irrespective of CP level, respectively, as presented in Table (13).

However, the highest feed intake (234.81 g) was recorded by fish of PL2EL1 (25% CP and 2500 kcal ME/kg) treatment followed by that of fish of treatment PL3EL3 (30% CP and 3500 kcal ME/kg), being 232.61 g. Whereas the lowest feed intake (179.80 g) was achieved by fish of treatments PL1EL1 (20% CP and 2500 kcal ME/kg). Fish of treatment PL3EL3 (30% CP and 3500 kcal ME/kg) consumed the highest CP and energy intakes (68.99 g and 808.2 kcal ME, respectively), while those of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) recorded the lowest intakes, being 36.53g CP and 454.75 kcal ME (Table 13).

4.1.2.2. Feed conversion ratio:

The effect of dietary protein and energy levels and their interactions on feed conversion ratio (FCR) of Nile tilapia are shown in Table (14). Results of this table showed that the best FCR value (2.12) was achieved by fish fed on PL3EL1 (30% CP and 2500 kcal ME/kg) diet, whereas, the poorest one (2.94) was recorded by fish of PL3EL3 (30% CP and 3500 kcal ME/kg) treatment.

Data presented in Tables (14 and 15) showed that the best FCR (2.33) was obtained with Nile tilapia fed 25% dietary CP level (PL2), followed by that of fish fed 30% CP level (PL3) being 2.43. The differences in FCR between fish fed the two CP levels i-e-25 and 30 % were not significant. Whereas, the poorest ($P<0.05$) FCR (2.58) was recorded by fish fed the lowest PL (20% CP, PL1). In another words, FCR's for Nile tilapia improved with increasing PL from 20% to 25% or 30%. In agreement with the previous results, **Siddiqui *et al.* (1988)** revealed that, FCR for fry and young Nile tilapia improved as dietary protein level increased from 20 to 30% and decreased when the diet contained 40 and 50% protein. Similarly, **Watanabe *et al.* (1990)** found that FCR for Florida red tilapia was better in fish fed the diet of 32% CP than that in fish fed the diet contained 28% CP. **El-Dahhar (1994)** reported that, FCR was significantly improved with increasing CP level from 17-30% for Nile tilapia fry and from 17-22% for Nile tilapia fingerlings. **Cisse (1996)**; **Hafedh (1999)** and **Samra (2002)** came to the same conclusion that FCR of Nile tilapia was improved with increasing in dietary CP level.

Fish fed the lowest energy level (2500 kcal ME/kg) recorded the best FCR (2.30) followed by those fed the 3000 kcal ME/kg level, being 2.37, with no significant differences (Table, 14). The poorest ($P<0.05$) FCR value (2.63) was achieved by fish fed the highest energy level (3500 kcal ME/kg). The previous results are in complete accordance with those

Table (14): Least square means and standard errors for the effect of different dietary protein and energy levels on feed conversion ratio (g feed/g gain) of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Feed conversion ratio	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	91	2.58±0.21 a
25% CP (PL2)	90	2.33±0.24 b
30% CP (PL3)	87	2.43±0.29 b
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	2.30±0.21 b
3000 kcal ME /kg (EL2)	90	2.37±0.20 b
3500 kcal ME/kg (EL3)	89	2.63±0.21 a
PL×EL		
PL1×EL1	30	2.50±0.33 bc
PL1×EL2	31	2.81±0.32 ab
PL1×EL3	30	2.32±0.33 bc
PL2×EL1	30	2.33±0.33 bc
PL2×EL2	30	2.04±0.33 d
PL2×EL3	30	2.72±0.33 ab
PL3×EL1	29	2.12±0.25 d
PL3×EL2	29	2.33±0.35 bc
PL3×EL3	29	2.94±0.35 a

a, b and c means in the same column with different superscripts are significantly (P<0.05)different

Table (15): Analysis of variance for the effect of different dietary protein and energy levels on feed conversion ratio of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Feed conversion ratio	
	df	F-ratio
Protein level (PL)	2	2.31*
Energy level (EL)	2	6.49 *
PL×EL	4	10.49 *
Remainder df	259	
Remainder MS		0.335

* = P<0.05 ** = P<0.01

reported by **Samra (2002)** who found that decreasing the dietary energy level from 3600 to 3300 and 3000 kcal/kg improved the FCR of Nile tilapia. **Chou and Shiau (1996)** and **El-Saidy and Gaber (2002)** reported that FCR for hybrid tilapia (*O. niloticus* × *O. aureus*) improved with decreasing dietary lipid contents from 20 to 15, 10, 5 and 0%. **El-Dahhar and Lovell (1995)** concluded that, excess energy may inhibit proper utilization of feed stuffs by fish.

4.1.2.3. Protein efficiency ratio:

Averages of protein efficiency ratio (PER) of Nile tilapia as affected by dietary protein and energy levels and their interactions are illustrated in Table (16) and the analysis of variance of results are presented in Table (17). The highest (best) PER value (2.33) was shown by fish of treatment PL2EL1, (25% CP and 2500 kcal ME/kg), while the lowest (poorest) value (1.23) was recorded by fish of treatment PL3EL3, (30% CP and 3500 kcal ME/kg) as shown in Table (16).

With respect to the effect of PL on PER values, results in Table (16) cleared that these values increased with increasing the dietary CP level from 20% to 25%, then slightly decreased with increasing the PL from 25 to 30%. Fish fed 25 and 30% dietary CP levels (PL2 and PL3) recorded the best PER values being 1.87 and 1.83, respectively, with no significant differences between the two levels of protein. Whereas, fish fed the lower PL (20% CP) showed the poorest ($P<0.05$) PER value, being 1.57. Similar results were reported by **Cisse (1996)** who found that, PER values was improved with each increase in protein

Table (16): Least square means and standard errors for the effect of different dietary protein and energy levels on protein efficiency ratio (g gain/g CP intake) of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Protein efficiency ratio	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	91	1.57±0.04 b
25% CP (PL2)	90	1.87±0.04 a
30% CP (PL3)	87	1.83±0.04 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	2.17±0.04 a
3000 kcal ME/kg (EL2)	90	1.77±0.04b
3500 kcal ME/kg (EL3)	89	1.33±0.04 c
PL×EL		
PL1×EL1	30	1.72±0.07 c
PL1×EL2	31	1.51±0.07 cd
PL1×EL3	30	1.51±0.07 cd
PL2×EL1	30	2.33±0.07 a
PL2×EL2	30	2.02±0.07 b
PL2×EL3	30	1.32±0.07 d
PL3×EL1	29	2.51±0.07 a
PL3×EL2	29	1.84±0.07 b
PL3×EL3	29	1.23±0.07 d

a, b, c and d means in the same column with different superscripts are significantly (P<0.05)different

Table (17): Analysis of variance for the effect of different dietary protein and energy levels on protein efficiency ratio of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Protein efficiency ratio	
	df	F-ratio
Protein level (PL)	2	12.77 *
Energy level (EL)	2	74.9 **
PL×EL	4	15.72 *
Remainder df	259	
Remainder MS		0.168

* = P<0.05   ** = P<0.01

content of tilapia diet. However, **El-Dahhar (1994)** and **Twibell and Brown (1998)** found that, increasing dietary CP level had no significant effect on PER's for fry and fingerlings on Nile tilapia (*O. niloticus*). Whereas, **Siddiqui *et al.* (1988)** found that, PER for Nile tilapia decreased with increasing dietary protein level from 20 to 50%. **Shiau and Huang (1989)** came to the same conclusion that PER of Nile tilapia fed purified diets decreased with increasing dietary protein level from 0 to 56% (in 8% increments). Similarly, **Samra (2002)** reported that PER values for Nile tilapia decreased significantly ($P<0.05$) with increasing dietary CP level from 20% to 25% and 30%.

Results in Table (16) indicated that PER values decreased significantly ($P<0.01$) with increasing the EL from 2500 to 3000 and 3500 kcal ME/kg. The best PER value (2.17) was achieved by fish fed 2500 kcal ME/kg (EL1), followed by those fed the EL2 (3000 kcal ME/kg), being 1.77. While the lowest (poorest) PER value (1.33) was recorded by fish fed 3500 kcal ME/kg (EL3). The differences in PER values between each EL and the others were significant ($P<0.05$). Similar results were reported by **Samra (2002)** who indicated that PER values for Nile tilapia decreased with increasing dietary energy level from 3000 to 3300 and 3600 kcal/kg, and the differences between PER means attributed to dietary energy level were significant. **Chou and Shiau (1996)** found that, increasing lipid level in hybrid tilapia (*O. niloticus* × *O. aureus*) diets from 10 to 15 and 20% decreased PER values. Also, **El-Saidy and Gaber (2002)** revealed that, Nile tilapia fed diets with 10-12% fat recorded higher PER values than those fed diets with 12, 14, 16 and 18% fat.

4.1.2.4. Protein productive value:

The effect of dietary protein and energy levels and their interactions on protein productive value (PPV%) of Nile tilapia are illustrated in Table (18). Results of this table cleared that the best PPV (43.98%) was achieved by fish of treatment PL3EL2 (30% CP and 2500 kcal ME/kg) and the poorest one (23.32%) was recorded by fish of treatment PL1EL3 (20% CP and 3500 kcal ME/kg). In this respect, **Wafa (2002)** found that the best PPV was recorded by hybrid Nile tilapia fed the diet contained 25% CP and 2000 kcal ME/kg and the poorest value was shown by fish fed 25% CP and 2500 kcal ME/kg diet.

Data in Table (18) revealed that PPV's increased with increasing the PL from 2o to 25% and 30% being 30.21, 35.98 and 38.21%, respectively, indicating that fish utilize the dietary protein more efficient with each increase in PL, and the differences in PPV's due to PL effect were significant ($P<0.05$) as shown in Table (19). The differences in PPV% between PL1 (20% CP) and each of PL2 (25% CP) and PL3 (30% CP) were significant, whereas no significant differences were detected between PL2 and PL3. Similar results were reported by **Mazid et al., (1979)** who reported that PPV's of Nile tilapia increased linearly with increasing dietary CP levels from 21 to 30%, while it decreased as dietary CP level increased from 34.7 to 53.64%. Also, **Goda (1996)** revealed that PPV's of Nile tilapia (*O. niloticus*) increased ($P<0.05$) with increasing the dietary protein

Table (18): Least square means and standard errors for the effect of different dietary protein and energy levels on protein productive value of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Protein productive value	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	24	30.21±1.66 b
25% CP (PL2)	24	35.98±1.66 a
30% CP (PL3)	24	38.21±1.66 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	24	39.65±1.66 a
3000 kcal ME/kg (EL2)	24	35.80±1.66 b
3500 kcal ME/kg (EL3)	24	28.95±1.66 c
PL×EL		
PL1×EL1	8	40.06±2.88 ab
PL1×EL2	8	27.26±2.88 c
PL1×EL3	8	23.32±2.88 c
PL2×EL1	8	42.65±2.88 a
PL2×EL2	8	36.17±2.88 b
PL2×EL3	8	29.12±2.88 c
PL3×EL1	8	36.25±2.88 b
PL3×EL2	8	43.98±2.88 a
PL3×EL3	8	34.41±2.88 bc

a, b and c means in the same column with different superscripts are significantly (P<0.05)different

Table (19): Analysis of variance for the effect of different dietary protein and energy levels on protein productive value of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Protein productive value	
	df	F-ratio
Protein level (PL)	2	18.40 *
Energy level (EL)	2	32.00 **
PL×EL	4	10.82 *
Remainder df	63	
Remainder MS		66.352

* = P<0.05 ** = P<0.01

level from 20 to 25 and 30%. Whereas, **Viola and Zohar (1984)** and **Wafa (2002)** indicated that PPV's for hybrid tilapia decreased with increasing the dietary protein level from 25 to 30 and 35%. However, **Omar (1994)** found no significant differences in PPV's of Nile tilapia (*O. niloticus*) due to increasing dietary protein level from 23 to 50%.

With respect to the effect of EL on PPV's, results in Table (18) showed that PPV% decreased significantly ($P<0.05$) with each increase of EL from 2500 to 3000 and 3500 kcal ME/kg, being 39.65, 35.80 and 28.95%, respectively. These results indicated that fish fed on the lower EL (2500 kcal ME/kg) utilize the dietary protein more efficiently than those fed the higher energy levels (3000 and 3500 kcal ME/kg). In accordance with the previous results, **Wafa (2002)** found that PPV's of hybrid Nile tilapia increased with decreasing dietary energy level from 3300 to 2800 and 2300 kcal ME/kg.

4.1.2.5. Energy retention:

Averages of ER% of Nile tilapia as affected by dietary protein and energy levels are shown in Table (20). Analysis of variance for results obtained are presented in Table (21). Among the 9 experimental treatments, the PL2EL2 (25% CP and 3000 kcal ME/kg) treatment recorded the highest ER value (23.52%) and PL2EL3 (25% CP and 3500 kcal ME/kg) treatment showed the lowest value (15.54%), as shown in Table (20).

Values of ER decreased with increasing the PL, being 20.81, 20.13 and 16.77% for fish fed diets with 20, 25 and 30% CP levels (PL1,PL2 and PL3), respectively. Analysis of variance

Table (20): Least square means and standard errors for the effect of different dietary protein and energy levels on energy retention of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Energy retention	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	24	20.81±1.10 a
25% CP (PL2)	24	20.13±1.10 a
30% CP (PL3)	24	16.77±1.10 b
Energy level (EL)		
2500 kcal ME/kg (EL1)	24	19.50±1.10 a
3000 kcal ME/kg (EL2)	24	20.17±1.10 a
3500 kcal ME/kg (EL3)	24	18.03±1.10 b
PL×EL		
PL1×EL1	8	19.92±1.90 bc
PL1×EL2	8	20.63±1.90 bc
PL1×EL3	8	21.91±1.90 b
PL2×EL1	8	21.43±1.90 b
PL2×EL2	8	23.52±1.90 a
PL2×EL3	8	15.54±1.90 d
PL3×EL1	8	17.21±1.90 c
PL3×EL2	8	16.44±1.90 d
PL3×EL3	8	16.73±1.90 d

a, b, c and d means in the same column with different superscripts are significantly (P<0.05)different

Table (21): Analysis of variance for the effect of different dietary protein and energy levels on energy retention of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Energy retention	
	df	F-ratio
Protein level (PL)	2	20.50 **
Energy level (EL)	2	4.98 *
PL×EL	4	10.93 *
Remainder df	63	
Remainder MS		28.983

* = P<0.05 ** = P<0.01

(Table, 21) proved that the PL exerted a significant ($P<0.01$) effect on ER values. The differences in ER values between PL3 (30% CP) and each of PL1 (20% CP) and PL2 (25%CP) were significant ($P<0.05$), whereas those between PL1 an PL2 were not significant. However, in contrast to the previous results, **Omar (1994)** reported that ER values for Nile tilapia (*O. niloticus*) increased with increasing dietary protein level from 23.5 to 50.3%. Also, **Goda (1996)** concluded that, ER values for Nile tilapia improved significantly ($P<0.05$) with increasing the dietary protein level from 20 to 25 and 30%.

Concerning the effect of EL on ER values, results in Table (20) indicated that fish fed EL2 (3000 kcal ME/kg) recorded the highest ER value (20.17%), followed by those fed the diet of EL1 (2500 kcal ME/kg) being 19.50%, with no significant differences. Whereas, fish fed the diet with EL3 (3500 kcal ME/kg) showed the lowest ($P< 0.05$) ER value (18.03%).

In this concern, **Wafa, (2002)** found that ER of hybrid Nile tilapia decreased with increasing dietary energy level from 2300 to 2800 and 3300 kcal ME/kg, indicating that fish fed the lower energy level (2300 kcal ME/kg) retained more energy than those fed the higher energy levels (2800 and 3300 kcal ME/kg).

4.1.3. Effect of dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia of small initial size (22.87 g):

The effect of dietary protein and energy levels and their interactions on hepato-somatic index (HSI) values are shown in Table (22) and the analysis of variance for these values are illustrated in Table (23). Fish of treatment PL3EL2 (30% CP and 2500 kcal ME/kg) recorded the highest HSI value (4.04), while those of treatment PL2EL1 (25% CP and 2500 kcal ME/kg) showed the lowest one (2.98).

Results in Table (22) showed that fish fed the PL3 (30% CP) had the highest HSI value (3.80) and those fed the PL2 (25% CP) had the lowest value (3.12), however, the differences in HSI values due to PL effect were not significant (Table 23).

Values presented in Tables (22) and (23) showed the HSI values decreased with increasing the EL, being 3.57, 3.55 and 3.33 for fish fed diets contained 2500, 3000 and 3500 kcal ME/kg (EL1, EL2 and EL3), respectively, but the differences were not significant.

At the termination of the experimental period, males of PL2EL1 (25% CP and 2500 kcal ME/kg) treatments recorded the highest gonado-somatic index (GSI) value (1.10), and those of PL1EL1 (20% CP and 2500 kcal ME/kg) showed the lowest value (0.50). The corresponding values for females (2.10 and 0.70) were achieved by fish of PL3EL1 (30% CP and 2500 kcal ME/kg), PL1EL2 (20% CP and 3000 kcal ME/kg) and PL2EL3 (25% CP and 3500 kcal ME/kg) treatments. It obvious that females had always higher GSI values than males (Table 22).

Results in Table (22) showed that males of PL2 (25% CP) recorded the highest ($P<0.05$) GSI value (0.87), while, those of PL1 (20% CP) and PL3 (30% CP) had nearly the same GSI values being 0.76 and 0.72, respectively, with no significant differences among these two levels. On the contrary, females of PL2 (25%, CP) recorded the lowest ($P<0.05$) GSI value (0.99)

Table (22): Least square means and standard errors for the effect of different dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	Hepato-somatic index		Gonado-somatic index (Means±SE)		
	No.	Means±SE	No.	Males	Females
Protein level (PL)					
20% CP (PL1)	24	3.54±0.18	12	0.76±0.24 b	1.61±0.25 a
25% CP (PL2)	24	3.12±0.18	12	0.87±0.24 a	0.99±0.25 b
30% CP (PL3)	24	3.80±0.18	12	0.72±0.24 b	1.95±0.25 a
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	3.57±0.18	12	0.77±0.24 b	1.77±0.25 a
3000 kcal ME /kg (EL2)	24	3.55±0.18	12	0.86±0.24 a	1.63±0.25 a
3500 kcal ME/kg (EL3)	24	3.33±0.18	12	0.75±0.24 b	1.14±0.25 b
PL×EL					
PL1×EL1	8	3.72±0.32	4	0.50±0.42 c	1.10±0.43 c
PL1×EL2	8	3.52±0.32	4	1.01±0.42 a	2.10±0.43 a
PL1×EL3	8	3.37±0.32	4	0.86±0.42 b	1.62±0.43 b
PL2×EL1	8	2.98±0.32	4	1.10±0.42 a	1.11±0.43 c
PL2×EL2	8	3.08±0.32	4	0.75±0.42 b	1.15±0.43 c
PL2×EL3	8	3.29±0.32	4	0.75±0.42 b	0.70±0.43 d
PL3×EL1	8	4.02±0.32	4	0.60±0.42 c	2.10±0.43 a
PL3×EL2	8	4.04±0.32	4	0.83±0.42 b	1.65±0.43 b
PL3×EL3	8	3.33±0.32	4	0.63±0.42 c	1.10±0.43 c

a, b, c and d means in the same column with different superscripts are significantly (P<0.05) different

Table (23): Analysis of variance for the effect of different dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	Hepato-somatic index		Gonado-somatic index		
			df	F-ratio	
	df	F-ratio		Males	Females
Protein level (PL)	2	2.47	2	2.42 *	3.26 *
Energy level (EL)	2	1.04	2	1.76 *	1.69 *
PL×EL	4	0.826	4	2.92 *	2.87 *
Remainder df	63		27		
Remainder MS		0.8064		0.693	0.738

* = P<0.05

and those of PL1 (20% CP) and PL3 (30% CP) had nearly similar GSI values being 1.61 and 1.95, and the differences were not significant.

Averages of GSI values for males fed the different energy levels, showed the same trend observed with males fed the different protein levels. Males fed on PL2 achieved the highest ($P<0.05$) GSI value (0.86), while those fed on PL1 and PL3 had nearly the same values being 0.77 and 0.75, respectively, with no significant differences (Tables 22 and 23). On contrast, GSI values for females decreased with increasing the EL, being 1.77, 1.63 and 1.14 for females fed EL1, EL2 and EL3 (2500 and 3000 and 3500 kcal ME/kg), respectively. The effect of EL on GSI values was significant ($P<0.05$). The differences were only significant between fish fed EL3 and those fed either EL1 or EL2.

4.1.4. Effect of dietary protein and energy levels on carcass traits and chemical composition of Nile tilapia of small initial size (22.87 g):

4.1.4.1. Carcass traits:

Results of carcass traits of Nile tilapia of small initial size as affected by dietary protein and energy levels and their interactions are shown in Table (24). Analysis of variance for the same factors are illustrated in Table (25). The highest dressing, flesh, head and bone percentages were recorded by fish of treatments PL2EL1, PL2EL1, PL1EL2 and PL2EL3, respectively. The lowest corresponding percentages were achieved by fish of treatments PL1EL2, PL1EL2, PL2EL3 and PL1EL2 (Table 24).

Table (24): Least square means and standard errors for the effect of different dietary protein and energy levels on carcass traits of Nile tilapia (initial weight 22.87 g) reared for 180 days.

Items	No.	Dressing %	Flesh %	Head %	Bone %
Protein level (PL)					
20% CP (PL1)	24	51.78±0.13 b	47.32±0.14 b	23.37±0.16 a	4.08±0.18
25% CP (PL2)	24	55.74±0.13 a	50.83±0.14 a	21.88±0.16 b	4.17±0.18
30% CP (PL3)	24	54.95±0.13 a	50.40±0.14 a	22.49±0.16 b	4.18±0.18
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	56.11±0.13 a	51.61±0.14 a	20.54±0.16 b	3.58±0.18 b
3000 kcal ME /kg (EL2)	24	51.98±0.13 b	47.04±0.14 b	25.35±0.16 a	3.64±0.18 b
3500 kcal ME /kg (EL3)	24	57.37±0.13 a	49.91±0.14 ab	21.86±0.16 b	5.22±0.18 a
PL×EL					
PL1×EL1	8	56.21±0.22 a	51.73±0.25 b	20.30±0.28 b	3.70±0.30 b
PL1×EL2	8	48.52±0.22 c	44.12±0.25 c	27.12±0.28 a	3.41±0.30 b
PL1×EL3	8	50.60±0.22 c	46.13±0.25 c	22.70±0.28 b	5.13±0.30 a
PL2×EL1	8	56.90±0.22 a	52.51±0.25 a	20.12±0.28 b	3.50±0.30 b
PL2×EL2	8	53.71±0.22 bc	47.83±0.25 c	25.80±0.28 a	3.70±0.30 b
PL2×EL3	8	56.62±0.22 a	52.24±0.25 a	19.72±0.28 b	5.31±0.30 a
PL3×EL1	8	55.23±0.22 b	50.63±0.25 ab	21.20±0.28 b	3.53±0.30 b
PL3×EL2	8	53.71±0.22 bc	49.24±0.25 c	23.14±0.28 b	3.80±0.30 b
PL3×EL3	8	55.90±0.22 ab	51.41±0.25 b	23.15±0.28 b	5.22±0.30 a

a, b and c means in the same column with different superscripts are significantly ($P<0.05$)different

Table (25): Analysis of variance for the effect of different dietary protein and energy levels on carcass traits of Nile tilapia (initial weight 22.87 g) reared for 180 days.

SOV	df	F-ratios			
		Dressing %	Flesh %	Head %	Bone %
Protein level (PL)	2	4.352 *	3.451 *	7.53 *	1.46
Energy level (EL)	2	6.068 *	5.135 *	8.053 *	5.067 *
PL×EL	4	5.088 *	4.105 *	5.055 *	7.136 *
Remainder df	63				
Remainder MS		0.394	0.483	0.624	0.732

* = $P<0.05$

Fish fed PL1 (20% CP) recorded the highest ($P<0.05$) head percentage and the lowest dressing ($P<0.05$), flesh ($P<0.05$) and bone percentages. Whereas, fish fed PL2 (25 CP) achieved the highest dressing and flesh percentages and the lowest head and bone percentage. Fish fed PL3 (30% CP) showed the highest bone percentage (Table 24). In accordance with the previous results, **Abdel-Hakim *et al.* (2001 b)** reported that increasing the dietary PL from 25 to 30% decreased the dressing and flesh percentages of Nile tilapia. Similar results were reported by **Samra (2002)** who reported that increasing protein level from 20 to 25 and 30% followed by an increase in bone percentage and decrease in dress-out and flesh percentages.

Concerning the effect of EL on carcass traits of Nile tilapia, results in Tables (24) and (25) revealed that the highest flesh percentage and the lowest head and bone percentages were recorded by fish fed EL1 (2500 kcal ME/kg). Whereas the highest dressing and bone ($P<0.05$) percentages were shown by fish fed EL3(3500 kcal ME/kg). However, the highest ($P<0.05$) head percentage and lowest dressing ($P<0.05$) and flesh percentages were achieved by fish fed EL2 (3000 kcal ME/kg). In this concern, **Samra (2002)** concluded that increasing the energy level from 3000 to 3300 and 3600 kcal ME/kg diet, followed by decrease in the percentages of dress-out and flesh, whereas head and bone percentages increased with increasing the energy level from 3000 to 3300 kcal ME/kg, then values decreased with the higher energy level (3600 kcal ME/kg).

4.1.4.2. Chemical composition of whole fish:

Chemical analysis of Nile tilapia whole fish of small initial size as affected by dietary protein and energy levels and their interactions are illustrated in Table (26). Analysis of variance for the results obtained are shown in Table (27). The highest moisture, protein, fat and ash contents were achieved by treatments PL1EL1, PL3EL3, PL2EL2 and PL1EL2, respectively, and the lowest corresponding contents were recorded by treatments PL2EL2, PL2EL3, PL3EL1 and PL3EL3 (Table 26).

Results in Table (26) showed that fish fed the higher CP level (30% CP) recorded the highest moisture, protein and fat contents and the lowest ($P<0.05$) ash content, while those fed the lower CP level (20% CP) showed the highest ash percentage and lowest fat percentage. Fish fed PL2 (25% CP) achieved the lowest moisture ($P<0.05$) and protein contents. In partial agreement with the previous results, **Winfree and Stickney (1981)** reported that dietary protein level had no effect on fish body protein. Also, **Hafedh (1999)** concluded that dietary protein level (25-45%) had no significant effect on Nile tilapia body protein content, but lipid content decreased with increasing protein level, where no clear trends were observed with ash content. On the other hand, **Shiau and Haung (1989)** found that Nile tilapia fish fed the lower dietary protein levels (0, 8, 12 and 16%) had significantly lower protein and moisture contents than those fed higher dietary protein levels (24, 32, 40, 48 and 56%). Body lipid content showed a reverse trend, while ash content in tilapia was not affected by the dietary protein level. Similar results were reported by **Samra (2002)** with Nile tilapia.

Table (26): Least square means and standard errors for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia whole fish on DM basis (initial weight 22.87 g) reared for 180 days.

Items	No.	Moisture %	Protein %	Fat %	Ash %
Protein level (PL)					
20% CP (PL1)	24	73.71±0.97 a	55.53±1.24	30.13±1.32	14.33±0.92 a
25% CP (PL2)	24	71.73±0.97 b	54.81±1.24	30.83±1.32	13.91±0.92 a
30% CP (PL3)	24	73.93±0.97 a	55.73±1.24	31.51±1.32	12.77±0.92 b
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	74.92±0.97 a	55.32±1.24	31.01±1.32	13.52±0.92 b
3000 kcal ME /kg (EL2)	24	72.23±0.97 b	55.03±1.24	30.72±1.32	14.23±0.92 a
3500 kcal ME /kg (EL3)	24	73.03±0.97 b	55.73±1.24	30.77±1.32	13.34±0.92 b
PL×EL					
PL1×EL1	8	76.73±1.69 a	54.60±2.14	31.41±2.28	14.01±1.59 a
PL1×EL2	8	71.14±1.69 c	56.11±2.14	29.01±2.28	15.03±1.59 a
PL1×EL3	8	73.33±1.69 b	56.15±2.14	30.11±2.28	14.20±1.59 a
PL2×EL1	8	73.01±1.69 b	56.21±2.14	28.62±2.28	14.05±1.59 a
PL2×EL2	8	70.63±1.69 c	54.14±2.14	31.62±2.28	14.13±1.59 a
PL2×EL3	8	71.64±0.50 c	54.13±2.14	31.32±2.28	13.62±1.59 ab
PL3×EL1	8	75.05±1.69 a	55.11±2.14	28.23±2.28	12.53±1.59 b
PL3×EL2	8	72.63±1.69 b	55.04±2.14	31.51±2.28	13.54±1.59 ab
PL3×EL3	8	73.21±1.69 b	57.15±2.14	31.21±2.28	12.34±1.59 b

a, b and c means in the same column with different superscripts are significantly ($P<0.05$)different

Table (27): Analysis of variance for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia whole fish (initial weight 22.87 g) reared for 180 days.

SOV	df	F-ratios			
		Moisture %	Protein %	Fat %	Ash %
Protein level (PL)	2	7.23 *	2.65	2.34	16.21 *
Energy level (EL)	2	4.84 *	1.37	2.67	5.36 *
PL×EL	4	12.62 *	3.64	1.69	9.23 *
Remainder df	63				
Remainder MS		22.73	36.71	41.62	20.16

* = $P<0.05$

With regard to the effect of EL on chemical composition of Nile tilapia whole fish, results in Tables (25) and (26) showed that fish fed EL3(30% CP) showed the highest protein content and lowest ash content, whereas those fed EL1(2500 kcal ME/kg) recorded the highest moisture ($P<0.05$) and fat percentages. Fish fed EL2(3000 kcal ME/kg) recorded the highest ash ($P<0.05$) content and the lowest moisture, protein and fat contents. In this respect, **Samra (2002)** reported that increasing the dietary energy level decreased the percentages of moisture, protein and ash and increased the percentage of fat in whole Nile tilapia body.

4.1.4.3. Chemical composition of fish flesh:

The effect of dietary protein and energy levels and their interactions on chemical analysis of Nile tilapia flesh of small initial size are presented in Table (28), and the analysis of variance for the same factors are shown in Table (29). The highest moisture, protein, fat and ash percentages were recorded by fish of treatments PL2EL1, PL1EL3, PL3EL2 and PL1EL1, respectively, and the lowest corresponding percentages were achieved by fish of treatments PL3EL2, PL2EL2, PL1EL1 and PL3EL1 as shown in Table (28).

Fish fed PL3 (30% CP) had the highest ($P<0.05$) fat content and the lowest moisture and ash contents, whereas those fed PL1(20% CP) showed the highest ($P<0.05$) protein and ash percentages and lowest moisture and fat ($P<0.05$) percentages. The lowest protein content was recorded by fish fed 25% CP(PL2).

Table (28): Least square means and standard errors for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia flesh on DM basis (initial weight 22.87 g) reared for 180 days.

Items	No.	Moisture %	Protein %	Fat %	Ash %
Protein level (PL)					
20% CP (PL1)	24	76.15±0.15	77.81±0.16 a	13.58±0.17 c	7.32±0.16a
25% CP (PL2)	24	76.54±0.15	76.01±0.16 b	15.43±0.17 b	6.59±0.16 b
30% CP (PL3)	24	75.85±0.15	76.62±0.16 b	16.25±0.17 a	6.45±0.16 b
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	78.02±0.15 a	77.81±0.16 a	13.65±0.17 b	6.97±0.16 a
3000 kcal ME /kg (EL2)	24	75.17±0.15 b	74.62±0.16 b	17.06±0.17 a	6.91±0.16 a
3500 kcal ME /kg (EL3)	24	75.36±0.15 b	78.01±0.16 a	14.62±0.17 b	6.49±0.16 a
PL×EL					
PL1×EL1	8	76.70±0.26 b	78.61±0.28 b	10.90±0.30 d	8.13±0.28 a
PL1×EL2	8	75.22±0.26 bc	74.60±0.28 c	16.62±0.30 b	7.50±0.28 ab
PL1×EL3	8	76.53±0.26 b	80.22±0.28 a	13.23±0.30 c	6.33±0.28 b
PL2×EL1	8	79.14±0.26 a	75.60±0.28 c	15.73±0.30 bc	7.25±0.28 ab
PL2×EL2	8	77.15±0.26 b	74.14±0.28 c	16.42±0.30 b	6.72±0.28 b
PL2×EL3	8	73.33±0.26 bc	78.30±0.28 b	14.13±0.30 c	5.81±0.28 c
PL3×EL1	8	78.22±0.26 a	79.22±0.28 a	14.32±0.30 c	5.52±0.28 c
PL3×EL2	8	73.13±0.26 bc	75.13±0.28 c	18.13±0.30 a	6.51±0.28 b
PL3×EL3	8	76.21±0.26 b	75.51±0.28 c	16.30±0.30 b	7.33±0.28 ab

a, b and c means in the same column with different superscripts are significantly ($P<0.05$)different

Table (29): Analysis of variance for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia flesh (initial weight 22.87 g) reared for 180 days.

SOV	df	F-ratios			
		Moisture %	Protein %	Fat %	Ash %
Protein level (PL)	2	1.71	2.11 *	3.64 *	4.15 *
Energy level (EL)	2	6.932 *	3.72 *	5.77 *	1.35
PL×EL	4	7.737 *	6.324 *	6.13 *	8.053 *
Remainder df	63				
Remainder MS		0.533	0.624	0.733	0.645

* = P<0.05

In general, PL had no significant effect on moisture content of Nile tilapia flesh, whereas increasing dietary protein level significantly ($P<0.05$) decreased both protein and ash contents and increased ($P<0.05$) fat percentage of fish flesh. **Abdel-Hakim et al., (2001 b)** revealed that increasing protein content in tilapia diets from 25 to 30% had no significant effect on flesh moisture, protein, fat and ash percentages. Whereas, **Samra (2002)** found that increasing dietary protein level from 20 to 25 and 30% significantly increased both moisture and protein contents in Nile tilapia flesh but decreased fat and ash percentages.

Results illustrated in Table (28) revealed that fish fed the highest EL(3500 kcal ME/kg) had the highest protein content and lowest ash content, while those fed the lowest EL(2500 kcal ME/kg) had the highest moisture ($P<0.05$) and ash percentages and lowest fat percentage. However, the highest ($P<0.05$) fat content and lowest moisture and protein ($P<0.05$) contents were achieved by fish fed EL2(3000 kcal ME/kg). **De Silva et al., (1991)** found that tilapia carcass lipids content increased with increasing dietary lipid at the three protein levels tested (15, 20 and 25%) and the opposite trend was observed with carcass protein. While, **Samra (2002)** indicated that as energy level in tilapia diet increased (3000 to 3300 and 3600 kcal ME/kg), moisture, protein and fat percentages increased but ash percentage decreased.

4.1.5. Effect of dietary protein and energy levels on fish production and profit index of Nile tilapia of small initial size (22.87 g).

Results in Table (30) showed that fish of treatments PL2EL2 and PL2EL1 (25% CP and 3000 kcal ME/kg; 25% CP and 2500 kcal ME/kg, respectively) achieved the highest fish production (0.51 and 0.49 kg/m^2, respectively) and profit index (2.02 and 2.11, respectively). The lowest feed costs/kg WG were shown by fish of treatments PL2EL1 (1.81 LE) and PL1EL1 (1.82 LE). Whereas, fish of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) recorded the lowest fish production (0.37 kg/m^2) and fish of treatment PL3EL3 (30% CP and 3500 kcal ME/kg) showed the lowest profit index (1.22) and highest feed costs/ kg Wg (3.29 LE).

Fish production increased from 0.40 to 0.47 kg/m^2 with increasing PL from 20 to 25%, then slightly decreased with increasing dietary CP level to 30%, being 0.45 kg/m^2. Profit index decreased with each increase in PL from 20 to 25 and 30% CP being 1.92, 1.88 and 1.59, respectively. Whereas, feed costs/kg WG increased from 2.10 to 2.15 and 2.62 LE with increasing dietary CP level from 20 to 25 and 30%, respectively (Table 30). Increasing dietary EL from 2500 to 3000 kcal ME/kg increased fish production from 0.44 to 0.46 kg/m^2, while increasing the EL from 3000 to 3500 kcal ME/kg decreased fish production to reach 0.42 kg/m^2.

Profit index decreased with each increase in dietary EL, being 2.08, 1.81 and 1.51 for fish fed diets contained 2500, 3000 and 3500 kcal ME/kg, respectively. Whereas, a reverse trend was

Table (30): Least square means and standard errors for the effect of different dietary protein and energy levels on fish production and profit index of Nile tilapia (initial weight, 22.87 g) reared for 180 days.

Items	Fish production (kg/m^2)	Feed costs/kg WG (LE)	Profit index
Protein level (PL)			
20% CP (PL1)	0.40±0.04	2.10±0.08	1.92±0.05
25% CP (PL2)	0.47±0.05	2.15±0.84	1.88±0.26
30% CP (PL3)	0.45±0.02	2.62±0.72	1.59±0.21
Energy level (EL)			
2500 kcal ME/kg (EL1)	0.44±0.05	1.90±0.05	2.08±0.03
3000 kcal ME /kg (EL2)	0.46±0.03	2.24±0.17	1.81±0.09
3500 kcal ME/kg (EL3)	0.42±0.07	2.73±0.76	1.51±0.22
PL×EL			
PL1×EL1	0.37	1.82	2.18
PL1×EL2	0.40	2.24	1.79
PL1×EL3	0.44	2.23	1.80
PL2×EL1	0.49	1.81	2.11
PL2×EL2	0.51	1.98	2.02
PL2×EL3	0.42	2.66	1.50
PL3×EL1	0.47	2.07	1.94
PL3×EL2	0.47	2.49	1.61
PL3×EL3	0.40	3.29	1.22

Profit index=Price of 1 kg×fish production (kg)/Price of 1 kg feed×feed intake (kg) observed with feed costs/kg WG as it increased with each increase in dietary EL, being 1.90, 2.24 and 2.73 LE for fish fed diets with 2500, 3000 and 3500 kcal ME/kg, respectively (Table 30).

4.2. Second Experiment:

4.2.1. Effect of dietary protein and energy levels on growth performance of Nile tilapia of large initial size (39.82 g):

4.2.1. Body weight:

Results of BW of Nile tilapia fish with large initial size as affected by dietary protein and energy levels and their interactions are presented in Table (31). The analysis of variance for the same factors are shown in Table (32). The initial BW of fish within all treatments at the start of the experiment was nearly similar (ranged between 39.22 and 40.13 g) with no significant differences. At the termination of the experiment, fish of treatment PL3EL1 (30% CP and 2500 kcal ME/kg) recorded the highest final BW (183.33 g) and those of treatment PL1EL2 (20% CP and 3000 kcal ME/kg)showed the lowest one (100.72 g) as shown in Table (31). However, **Wafa (2002)** with hybrid Nile tilapia (*O. niloticus* × *O. aureus*) of about 41 g initial weight, found that the highest final BW was obtained with fish fed diets containing 25% CP and 2500 kcal ME/kg and those fed diets with 25% CP and 2000 kcal ME/kg recorded the lowest final BW.

Table (31): Least square means and standard errors for the effect of different dietary protein and energy levels on body weight (g) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Initial body weight		Final body weight	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	39.70±0.17	89	126.08±3.25 b
25% CP (PL2)	96	39.91±0.17	88	158.04±3.26 a
30% CP (PL3)	96	39.86±0.17	90	157.04±3.23 a
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	39.94±0.17	89	141.97±3.25
3000 kcal ME/kg (EL2)	96	39.50±0.17	88	140.28±3.26
3500 kcal ME/kg (EL3)	96	40.03±0.17	90	148.92±3.23
PL×EL				
PL1×EL1	32	39.81±0.33	29	104.10±5.58 e
PL1×EL2	32	39.22±0.33	29	100.72±5.58 e
PL1×EL3	32	40.13±0.33	31	173.42±5.58 ab
PL2×EL1	32	40.06±0.33	30	138.47±5.59 cd
PL2×EL2	32	39.67±0.33	29	181.21±5.58 a
PL2×EL3	32	40.05±0.33	29	154.45±5.58 bc
PL3×EL1	32	39.96±0.33	30	183.33±5.59 a
PL3×EL2	32	39.62±0.33	30	138.92±5.59 cd
PL3×EL3	32	40.04±0.33	30	118.91±5.59 de

a, b, c, d and e means in the same column with different superscripts are significantly (P<0.05)different

Table (32): Analysis of variance for the effect of different dietary protein and energy levels on body weight of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Initial body weight		Final body weight	
	Df	F-ratio	df	F-ratio
Protein level (PL)	2	2.38	2	2.29 *
Energy level (EL)	2	0.26	2	2.08
PL×EL	4	0.27	4	50.81 **
Remainder df	279		258	
Remainder MS		3.4156		936.94

* P< 0.05 *** = P<0.001

observed with feed costs/kg WG as it increased with each increase in dietary EL, being 1.90, 2.24 and 2.73 LE for fish fed diets with 2500, 3000 and 3500 kcal ME/kg, respectively (Table 30).

4.2. Second Experiment:

4.2.1. Effect of dietary protein and energy levels on growth performance of Nile tilapia of large initial size (39.82 g):

4.2.1. Body weight:

Results of BW of Nile tilapia fish with large initial size as affected by dietary protein and energy levels and their interactions are presented in Table (31). The analysis of variance for the same factors are shown in Table (32). The initial BW of fish within all treatments at the start of the experiment was nearly similar (ranged between 39.22 and 40.13 g) with no significant differences. At the termination of the experiment, fish of treatment PL3EL1 (30% CP and 2500 kcal ME/kg) recorded the highest final BW (183.33 g) and those of treatment PL1EL2 (20% CP and 3000 kcal ME/kg)showed the lowest one (100.72 g) as shown in Table (31). However, **Wafa (2002)** with hybrid Nile tilapia (*O. niloticus* × *O. aureus*) of about 41 g initial weight, found that the highest final BW was obtained with fish fed diets containing 25% CP and 2500 kcal ME/kg and those fed diets with 25% CP and 2000 kcal ME/kg recorded the lowest final BW.

Table (31): Least square means and standard errors for the effect of different dietary protein and energy levels on body weight (g) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Initial body weight		Final body weight	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	39.70±0.17	89	126.08±3.25 b
25% CP (PL2)	96	39.91±0.17	88	158.04±3.26 a
30% CP (PL3)	96	39.86±0.17	90	157.04±3.23 a
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	39.94±0.17	89	141.97±3.25
3000 kcal ME/kg (EL2)	96	39.50±0.17	88	140.28±3.26
3500 kcal ME/kg (EL3)	96	40.03±0.17	90	148.92±3.23
PL×EL				
PL1×EL1	32	39.81±0.33	29	104.10±5.58 e
PL1×EL2	32	39.22±0.33	29	100.72±5.58 e
PL1×EL3	32	40.13±0.33	31	173.42±5.58 ab
PL2×EL1	32	40.06±0.33	30	138.47±5.59 cd
PL2×EL2	32	39.67±0.33	29	181.21±5.58 a
PL2×EL3	32	40.05±0.33	29	154.45±5.58 bc
PL3×EL1	32	39.96±0.33	30	183.33±5.59 a
PL3×EL2	32	39.62±0.33	30	138.92±5.59 cd
PL3×EL3	32	40.04±0.33	30	118.91±5.59 de

a, b, c, d and e means in the same column with different superscripts are significantly (P<0.05)different

Table (32): Analysis of variance for the effect of different dietary protein and energy levels on body weight of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Initial body weight		Final body weight	
	Df	F-ratio	df	F-ratio
Protein level (PL)	2	2.38	2	2.29 *
Energy level (EL)	2	0.26	2	2.08
PL×EL	4	0.27	4	50.81 **
Remainder df	279		258	
Remainder MS		3.4156		936.94

* P< 0.05   *** = P<0.001

Results of Table (31) indicated that, final BW of fish increased with increasing the PL from 20% to either 25 or 30% CP. The highest final BW was recorded by fish fed 25 and 30% CP, being 158.04 and 157.04 g, respectively. The differences in final BW between the previous two CP levels were not significant. The lowest ($P<0.05$) final BW (126.08 g) was achieved by fish fed PL1 (20% CP), Table (31). In agreement with he previous results, **Balarin and Haller (1982)** found that the best growth of O. niloticus was obtained with 25-30% dietary protein level. **Viola and Zohar (1984)** cleared that increasing the protein level in diets of hybrid tilapia (*O. niloticus* × *O. aureus*) from 25 to 30 or 35% significantly increased the growth rate. Similarly, **Wang *et al.* (1985)** found that tilapia fed on 30% dietary protein level recorded the best growth performance. **Sweilum (1995)** mentioned that maximum weight of Nile tilapia (332 g after 240 days) was recorded with the diet contained 30% CP. **Goda (1996)** found that the diet contained 30% protein seemed to be sufficient to meet the maximum growth of tilapia (*O. niloticus*). **Samra (2002)** concluded that protein requirements for growth of Nile tilapia reared in tanks is above 25% CP. **Wafa (2002)** reported that the highest final BW of hybrid Nile tilapia (*O. niloticus* × *O. aureus*) was recorded with fish fed 30% dietary CP.

The final BW of Nile tilapia fish varied slightly with dietary EL level, fish fed EL3 (3500 kcal ME/kg) had slightly higher final BW than those fed either EL1 (2500 kcal ME/kg) or EL2 (3000 kcal ME/kg), being 148.92, 141.97 and 140.28 g, respectively. The differences in final BW of fish due to EL effects were not significant

(Table, 32). In this respect, **Wafa (2002)** reported that the highest (P<0.05) final BW of hybrid Nile tilapia was recorded with fish fed the diet contained 2800 kcal ME/kg compared with those fed either 3300 or 2300 kcal ME/kg diet. Whereas, **Samra (2002)** revealed that the best (P<0.05) final BW of Nile tilapia was obtained with fish fed 3000 kcal/kg diet and increasing dietary EL to 3300 or 3600 kcal/kg decreased (P<0.05) final BW. **Winfree and Stickney (1981)** mentioned that *O. aureus* grow most rapidly when fed a 34% protein with 3200 kcal/kg diet. Similar results were reported by **El-Dahhar and Lovell (1995)** with *O. mossambicus.*

4.2.1.2. Weight gain:

The effect of dietary protein and energy levels on WG of Nile tilapia fish with large initial size is shown in Table (33) and analysis of variance for the same factors are illustrated in Table (34). The highest WG (143.37 g) was recorded by fish of treatment PL3EL1 (30% CP and 2500 kcal ME/kg), while the lowest one (61.21 g) was shown by fish of treatment PL1EL2 (20% CP and 3000 kcal ME/kg), Table (33). In this respect, **Wafa (2002)** reported that hybrid Nile tilapia (41 g, initial weight) fed 30% CP and 3000 kcal ME/kg diet recorded the highest WG, whereas those fed 30% CP and 2500 kcal ME/kg diet achieved the lowest one.

As shown in Table (33), Nile tilapia fed dietary 25 and 30% CP levels showed the highest WG, being 117.68 and 117.15 g, respectively, with no significant differences between the two CP levels in WG. The lowest (P<0.05) WG was recorded by fish fed 20% CP in the diet (Table 33). Results of WG showed the same trend observed with final BW. Similar results were reported

Table (33): Least square means and standard errors for the effect of different dietary protein and energy levels on weight gain (g) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Weight gain	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	89	86.32±3.20 b
25% CP (PL2)	88	117.68±3.23 a
30% CP (PL3)	90	117.15±3.20 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	102.07±3.20
3000 kcal ME/kg (EL2)	88	100.68±3.23
3500 kcal ME/kg (EL3)	90	108.41±3.20
PL×EL		
PL1×EL1	29	64.44±5.63 e
PL1×EL2	29	61.21±5.63 e
PL1×EL3	31	133.32±5.45 ab
PL2×EL1	30	98.41±5.54 cd
PL2×EL2	29	141.54±5.63 a
PL2×EL3	29	113.15±5.63 b
PL3×EL1	30	143.37±5.54 a
PL3×EL2	30	99.28±5.54 c
PL3×EL3	30	78.82±5.54 d

a, b, c,d and e means in the same column with different superscripts are significantly ($P<0.05$)different

Table (34): Analysis of variance for the effect of different dietary protein and energy levels on weight gain of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Weight gain	
	df	F-ratio
Protein level (PL)	2	22.51 **
Energy level (EL)	2	1.69
PL×EL	4	5.19 **
Remainder df	258	
Remainder MS		919.77

** = $P<0.01$

by **Campell (1985)** and **Siddiqui *et al.* (1988).** They found that the highest daily WG was obtained when *O. niloticus* was reared on 30% dietary CP. **EL-Dahhar, (1994)** reported that body WG of Nile tilapia (*O. niloticus*) fry and fingerlings increased linearly with increasing dietary CP contents. **Goda (1996)** revealed that tilapia fish fed 30% dietary CP level achieved higher average daily gain than those fed diets with either 20 or 25% protein. **Samra (2002)** cleared that increasing dietary protein level from 20 to 25 and 30% subsequently followed by increasing WG of Nile tilapia during all periods studied. **Wafa (2002)** concluded that the best WG of hybrid Nile tilapia was shown by fish fed 30% dietary CP.

With regard to the effect of EL on WG, results in Table (33) showed that WG values obtained were nearly similar being, 102.07, 100.68 and 108.41 g for Nile tilapia fed EL1, EL2 and EL3, respectively and the differences between these values were not significant. In this concern, **Shiau and Huang (1990)** found that WG of hybrid tilapia (*O. niloticus* × *O. aureus*) was improved at dietary energy levels higher than 3100 kcal/kg when fed 21% dietary protein level and higher than 2300 kcal/kg when fed the 24% dietary protein level. Results of **El-Dahhar and Lovell (1995)** indicated that the highest values of WG of *O. mossambicus* (42.0 g/fish) were observed in fish fed 35% dietary protein with 14.7 KJ/g diet energy level. **Samra (2002)** found that Nile tilapia fish fed the 3000 kcal/kg energy level gained significantly ($P<0.05$) higher WG compared with those fed the other two energy levels (3300 and 3600 kcal/kg). **Wafa (2002)** indicated that the highest WG of hybrid Nile tilapia fish was shown by fish fed the diet contained 2800 kcal ME/kg.

4.2.1.3. Body length:

Averages of BL of Nile tilapia with large initial size as affected by dietary protein and energy levels and their interactions are presented in Table (35). The analysis of variance for results obtained are illustrated in Table (36). Results presented in Table (35) showed that the differences in initial BL of fish among different treatments were insignificant indicating that the experimental groups at the start of the experiment were randomly distributed.

At the end of the experiment, fish fed on diet PL3EL1 (30% CP and 2500 kcal ME/kg) treatment showed the longest final BL (22.03 cm), whereas those of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) recorded the shortest one (18.27 cm). However, **Wafa (2002)** found that hybrid Nile tilapia fed 25% CP and 2500 kcal ME/kg diet recorded the longest final BL, while those fed 25% CP and 2000 kcal ME/kg diet achieved the shortest one.

At the end of the experiment, fish fed PL2 (25% CP) showed the longest final BL (20.85 cm), while those fed PL1 (20% CP) recorded the shortest one (19.33 cm). Data in Table (36) showed that the effect of PL on the final BL of fish was significant ($P<0.01$). The differences in final BL of fish fed PL1 (20% CP) and those fed either PL2 (25% CP) or PL3 (30% CP) were significant ($P<0.05$), whereas the differences in final BL of fish fed PL2 and PL3 were non-significant, indicating the same trend observed with both final BW and WG. In partial agreement with the previous results, **Abdel-Hakim *et al.* (2001 b)** concluded that BL of Nile tilapia fish fed the 30% CP level was

Table (35): Least square means and standard errors for the effect of different dietary protein and energy levels on body length (cm) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Initial body length		Final body length	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	15.30±0.06	89	19.33±0.16 b
25% CP (PL2)	96	15.40±0.06	88	20.85±0.16 a
30% CP (PL3)	96	15.24±0.06	90	20.22±0.16 a
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	15.29±0.06	89	20.27±0.16 a
3000 kcal ME/kg (EL2)	96	15.35±0.06	88	19.85±0.16 b
3500 kcal ME/kg (EL3)	96	15.32±0.06	90	20.38±0.16 a
PL×EL				
PL1×EL1	32	15.32±0.10	29	18.27±0.28 e
PL1×EL2	32	15.29±0.10	29	18.50±0.28 d
PL1×EL3	32	15.34±0.10	31	21.22±0.25 ab
PL2×EL1	32	15.30±0.10	30	20.25±0.26 bc
PL2×EL2	32	15.51±0.10	29	21.43±0.28 ab
PL2×EL3	32	15.39±0.10	29	20.88±0.28 b
PL3×EL1	32	15.25±0.10	30	22.03±0.26 a
PL3×EL2	32	15.24±0.10	30	19.62±0.26cd
PL3×EL3	32	15.24±0.10	30	19.04±0.26 d

a , b, c, d and e means in the same column with different superscripts are significantly (P<0.05)different

Table (36): Analysis of variance for the effect of different dietary protein and energy levels on body length of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Initial body length		Final body length	
	df	F-ratio	df	F-ratio
Protein level (PL)	2	1.69	2	22.55 **
Energy level (EL)	2	0.209	2	3.05 *
PL×EL	4	0.414	4	31.53 **
Remainder df	279		258	
Remainder MS		0.341		2.2962

* = P<0.05 ** = P<0.01

significantly (P<0.05) higher than that of fish fed the 25% CP diet. Similarly, **Wafa (2002)** reported that the longest final BL of hybrid Nile tilapia was recorded by fish fed the 30% dietary CP level. **Samra (2002)** found that BL of tilapia fish increased significantly (P<0.05 and P<0.01) with each increase in dietary protein level (from 20 to 25 and 30%) and the diet contained 30% CP released the longest BL of fish.

Results in Table (35) revealed that fish fed EL2 (3000 kcal ME/kg) had significantly (P<0.05) shortest final BL (19.85 cm) than those fed either EL1 (2500 kcal ME/kg) or EL3 (3500 kcal ME/kg) being, 20.27 and 20.38 cm, respectively. The differences among the latter dietary energy levels (EL1 and EL3) in final BL were not significant. In this concern, **Wafa (2002)** reported that the highest final BL of hybrid Nile tilapia was recorded by fish fed 2800 kcal ME/kg diet. Whereas, **Samra (2002)** found that BL of Nile tilapia decreased (P<0.05) with each increase in energy level from 3000 to 3300 and 3600 kcal/kg diet, and the diet of 3000 kcal/kg diet recorded the longest fish BL.

4.2.1.4. Condition factor:

At the start of the experiment, the initial K values for all treatments ranged between 1.63 and 1.80 with no significant differences (Tables 37 and 38); indicating that distribution of fish at the start of the experiment was almost at random. At the termination of the experiment, the highest K value (2.14) was obtained by fish of PL2EL1 (25% CP and 2500 kcal ME/kg) treatment and the lowest one (1.72) was recorded by fish of PL3EL3 (30% CP and 3500 kcal ME/kg) treatment as presented in Table (37).

Table (37): Least square means and standard errors for the effect of different dietary protein and energy levels on condition factor of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Initial condition factor		Final condition factor	
	No.	Means±SE	No.	Means±SE
Protein level (PL)				
20% CP (PL1)	96	1.71±0.09	89	1.91±0.10
25% CP (PL2)	96	1.71±0.09	88	2.12±0.10
30% CP (PL3)	96	1.74±0.09	90	1.93±0.10
Energy level (EL)				
2500 kcal ME/kg (EL1)	96	1.72±0.09	89	1.96±0.10
3000 kcal ME/kg (EL2)	96	1.75±0.09	88	2.04±0.10
3500 kcal ME/kg (EL3)	96	1.71±0.09	90	1.90±0.10
PL×EL				
PL1×EL1	32	1.73±0.14	29	1.81±0.17
PL1×EL2	32	1.76±0.14	29	2.03±0.17
PL1×EL3	32	1.64±0.14	31	1.92±0.17
PL2×EL1	32	1.63±0.14	30	2.14±0.17
PL2×EL2	32	1.79±0.14	29	2.02±0.17
PL2×EL3	32	1.70±0.14	29	2.11±0.17
PL3×EL1	32	1.74±0.14	30	2.03±0.17
PL3×EL2	32	1.70±0.14	30	2.04±0.17
PL3×EL3	32	1.80±0.14	30	1.72±0.17

Table (38): Analysis of variance for the effect of different dietary protein and energy levels on condition factor of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Initial condition factor		Final condition factor	
	df	F-ratio	df	F-ratio
Protein level (PL)	2	1.35	2	1.24
Energy level (EL)	2	0.896	2	0.708
PL×EL	4	1.093	4	1.440
Remainder df	279		258	
Remainder MS		0.6371		0.8713

Results of final K values presented in Table (37) indicated the value increased with increasing the PL from 20 to 25% CP, then decreased with PL3 (30% CP). The final K value for fish fed PL2 was 2.12, while values for fish fed either 20% CP (PL1) or 30% CP(PL3) were nearly the same being 1.91 and 1.93, respectively. Results in Table (38) cleared that PL had no significant effect on final K values of Nile tilapia. In accordance with the previous results, **Wafa (2002)** reported that hybrid tilapia fed 25% dietary CP level showed slightly higher K values than those fed 30% dietary CP level, but the differences in K values were not significant. **Samra (2002)** came to the same conclusion, he found that the differences in K values of Nile tilapia due to dietary CP level (20, 25 and 30%) effect were not significant. Whereas, **Goda (1996)** concluded that Nile tilapia fed 30% CP had higher ($P<0.05$) K value than those fed either 20 or 25% CP.

Energy levels used in this experiment (2500, 300 and 3500 kcal ME/kg diet) had no significant effect on final K values of Nile tilapia fish being, 1.96, 2.04 and 1.90, respectively (Table 37). In agreement with results obtained, **Wafa (2002)** found that dietary energy levels of 3300 and 2800 kcal ME/kg diet had no significant effect on final K values of hybrid Nile tilapia, while the level of 2300 kcal ME/kg diet significantly ($P<0.05$) decreased K values. Whereas, **Samra (2002)** reported that increasing the dietary energy level from 3000 kcal/kg to either 3300 or 3600 kcal/kg diet decreased ($P<0.05$) final K values of Nile tilapia.

4.2.1.5. Specific growth rate:

The effect of dietary protein and energy levels and their interactions on SGR of Nile tilapia fish with large initial size are illustrated in Table (39). Fish of treatment PL3EL1 (30% CP and 2500 kcal ME/kg) recorded the highest SGR value (0.89) at the end of the experiment, while those of treatments PL1EL2 (20% CP and 3000 kcal ME/kg) and PL3EL3 (30% CP and 3500 kcal ME/kg) showed the lowest one (0.54).

As present in Table (39), SGR values increased with increasing the PL from 20 to 25% CP, then it decreased with increasing the PL from 25% to 30% CP, indicating the same trend observed with K values. The SGR values were 0.61, 0.74 and 0.71 for fish fed PL1 (20% CP), PL2 (25% CP) and PL3 (30% CP), respectively. Data in Table (40) showed that the effect of PL on SGR values of fish was significant ($P<0.01$). The differences in SGR values between fish fed PL1 and those fed either PL2 or PL3 were significant ($P<0.05$), while those between fish fed PL2 and PL3 were not significant. Similar results were reported by **Viola and Zohar (1984)** and **Siddique *et al.* (1988)**. They found that the highest SGR of Nile tilapia was recorded with the 30% CP dietary level. Also, **Sweilum (1995)** found that the maximum mean values of SGR for tilapia was achieved at 30% protein. **Abdel-Hakim and Moustafa (2000)** indicated that SGR for Nile tilapia reared in cages improved almost significantly with each increase in the dietary protein level fed (from 20 to 32%). **Wafa (2002)** reported that hybrid Nile tilapia fed 30% CP level had higher SGR value compared with those fed 25% CP in the diet.

Table (39): Least square means and standard errors for the effect of different dietary protein and energy levels on specific growth rate of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Specific growth rate	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	89	0.61±0.01b
25% CP (PL2)	88	0.74±0.01 a
30% CP (PL3)	90	0.71±0.01 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	0.76±0.01 a
3000 kcal ME/kg (EL2)	88	0.69±0.01b
3500 kcal ME/kg (EL3)	90	0.65±0.01 b
PL×EL		
PL1×EL1	29	0.55±0.02e
PL1×EL2	29	0.54±0.02 e
PL1×EL3	31	0.75±0.02 bc
PL2×EL1	30	0.71±0.02 c
PL2×EL2	29	0.85±0.02 ab
PL2×EL3	29	0.67±0.02 d
PL3×EL1	30	0.89±0.02 a
PL3×EL2	30	0.69±0.02 d
PL3×EL3	30	0.54±0.02 e

a, b, c, d and e means in the same column with different superscripts are significantly (P<0.05)different

Table (40): Analysis of variance for the effect of different dietary protein and energy levels on specific growth rate of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Specific growth rate	
	df	F-ratio
Protein level (PL)	2	17.90 **
Energy level (EL)	2	5.32 *
PL×EL	4	37.90 ***
Remainder df	258	
Remainder MS		0.01626

* = P<0.05 ** = P<0.01 *** P<0.001

Results of Table (39) showed that SGR values decreased with increasing EL being, 0.76, 0.69 and 0.65 for fish fed EL1 (2500 kcal ME/kg), EL2 (3000 kcal ME/kg) and EL3 (3500 kcal ME/kcal), respectively. The differences in SGR values of fish fed EL1 and those fed either EL2 or EL3 were significant ($P<0.05$), whereas no significant differences were detected in SGR values of fish fed either EL2 or EL3 (Table 39). **Wafa (2002)** mentioned that the highest SGR for hybrid Nile tilapia was recorded with fish fed 2800 kcal ME/kg diet, and values decreased with decreasing the EL to 2300 kcal ME/kg. Similarly, **Samra (2002)** reported that SGR decreased significantly ($P<0.05$) with increasing the dietary EL from 3000 to 3300 and 36000 kcal/kg diet.

4.2.2. Effect of dietary protein and energy levels on feed utilization of Nile tilapia of large initial size (39.82 g):

4.2.2.1. Means of feed, protein and energy intakes:

Results in Table (41) showed that feed intake and energy intake of Nile tilapia of large initial size increased from 288.89 to 347.56 g and from 889.28 to 1052.19 kcal ME with increasing PL from 20 to 25% CP, respectively, after which values decreased to reach 333.27 g and 995.92 kcal ME with increasing PL from 25 to 30% CP. Whereas, protein intake increased, as expected in a linear manner with each increase in PL being, 58.33, 85.77 and 99.51 g CP for fish fed PL1, PL2 and PL3, respectively. In this concern, **Wafa (2002)** reported that feed, protein and energy intakes increased with increasing the dietary CP level from 25% to 30%.

Table (41): Means of feed, protein and energy intakes of Nile tilapia (initial weight 39.82 g) reared for 180 days as affected by different dietary protein and energy levels.

Items	No.	Feed intake (g)	Protein intake (g)	Energy intake (kcal ME)
Protein level (PL)				
20% CP (PL1)	89	288.59	58.33	889.28
25% CP (PL2)	88	347.56	85.77	1052.19
30% CP (PL3)	90	333.27	99.51	995.92
Energy level (EL)				
2500 kcal ME/kg (EL1)	89	303.75	78.22	768.29
3000 kcal ME/kg (EL2)	88	309.36	77.74	925.88
3500 kcal ME/kg (EL3)	90	356.86	87.66	1243.22
PL×EL				
PL1×EL1	29	236.28	48.02	597.65
PL1×EL2	29	241.21	47.88	715.07
PL1×EL3	31	388.28	79.08	1355.14
PL2×EL1	30	303.53	75.12	762.41
PL2×EL2	29	373.10	92.12	1118.52
PL2×EL3	29	366.04	90.08	1275.65
PL3×EL1	30	371.45	111.51	944.82
PL3×EL2	30	313.76	93.22	944.07
PL3×EL3	30	316.27	93.81	1098.88

Values of feed, protein as well as energy intakes increased progressively with increasing EL being, 303.75, 309.36 and 356.86 g feed intake; 78.22, 77.74 and 87.66 g CP intake and 768.29, 925.88 and 1243.22 kcal ME intake for Nile tilapia fed 2500 (EL1), 3000 (EL2) and 3500 (EL3) kcal ME/kg diet, respectively. However, **Wafa (2002)** found that feed intake and protein intake of hybrid Nile tilapia increased with decreasing EL from 3300 to 2800 kcal ME/kg diet, then decreased with decreasing the EL to 2300 kcal ME/kg. Whereas energy intake decreased with decreasing dietary EL from 3300 to 2800 and 2300 kcal ME/kg diet

Data in Table (41) showed that Nile tilapia of PL1EL3 (20% CP and 3500 kcal ME/kg) treatment recorded the highest feed and energy intakes, being388.28 g feed and 1355.14 kcal ME, respectively and those of PL3EL1 (30% CP and 2500 kcal ME/kg) treatment recorded the highest protein intake (111.51 g CP). Whereas, fish of PL1EL2 (20% CP and 2500 kcal ME/kg) consumed the lowest feed and protein intakes, being 241.21 g feed and 47.88 g CP, respectively, while those of treatment PL1EL1 (20% CP and 2500 kcal ME/kg) recorded the lowest energy intake (597.65 kcal ME).

4.2.2.2. Feed conversion ratio:

Results of FCR of Nile tilapia fish with large initial size as affected by dietary protein and energy levels and their interactions are presented in Table (42). These results showed that the best FCR (2.43) was recorded by fish of PL2EL2 (25% CP and 3000 kcal ME/kg) treatment and the poorest ratio (4.72) was shown by fish of PL1EL2 (20% CP and 3000 kcal ME/kg) treatment. In this respect, **Wafa (2002)** reported that the best FCR's for hybrid Nile tilapia were obtained with diets contained either 25% CP and 2500 kcal ME/kg or 30% CP and 3000 kcal ME/kg and the poorest ratio with diets of 25% CP and 2000 kcal ME/kg.

Data in table (42) revealed that fish fed PL2 (25% CP) showed the best FCR (2.77), followed by those fed PL3(30% CP) being 3.17, whereas the poorest FCR (3.61) was recorded by fish fed PL1 (20% CP).

Analysis of variance (Table 43) cleared that PL exerted significant ($P<0.05$) effect on FCR's. The differences in FCR between fish fed PL2 and those fed PL1 were significant ($P<0.05$), while the differences between fish fed PL3 and those fed either PL1 or PL2 in FCR were not significant (Table 42). In partial agreement with the previous results, **Sweilum (1995)** reported that FCR of Nile tilapia (*O. niloticus*) under polyculture system improved with increasing dietary protein level (20, 30 and 40%) and the best FCR was recorded by fish fed the 30% dietary protein level. **Goda (1996)** and **De Silva et al., (1991)** came to the same conclusion that FCR of Nile tilapia was improved with increasing the dietary protein level. Similarly, **Abdel-Hakim et al., (2001 b)** and **Wafa (2002)** concluded that, increasing the dietary CP level from 25 to 30% improved FCR of Nile tilapia (*O. niloticus*).

Fish fed EL1 (2500 kcal ME/kg) showed the best FCR (3.03), while those fed EL2 (3000 kcal ME/kg) recorded the poorest value (3.33), with significant differences between these

Table (42): Least square means and standard errors for the effect of different dietary protein and energy levels on feed conversion ratio (g feed/g gain) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Feed conversion ratio	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	89	3.61±0.11 a
25% CP (PL2)	88	2.77±0.11 b
30% CP (PL3)	90	3.17±0.11 ab
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	3.03±0.11 b
3000 kcal ME/kg (EL2)	88	3.33±0.11 a
3500 kcal ME/kg (EL3)	90	3.17±0.11 ab
PL×EL		
PL1×EL1	29	3.63±0.20 b
PL1×EL2	29	4.72±0.20 a
PL1×EL3	31	2.63±0.20 d
PL2×EL1	30	3.04±0.20 c
PL2×EL2	29	2.43±0.20 d
PL2×EL3	29	2.92±0.20 c
PL3×EL1	30	2.64±0.20 d
PL3×EL2	30	2.93±0.20 c
PL3×EL3	30	4.02±0.20 b

a, b, c and d means in the same column with different superscripts are significantly (P<0.05) different.

Table (43): Analysis of variance for the effect of different dietary protein and energy levels on feed conversion ratio of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Feed convertion ratio	
	df	F-ratio
Protein level (PL)	2	6.246 *
Energy level (EL)	2	5.174 *
PL×EL	4	22.99 **
Remainder df	258	
Remainder MS		1.1592

** = P<0.01 *** P<0.001

two levels of energy in FCR's as shown in Tables (42) and (43). However, no significant differences were exerted between the FCR of fish fed EL3 (3500 kcal ME/kg) and those of fish fed either EL1 or EL2. In this concern, **Wafa (2002)** reported that the best FCR values were obtained with hybrid Nile tilapia fed diets with 2800 kcal ME/kg followed by those fed diets with 3300 kcal ME/kg. Whereas, fish fed diets with 2300 kcal ME/kg achieved the poorest FCR values. **Samra (2002)** found that Nile tilapia fed the 3000 kcal ME/kg dietary energy level recorded the best FCR, increasing the energy level to either 3300 or 3600 kcal ME/kg resulted in poor FCR values.

4.2.2.3. Protein efficiency ratio:

The effect of dietary protein and energy levels and their interactions on PER values of Nile tilapia with large initial size are illustrated in Table (44). Statistical analysis of results obtained are shown in Table (45). Fish fed PL3EL1 (30% CP and 2500 kcal ME/kg) treatment showed the highest (best) PER value (2.13), while those of PL3EL3 (30% CP and 3500 kcal ME/kg) treatment recorded the lowest (poorest) one, being 0.81 (Table 44). However, **Wafa (2002)** revealed that the best PER value was show by fish fed the diet contained 25% CP and 2500 kcal ME/kg, while the lowest (poorest) value was recorded by fish fed the 30% CP and 2500 kcal ME/kg diet.

Results of PER values showed that fish fed PL2 (25% CP) recorded the best value (1.47) followed by that of fish fed PL3 (30% CP), being 1.43, with no significant differences between the two values (Table 44).

Table (44): Least square means and standard errors for the effect of different dietary protein and energy levels on protein efficiency ratio (g gain/g CP intake) of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	No.	Protein efficiency ratio Means ± SE
Protein level (PL)		
20% CP (PL1)	89	1.21±0.04 b
25% CP (PL2)	88	1.47±0. 04 a
30% CP (PL3)	90	1.43±0. 04 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	89	1.73±0.04 a
3000 kcal ME/kg (EL2)	88	1.30±0. 04 b
3500 kcal ME/kg (EL3)	90	1.07±0. 04 c
PL×EL		
PL1×EL1	29	1.42±0.08 cd
PL1×EL2	29	0.91±0.08 e
PL1×EL3	31	1.33±0.08 cd
PL2×EL1	30	1.72±0.08 b
PL2×EL2	29	1.63±0.08 bc
PL2×EL3	29	1.14±0.08 de
PL3×EL1	30	2.13±0.08 a
PL3×EL2	30	1.42±0.08 cd
PL3×EL3	30	0.81±0.08 e

a, b, c, d and e means in the same column with different superscripts are significantly ($P<0.05$)different

Table (45): Analysis of variance for the effect of different dietary protein and energy levels on efficiency ratio of Nile tilapia (initial weight 39.82 g) for 180 days.

SOV	Protein efficiency ratio	
	df	F-ratio
Protein level (PL)	2	8.54 *
Enrgy level (EL)	2	47.23 **
PL×EL	4	16.83 **
Remainder df	258	
Remainder MS		0.175

* = $P<0.05$ ** = $P<0.01$

Whereas, fish fed PL1 (20% CP) showed the lowest ($P<0.05$) value, being 1.21. The previous results are in accordance with those reported by **Cisse (1996)** who indicated that PER for Nile tilapia was improved with each increase in dietary protein level. On the other hand, **Mazid et al., (1979)** with T. zillii; **Jauncey (1982)** with *O. mossambicus*; **Teshima et al., (1985)**; **Siddiqui et al., (1988)** and **Samra (2002)** with Nile tilapia *O. niloticus* concluded that PER decreased linearly with increasing dietary protein level. However, **El-Dahhar (1994), Goda (1996) and Twibell and Brown (1998)** reported that, PER was not significantly affected by increasing the dietary protein level for fry and fingerlings of Nile tilapia (*O. niloticus*).

Data in Table (44) showed that PER values decreased with increasing the EL from 2500 to 3000 and 35000 kcal ME/kg diet, and the decrease was significant ($P<0.05$) with each increment in EL. These results indicated that PER values were improved with each decrease in EL tested. In agreement with the previous results, **Chou and Shiau (1996)** reported that PER values for hybrid Nile tilapia decreased with increasing the dietary lipid level from 10 to 15 and 20%. Similarly, **El-Saidy and Gaber (2002)** found that, Nile tilapia fed diets with 10-12% fat had higher PER values than those fed diets with 12, 14, 16 and 18% fats. Also, **Samra (2002)** concluded that increasing dietary energy level from 3000 to 3300 and 3600 kcal ME/kg, significantly decreased PER values of Nile tilapia.

4.2.2.4. Protein productive value:

Results of PPV% of Nile tilapia with large initial size as affected by dietary protein and energy levels as well as their interactions are presented in Table (46). These results revealed that, fish of PL3EL1 (30% CP and 2500 kcal ME/kg) treatment recorded the best PPV (38.52), while those of PL1EL2 (20% CP and 3000 kcal ME/kg) treatment showed the poorest value (15.33).

As shown in Table (46), the best PPV (28.43) was achieved by fish fed PL2 (25% CP), while the poorest one (19.07) was recorded by fish fed PL1 (20% CP). Analysis of variance (Table 47) indicated that the differences in PPV's attributed to PL effect were significant ($P<0.001$). The differences in PPV's between fish fed PL1 (20% CP) and those fed either PL2 (25% CP) or PL3 (30% CP) were significant ($P<0.05$), whereas, those between fish fed PL2 and PL3 were not significant. It is clear that results of PPV followed the same trend observed with PER values. In agreement with the previous results, **Mazid *et al.* (1979)** reported that PPV's for Nile tilapia increased linearly with increasing dietary protein level from 21 to 30% and decreased with dietary levels from 34.7 to 53.4%. Also, **Goda (1996)** indicated that increasing the dietary protein level from 20 to 25% and 30% improved ($P<0.05$) PPV's of Nile tilapia (*O. niloticus*). Whereas, **Omer (1994)** reported that dietary protein level (from 23 to 50%) had no significant effect on PPV's of Nile tilapia (*O. niloticus*).

With regard to the effect of EL on PPV's, results in Table (46) showed that PPV's decreased with each increase in EL being 29.83, 22.73 and 21.63% for fish fed EL1, EL2 and EL3

Table (46): Least square means and standard errors for the effect of different dietary protein and energy levels on protein productive value of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	No.	Protein productive value
		Means±SE
Protein level (PL)		
20% CP (PL1)	24	19.07±0.64 b
25% CP (PL2)	24	28.43±0.64 a
30% CP (PL3)	24	26.72±0.64 a
Energy level (EL)		
2500 kcal ME/kg (EL1)	24	29.83±0.64 a
3000 kcal ME/kg (EL2)	24	22.73±0.64 b
3500 kcal ME/kg (EL3)	24	21.63±0.64 b
PL×EL		
PL1×EL1	8	20.51±1.12 c
PL1×EL2	8	15.33±1.12 d
PL1×EL3	8	21.42±1.12 c
PL2×EL1	8	30.53±1.12 b
PL2×EL2	8	30.94±1.12 b
PL2×EL3	8	23.93±1.12 c
PL3×EL1	8	38.52±1.12 a
PL3×EL2	8	22.05±1.12 c
PL3×EL3	8	19.64±1.12 c

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$)different

Table (47): Analysis of variance for the effect of different dietary protein and energy levels on protein productive value of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	df	Protein productive value
		F-ratio
Protein level (PL)	2	47.70 ***
Energy level (EL)	2	40.40 ***
PL×EL	4	23.92 **
Remainder df	258	
Remainder MS		36.4226

** = $P<0.01$ ** = $P<0.001$

(2500, 3000 and 35000 kcal ME/kg), respectively, indicating that fish fed the lower EL (2500 kcal ME/kg) utilize the dietary protein more efficiently than those fed the higher energy levels (3000 and 3500 kcal ME/kg). However, the differences in PPV's for fish fed EL1 and those fed either EL2 or EL3 were significant ($P<0.05$), while no significant differences were observed between PPV's of fish fed EL2 or EL3. In **2002, Wafa** reported that PPV's of hybrid Nile tilapia increased with decreasing dietary energy level from 3300 to 2800 and 2300 kcal ME/kg, indicating that fish utilize dietary protein more efficient with each decrease in the dietary energy level.

4.2.2.5. Energy retention:

Averages of ER% of Nile tilapia with large initial size as affected by dietary protein and energy levels as well as their interactions are illustrated in table (48). Statistical analysis of results obtained are shown in Table (49). Among the different experimental treatments, fish of PL1EL3 (20% CP and 3500 kcal ME/kg) treatment showed the highest ER value (19.63) and those of PL3EL3 (30% CP and 3500 kcal ME/kg) treatment recorded the lowest one (12.23). In this concern, **Wafa (2002)** found that hybrid Nile tilapia fed 25% CP and 2500 kcal ME/kg achieved the highest ER value, while fish fed 30% CP and 3600 kcal ME/kg showed the lowest value.

Results in Table (48) showed that fish fed PL2 (25% CP) retained more energy than those fed either PL1 (20% CP) or PL3 (30%CP), being 17.43, 15.73 and 15.14%, respectively. Statistical analysis (Table 49) indicated that PL exhibited significant ($P< 0.01$)

Table (48): Least square means and standard errors for the effect of different dietary protein and energy levels on energy retention of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Energy retention	
	No.	Means±SE
Protein level (PL)		
20% CP (PL1)	24	15.73±0.47 b
25% CP (PL2)	24	17.43±0.47 a
30% CP (PL3)	24	15.14±0.47 b
Energy level (EL)		
2500 kcal ME/kg (EL1)	24	15.81±0.47
3000 kcal ME/kg (EL2)	24	15.97±0.47
3500 kcal ME/kg (EL3)	24	16.52±0.47
PL×EL		
PL1×EL1	8	14.33±0.83 c
PL1×EL2	8	13.32±0.83 c
PL1×EL3	8	19.63±0.83 a
PL2×EL1	8	16.14±0.83 bc
PL2×EL2	8	18.51±0.83 a
PL2×EL3	8	17.72±0.83 ab
PL3×EL1	8	17.05±0.83 ab
PL3×EL2	8	16.14±0.83 bc
PL3×EL3	8	12.23±0.83 c

a, b, and c means in the same column with different superscripts are significantly (P<0.05)different

Table (49): Analysis of variance for the effect of different dietary protein and energy levels on energy retention of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Energy retention	
	df	F-ratio
Protein level (PL)	2	9.74 **
Energy level (EL)	2	0.80
PL×EL	4	20.13 ***
Remainder df	258	
Remainder MS		20.0213

** = P<0.01 *** P<0.001

effect on ER values. The differences in ER values between fish fed PL2 and those fed either PL1 or PL3 were significant ($P<0.05$), while those among fish fed PL1 and those fed PL3 were not significant (Table 48). These results are in full agreement with those reported by **Wafa (2002)** who indicated that fish fed the 25% CP level retained significantly more energy than those fed the 30% CP level. **Goda (1996)** indicated that ER values for Nile tilapia improved significantly ($P<0.05$) with increasing the dietary protein level from 20 to 25 and 30%.

Values of ER for fish fed EL1, EL2 and EL3 (2500, 3000 and 3500 kcal/kg) were 15.81, 15.97 and 16.52%, respectively, and the differences between these ER values were insignificant (Tables 48 and 49). In contrast with the previous results, **Wafa (2002)** indicated that hybrid Nile tilapia fed the lower energy level (2300 kcal ME/kg) retained more energy than those fed the higher energy levels (2800 and 3300 kcal ME/kg).

4.2.3. Effect of dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia of large initial size (39.82 g):

Averages of HSI and GSI of Nile tilapia with large initial size as affected by dietary protein and energy levels and their interactions are presented in Table (50) and analysis of variance for the same factors are shown in Table (51). Averages of HSI revealed that fish of PL3EL1 (30% CP and 2500 kcal ME/kg) treatment recorded the highest value (3.91), while those of PL1EL2 (20% CP and 3000 kcal ME/kg) showed the lowest one (2.22).

Table (50): Least square means and standard errors for the effect of different dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	Hepato-somatic index		Gonado-somatic index (Means±SE)		
	No.	Means±SE	No.	Males	Females
Protein level (PL)					
20% CP (PL1)	24	2.83±0.16	12	0.91±0.90 a	1.77±0.83 a
25% CP (PL2)	24	3.20±0.16	12	0.63±0.90 b	1.27±0.83 b
30% CP (PL3)	24	3.33±0.16	12	0.53±0.90 b	1.66±0.83 a
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	3.57±0.16	12	0.70±0.90 ab	1.39±0.83 b
3000 kcal ME/kg (EL2)	24	2.63±0.16	12	0.44±0.90 b	1.44±0.83 b
3500 kcal ME/kg (EL3)	24	3.17±0.16	12	0.93±0.90 a	1.88±0.83 a
PL×EL					
PL1×EL1	8	3.21±0.28	4	1.22±1.55 a	0.90±1.45 d
PL1×EL2	8	2.22±0.28	4	0.41±1.55 c	1.91±1.45 b
PL1×EL3	8	3.13±0.28	4	1.10±1.55 a	2.51±1.45 a
PL2×EL1	8	3.61±0.28	4	0.45±1.55 c	1.35±1.45 c
PL2×EL2	8	2.70±0.28	4	0.39±1.55 c	1.63±1.45 b
PL2×EL3	8	3.33±0.28	4	1.05±1.55 ab	0.83±1.45 d
PL3×EL1	8	3.91±0.28	4	0.44±1.55 c	1.91±1.45 b
PL3×EL2	8	3.08±0. 28	4	0.51±1.55 bc	0.77±1.45 b
PL3×EL3	8	3.15±0. 28	4	0.63±1.55 b	2.31±1.45 a

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$) different

Table (51): Analysis of variance for the effect of different dietary protein and energy levels on hepato-somatic and gonado somatic indices of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	Hepato-somatic index		Gonado-somatic index		
			df	F-ratio	
	df	F-ratio		Males	Females
Protein level (PL)	2	2.18	2	3.37 *	2.73 *
Energy level (EL)	2	1.49	2	4.25 *	5.14 *
PL×EL	4	0.52	4	3.74 *	2.99 *
Remainder df	63		27		
Remainder MS		0.617		9.64	8.39

* = $P<0.05$

Data in Table (50) showed that HSI increased with increasing PL, being 2.83, 3.20 and 3.33 for fish fed PL1, PL2 and PL3 (20, 25 and 30% CP), respectively, but the difference were not significant (Table 51).

Concerning the effect of EL on HSI values, data illustrated in Table (50) showed that values obtained were nearly similar being 3.57, 2.63 and 3.17 for fish fed EL1, EL2 and EL3 (2500, 3000 and 3500 kcal ME/kg), respectively. The differences in HSI values due to EL effect were not significant (Table 51).

Data illustrated in Table (50) showed that the highest GSI value for males (1.22) was recorded by fish fed PL1EL1 (20% CP and 2500 kcal ME/kg) treatment and the lowest one (0.39) was shown by those fed PL2EL2 (25% CP and 3000 kcal ME/kg) treatment. The corresponding values for females (2.51 and 0.77) were shown by fish fed PL1PL3(20% CP and 3500 kcal ME/kg) and PL3EL2(30% CP and 3000 kcal ME/kg) treatments. However, females among all experimental treatments had almost higher GSI values than males.

Results in Table (50) indicated that fish of PL1 (20% CP) treatment recorded the highest GSI values being 0.91 for males and 1.77 for females. The lowest value for males (0.53) was shown by fish fed PL3 (30% CP), while that for females (1.27) was recorded by those fed PL2. Analysis of variance (Table 51) showed that the differences in GSI values due to PL effect for both males and females were significant ($P<0.05$). The differences in GSI for fish males fed PL1 and those fed either PL2 or PL3 were significant ($P<0.05$), whereas, the differences between fish males fed PL2 and PL3 were not significant. For females, the differences in GSI for fish fed PL2 and those fed either PL1 or PL3 were significant, while those between fish fed PL1 and PL3 were not significant.

Concerning the effect of EL on GSI values, results obtained showed that males fed EL3(3500 kcal ME/kg) recorded the highest GSI value (0.93) and those fed EL2 (3000 kcal ME/kg) showed the lowest one (0.44), the differences were only significant between GSI values of fish fed 3000 kcal ME/kg and those fed 3500 kcal ME/kg. For females, the GSI values increased with increasing the EL, fish fed the higher energy level (EL3, 3500 kcal ME/kg) showed the highest value (1.88) and those fed the lower energy level (EL1, 2500 kcal ME/kg) recorded the lowest value (1.39), with significant differences only between fish fed EL3 and those fed either EL1 or EL2 as presented in Table (50).

4.2.4. Effect of dietary protein and energy levels on carcass traits and chemical composition of Nile tilapia of large initial size (39.82 g).

4.2.4.1. Carcass traits:

Carcass traits of Nile tilapia of large initial size as affected by dietary protein and energy levels and their interactions are shown in Table (52). Analysis of variance for results obtained are shown in Table (53). The highest dressing, flesh, head and bone percentages were achived by treatments PL3EL1, PL3EL1, PL3EL2 and PL1EL1, respectively, whereas the lowest corresponding ones were shown by treatments PL3EL3, PL3EL3, PL2EL1 and PL1EL2 (Table 52).

Table (52): Least square means and standard errors for the effect of different dietary protein and energy levels on carcass traits of Nile tilapia (initial weight 39.82 g) reared for 180 days.

Items	No.	Dressing %	Flesh %	Head %	Bone %
Protein level (PL)					
20% CP (PL1)	24	52.55±0.51 c	48.12±0.43 b	24.29±0.48 a	4.40±0.43
25% CP (PL2)	24	54.56±0.51 a	50.25±0.43 a	22.36±0.48 b	4.36±0.43
30% CP (PL3)	24	53.42±0.51 b	48.99±0.43 b	24.35±0.48 a	4.53±0.43
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	54.85±0.51 a	50.41±0.43 a	22.62±0.48 b	5.08±0.43 a
3000 kcal ME /kg (EL2)	24	52.73±0.51 b	48.29±0.43 b	25.12±0.48 a	3.48±0.43 b
3500 kcal ME /kg (EL3)	24	52.84±0.51 b	48.66±0.43 b	23.25±0.48 b	4.72±0.43 a
PL×EL					
PL1×EL1	8	53.11±0.88 c	48.71±0.74 d	24.51±0.83 b	5.13±0.74 a
PL1×EL2	8	52.63±0.88 e	48.13±0.74e	24.22±0.83 b	3.34±0.74 cd
PL1×EL3	8	51.90±0.88 e	47.52±0.74 e	24.13±0.83 b	4.73±0.74 b
PL2×EL1	8	54.92±0.88 b	50.41±0.74 c	21.12±0.83 d	5.05±0.74 a
PL2×EL2	8	53.43±0.88 c	49.13±0.74 d	24.23±0.83 b	3.51±0.74 c
PL2×EL3	8	55.32±0.88 b	51.22±0.74 b	21.72±0.83 d	4.52±0.74 b
PL3×EL1	8	56.51±0.88 a	52.12±0.74 a	22.23±0.83 d	5.06±0.74 a
PL3×EL2	8	52.13±0.88 e	47.61±0.74 e	26.91±0.83 a	3.61±0.74 c
PL3×EL3	8	51.62±0.88 e	47.24±0.74 e	23.90±0.83 c	4.92±0.74 ab

a, b, c, d and e means in the same column with different superscripts are significantly ($P<0.05$)different

Table (53): Analysis of variance for the effect of different dietary protein and energy levels on carcass traits of Nile tilapia (initial weight 39.82 g) reared for 180 days.

SOV	df	F-ratios			
		Dressing %	Flesh %	Head %	Bone %
Protein level (PL)	2	3.69 *	5.12 *	3.67 *	2.32
Energy level (EL)	2	4.32 *	3.39 *	5.16 *	3.68 *
PL×EL	4	2.99 *	5.13 *	2.96 *	2.96 *
Remainder df	63				
Remainder MS		6.22	4.37	5.53	4.35

* = $P<0.05$

Results in Table (52) cleared that increasing PL from 20 to 25% CP significantly (P<0.05) increased both dressing and flesh percentages of fish, while it decreased (P<0.05) head percentage. However, a reverse trend was observed with increasing PL from 25 to 30%. Moreover, increasing PL from 20 to 25 and 30% had no significant effect on bone percentage (Table 53). In accordance with the previous results, **Abdel-Hakim et al., (2001 b)** concluded that increasing dietary protein level from 25 to 30% decreased dressing and flesh percentages of Nile tilapia. Whereas, **Samra (2002)** reported that increasing dietary CP level (20 to 25 and 30%) decreased the percentages of dress-out, flesh, head and viscera for tilapia (*O. niloticus*). Also, **Li et al., (2000)** found that channel catfish fillet yield was higher for fish fed the 36% dietary CP level than those fed the 24% CP one.

With respect to the effect of EL on carcass traits, results in Table (52) showed that increasing EL from 2500 to 3000 kcal ME/kg significantly (P<0.05) decreased dressing, flesh and bone percentages, whereas the percentage of head was increased (P<0.05). A reverse trend was observed when EL was increased from 3000 to 3500 kcal ME/kg. In this respt, **Samra (2002)** found that increasing the energy level from 300 to 330 and 360 kcal/100 g followed by decrease in the percentages of dress-out and flesh of Nile tilapia.

4.2.4.2. Chemical composition of whole fish:

Averages of chemical composition of Nile tilapia whole fish body of large initial size as affected by dietary protein and energy levels and their interactions are shown in Table (54), and the analysis of variance of results obtained are presented in Table (55). The highest moisture, protein, fat and ash contents were recorded by fish of treatments PL3EL2, PL3EL3, PL2EL1 and PL1EL3, respectively, while the lowest corresponding contents were achived by fish of treatments PL2EL3, PL1EL3, PL3EL3 and PL3EL3 as shown in Table (54).

With regard to the effect of PL on chemical composition of Nile tilapia whole fish body, results in Tables (54) and (55) showed that fish fed PL3 (30% CP) recorded the highest ($P<0.05$) protein content and the lowest fat and ash ($P<0.05$) percentages, whereas, those fed PL1 (20% CP) showed the highest moisture percentage and the lowest protein content in dry matter. The highest fat ($P<0.05$) and ash contents and lowest ($P<0.05$) moisture percentage were achieved by fish fed 25% CP (PL2). In general, increasing PL from 20 to 25% increased protein, fat and ash contents, but decreased moisture content, while increasing PL from 25 to 30% showed a reverse trend. In partial agreement with the previous results, **Samra (2002)** found that, increasing dietary CP level from 20 to 25% and 30% decreased protein and fat percentages but had no significant effect on either moisture or ash contents of Nile tilapia whole fish. **Abdel-Hakim et al., (2001 b)** came to the same conclusion with tilapia fish. They found that when dietary protein level increased from 25 to 30 %, the percentages of moisture, protein and ash were decreased, while those of fat were increased. Similar results were reported by **Shiau and Huang (1989)**. On the contrary, **Winfree and Stickney (1981)** revealed that the

Table (54): Least square means and standard errors for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia whole fish on DM basis (initial weight 39.82 g) reared for 180 days.

Items	No.	Moisture %	Protein %	Fat %	Ash %
Protein level (PL)					
20% CP (PL1)	24	71.51±0.19 a	54.97±0.17 b	30.43±0.18 b	13.43±0.18 a
25% CP (PL2)	24	69.80±0.19 b	55.31±0.17 b	31.27±0.18 a	13.60±0.18 a
30% CP (PL3)	24	71.23±0.19 a	57.70±0.17 a	29.83±0.18 b	12.37±0.18 b
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	71.31±0.19 a	54.87±0.17 b	31.43±0.18 a	13.23±0.18
3000 kcal ME/kg (EL2)	24	71.80±0.19 a	56.73±0.17 a	30.43±0.18 b	13.03±0.18
3500 kcalME/kg (EL3)	24	69.61±0.19 b	56.33±0.17 a	29.83±0.18 b	13.13±0.18
PL×EL					
PL1×EL1	8	72.15±0.33 b	54.72±0.29 d	31.33±0.31 ab	13.21±0.32 ab
PL1×EL2	8	70.80±0.33 c	56.21±0.29 cd	30.51±0.31 b	13.13±0.32 ab
PL1×EL3	8	71.62±0.33 bc	54.11±0.29 d	30.12±0.31 b	14.11±0.32 a
PL2×EL1	8	70.42±0.33 c	54.91±0.29 d	32.25±0.31 a	12.91±0.32 b
PL2×EL2	8	70.61±0.33 c	56.21±0.29 cd	30.81±0.31 b	14.08±0.32 a
PL2×EL3	8	68.32±0.33 d	55.11±0.29 d	31.12±0.31 ab	13.91±0.32 ab
PL3×EL1	8	70.60±0.33 c	55.13±0.29 d	31.15±0.31 ab	13.60±0.32 ab
PL3×EL2	8	74.14±0.33 a	58.12±0.29 b	30.07±0.31 b	12.06±0.32 b
PL3×EL3	8	68.91±0.33 d	60.11±0.29 a	28.51±0.31 c	11.53±0.32 bc

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$)different

Table (55): Analysis of variance for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia whole fish (initial weight 39.82 g) reared for 180 days.

SOV	df	F-ratios			
		Moisture %	Protein %	Fat %	Ash %
Protein level (PL)	2	4.62 *	3.97 *	5.21 *	3.57 *
Energy level (EL)	2	5.13 *	4.63 *	3.98 *	2.13
PL×EL	4	2.88 *	2.88 *	2.89 *	4.35 *
Remainder df	63				
Remainder MS		0.883	0.694	0.778	0.834

* = P<0.05

dietary protein level had no effect on fish body protein. Also, **Hafedh (1999)** found that dietary protein level (25 to 45%) had no significant influence on body protein content of Nile tilapia, but lipid content decreased with increasing dietary protein level and no clear trend was observed with ash content.

Results in Table (54) showed that fish fed EL1 (2500 kcal ME/kg) had the highest fat ($P<0.05$) and ash contents and lowest ($P<0.05$) protein percentage, while those fed EL2 (3000 kcal ME/kg) recorded the highest moisture and protein percentages and the lowest ash content. Fish fed EL3 (3500 kcal ME/kg) had the lowest fat and moisture contents. In this concern, **Samra (2002)** reported that increasing dietary energy contents (300 to 330 and 360 kcal/100 g) decreased the percentages of moisture, protein and ash and increased the percentage of fat in Nile tilapia whole fish body, but the differences due to EL effect were not significant. **Chou and Shiau (1996)** concluded that body lipid content of hybrid tilapia (*O. niloticus* × *O. aureus*) increased significantly with increasing dietary lipid level (0, 5, 10, 15 and 20%) but body protein and ash content were not significantly affected.

4.2.4.3. Chemical composition of fish flesh:

Chemical analysis on DM basis of Nile tilapia flesh of large initial size as affected by dietary protein and energy levels and their interactions are illustrated in Table (56). Analysis of variance for the results obtained are presented in Table (57). The highest moisture, protein, fat and ash percentages were achieved by treatments PL3EL3, PL2EL3, PL2EL2 and PL3EL2, respectively, while the lowest corresponding percentages were

Table (56): Least square means and standard errors for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia flesh on DM basis (initial weight 39.82 g) reared for 180 days.

Items	No.	Moisture %	Protein %	Fat %	Ash %
Protein level (PL)					
20% CP (PL1)	24	79.92±0.95 a	80.32±0.20	11.08±0.18 b	5.89±0.31 a
25% CP (PL2)	24	72.96±0.95 b	80.18±0.20	12.87±0.18 a	5.02±0.31 b
30% CP (PL3)	24	78.35±0.95 a	80.39±0.20	13.51±0.18 a	6.01±0.31 a
Energy level (EL)					
2500 kcal ME/kg (EL1)	24	76.11±0.95	79.05±0.20 b	14.08±0.18 a	5.45±0.31
3000 kcal ME/kg (EL2)	24	77.62±0.95	79.68±0.20 b	12.49±0.18 b	5.80±0.31
3500 kcalME/kg (EL3)	24	77.49±0.95	82.16±0.20 a	10.88±0.18 c	5.67±0.31
PL×EL					
PL1×EL1	8	78.32±1.64 b	78.11±0.35 bc	13.10±0.33 c	5.91±0.54 ab
PL1×EL2	8	80.72±1.64 a	80.62±0.35 b	9.42±0.33 d	5.43±0.54 b
PL1×EL3	8	80.73±1.64 a	82.23±0.35 ab	10.72±0.33 d	6.33±0.54 a
PL2×EL1	8	73.41±1.64 cd	78.91±0.35 bc	14.61±0.33 b	5.11±0.54 b
PL2×EL2	8	75.22±1.64 c	77.52±0.35 bc	15.90±0.33 a	5.53±0.54 b
PL2×EL3	8	70.25±1.64 d	84.11±0.35 a	8.11±0.33 d	4.42±0.54 c
PL3×EL1	8	76.61±1.64 c	80.13±0.35 b	14.54±0.33 b	5.32±0.54 b
PL3×EL2	8	76.92±1.64 c	80.90±0.35 b	12.17±0.33 bc	6.44±0.54 a
PL3×EL3	8	81.51±1.64 a	80.15±0.35 b	13.81±0.33 bc	6.26±0.54 a

a, b, c and d means in the same column with different superscripts are significantly ($P<0.05$) different

Table (57): Analysis of variance for the effect of different dietary protein and energy levels on chemical composition of Nile tilapia flesh (initial weight 39.82 g) reared for 180 days.

SOV	df	F-ratios			
		Moisture %	Protein %	Fat %	Ash %
Protein level (PL)	2	3.68 *	1.36	4.62 *	5.33 *
Energy level (EL)	2	2.17	4.25 *	5.31 *	2.14
PL×EL	4	4.37 *	13.62 *	6.13 *	9.27 *
Remainder df	63				
Remainder MS		21.63	0.988	0.797	2.362

* = $P<0.05$

recorded by treatments PL2EL3, PL2EL2, PL2EL3 and PL2EL3 (Table 56).

Results in Table (56) revealed that fish fed the lower CP level (20%) recorded the highest moisture content and the lowest ($P<0.05$) fat percentage, while those fed the higher CP level (30%) showed the highest protein, fat and ash contents. The lowest moisture ($P<0.05$), protein and ash ($P<0.05$) contents were achieved by fish fed PL2 (25% CP). Analysis of variance (Table 57) indicated that PL had significant ($P<0.05$) effect on chemical composition of Nile tilapia flesh except for protein content. In partial agreement with the previous results, **Samra (2002)** found that increasing protein level from 20 to 25 and 30% in Nile tilapia diets increased protein content in flesh, but it decreased moisture, fat and ash contents, and protein level had significant effect on all traits studied. Similarly **Wafa (2002)** reported that increasing the dietary CP level from 25 to 30% increased protein content, but decreased moisture, fat and ash contents in hybrid tilapia flesh. **Goda (1996)** claimed that increasing protein level from 20 to 25 and 30% increased protein percentage significantly and decreased fat content of Nile tilapia flesh, wheareas it had no significant effect on moisture, DM and ash contents. On the other hand, **Abdel-Hakim et al., (2001 b)** reported that increasing protein content in tilapia diets from 25 to 30% had no significant effect on the percentages of flesh moisture, protein, fat and ash.

Concerning the effect of EL on chemical composition of Nile tilapia flesh, data in Table (56) indicated that as dietary energy level increased from 2500 to 3000 and 3500 kcal ME/kg, moisture and protein contents increased, whereas fat content decreased. Ash content had no clear trend. However, analysis of variance (Table 57) showed that EL had significant ($P<0.05$) effect only on protein and fat percentages. Moreover, fish fed on EL3 (3500 kcal ME/kg) had the highest protein content and the lowest fat percentage, while those fed on EL1(2500 kcal ME/kg) showed the highest fat content and lowest moisture, protein and ash percentages. The highest moisture and ash contents were recorded by fish fed EL2 (3000 kcal ME/kg) as shown in Table (56). In this respect, **Samra (2002)** found that as energy level in tilapia diets increased from 300 to 330 and 360 kcal ME/100 g, moisture, protein and fat contents increased but ash percentage decreased. Similar results were reported by **De Silva et al., (1991).** They concluded that tilapia carcass lipids content increased with increasing protein level from 15 to 20 and 25%.

4.2.5. Effect of dietary protein and energy levels on fish production and profit index of Nile tilapia of large initial size (39.82 g).

As shown in Table (58), the highest fish production (0.70 kg/m^2) was recorded by fish of treatment PL1EL3 (20% CP and 3500 kcal ME/kg), whereas the lowest fish production (0.35 and 0.36 kg/m^2) was achieved by fish of treatments PL1EL2 (20% CP and 3000 kcal ME/kg) and PL1EL1 (20% CP and 2500 kcal ME/kg), respectively and fish of treatment PL2EL1 (25% CP and 2500 kcal ME/kg) showed the highest profit index (1.74) and lowest feed costs/kg WG (2.31 LE). Whereas, fish of treatment PL3EL3 (30% CP and 3500 kcal ME/kg) recorded the lowest profit index (1.05) and highest feed costs/kg WG (3.82 LE).

Table (58): Least square means and standard errors for the effect of different dietary protein and energy levels on fish production and profit index of Nile tilapia (initial weight, 39.82 g) reared for 180 days.

Items	Fish production (kg/m^2)	Feed costs/kg WG (LE)	Profit index
Protein level (PL)			
20% CP (PL1)	0.47±0.09	2.70±0.09	1.36±0.03
25% CP (PL2)	0.58±0.08	2.51±0.33	1.61±0.11
30% CP (PL3)	0.56±0.06	3.03±0.12	1.38±0.21
Energy level (EL)			
2500 kcal ME/kg (EL1)	0.51±0.09	2.33±0.19	1.57±0.06
3000 kcal ME/kg (EL2)	0.51±0.04	2.83±0.87	1.44±0.19
3500 kcal ME/kg (EL3)	0.59±0.07	3.09±0.17	1.33±0.20
PL×EL			
PL1×EL1	0.36	2.33	1.25
PL1×EL2	0.35	3.21	1.25
PL1×EL3	0.70	2.55	1.57
PL2×EL1	0.51	2.31	1.74
PL2×EL2	0.65	2.34	1.71
PL2×EL3	0.59	2.89	1.38
PL3×EL1	0.67	2.33	1.72
PL3×EL2	0.52	2.94	1.36
PL3×EL3	0.49	3.82	1.05

Profit index=Price of 1 kg fish×fish production (kg)/Price of 1 kg feed×feed intake (kg)

Fish fed the 25% dietary CP level showed the highest fish production (0. 58 kg/m^2), while those fed the 20% dietary CP level recorded the lowest fish production/m2 (0.47 kg). The same trend was observed with profit index as fish fed diet with 25% CP achieved the highest profit index (1.61), whereas, those fed the diets with 20% and 30% CP achieved nearly the same profit index, being 1.36 and 1.38, respectively. Moreover, fish fed the 25% dietary CP level showed the lowest feed costs/kg WG (2.51 LE) and those fed the 30% dietary CP level recorded the highest one, being 3.03 LE.

Fish fed 2500 and 3000 kcal ME/kg dietary energy levels recorded the same fish production value, being 0.51 kg/m^2, while those fed the higher dietary energy level (3500 kcal ME/kg) showed the highest (0.59 kg/m^2) value. Profit index decreased (1.57, 1.44 and 1.33) and feed costs/kg WG increased (2.33, 2.83 and 3.09 LE) with increasing dietary energy level from 2500 to 3000 and 3500 kcal ME/kg, respectively.

From the previous results of the first and second experiments it could be concluded that fish of small initial size fed the 30% dietary CP level recorded almost the best growth performance traits (BW, BL and WG), whereas those of large initial size fed the diet contained 25% achieved the best growth performance of all traits (BW, BL, WG and SGR). Regarding dietary energy level, small initial size fish fed the diet with 3000 kcal ME/kg showed the best growth performance of most traits (BW, BL and WG), while those of large initial size fed the 3500 kcal ME/kg dietary level recorded the best final BW, final BL and total WG.

The best feed utilization values for most triats of either small or large initial size fish were achived by those fed the diet contained 25% CP. Whereas, fish of either small or large initial size fed the diet with 2500 kcal ME/kg recorded the best feed utilization values for most traits.

The best fish production (kg/m^2) of Nile tilapia with either small or large initial size was recorded by fish fed the 25% dietary CP level. Whereas, fish of small initial size fed the diet contained 3000 kcal ME/kg showed the highest fish production (kg/m^2). The highest fish production (kg/m^2) for fish of large initial size was recorded by those fed the diet with 3500 kcal ME/kg. Feed costs/kg WG increased and profit index almost decreased with each increase in either dietary CP level (from 20 to 25 and 30%) or dietary energy level (from 2500 to 3000 and 3500 kcal ME/kg).

4.3. Effect of Different Initial Sizes on Growth Performance and Feed Utilization of Nile Tilapia:

The effect of initial size (22.87or 39.82 g) of Nile tilapia fish **on** growth performance traits, regardless of protein or energy effect, is shown in Table (59). Results of this table showed that fish of small initial size (22.87 g) had lower ($p<0.05$) final BW, WG and final BL when compared with those of large initial size (39.82 g) at the end of the rearing period (180 days), whereas, fish of small initial size recorded higher ($P < 0.05$) SGR than those of large initial size, indicating the fast growth of fish of small initial size. Initial size of Nile tilapia fish had no significant effect on final K values of fish.

Results of feed utilization traits as affected by initial size of Nile tilapia are show in Table (60). These results indicted that although fish of small initial size consumed lower (($p<0.05$) feed, protein and energy intakes (as expected) compared to those of large initial size, but they recorded the best ($p<0.05$) the best ($P < 0.05$) FCR, PER, PPV, ER, and profit index values, indicating that the start with Nile tilapia fish of small initial size (22.87 g) is economically more better in fish production than those of large initial size (39.82 g).

4.4. Nutrients Digestibility of the Experimental Diets:

The effect of different dietary protein and energy levels on nutrients digestibility of the experimental diets is shown in Table (61) and analysis of variance of the same factors are illustrated in Table (62). The highest DM, CP, EE, NFE and GE digestibility percentages were shown by diets of treatments PL1EL2, PL2EL1, PL2EL1, PL1EL2 and PL3EL3, respectively, while the lowest corresponding percentages were recorded by diets of treatments PL3EL3, PL1EL3, PL3EL3, PL3EL1 and PL1EL1 as illustrated in Table (61).

Results in Table (61) showed that the 20% dietary CP level recorded the highest DM ($P<0.05$) and NFE digestibilities, and lowest CP ($P<0.05$), EE and GE digestibility values. Whereas, the diet contained 25% CP showed the highest ($P<0.05$) EE and lowest GE digestibility percentages.The diet with the higher dietary CP level (30%) achieved the highest CP and GE ($P<0.05$) digestibility values and lowest DM ($P<0.05$) EE and NFE ($P<0.05$) values. It is clear that increasing the

Table (59): Least square means and standar errors for the effect of different initial sizes on growth performance of Nile tilapia.

Items	**Small initial size (22.87g) Mean ± SE**	**Large initial size (39.82g) Mean ± SE**
Final body weight (g)	109.71 ± 4.37 b	143.73 ± 10.58a
Weight gain (g)	90.70 ± 4.23 b	103.73 ± 10.53 a
Final body length (cm)	18.48 ± 0.25 b	20.14 ± 0.45 a
Final condition factor	1.95 ± 0.02	1.98 ± 0.05
Specific growth rate	0.88 ± 0.02 a	0.69 ± 0.04 b

a and b means in the same row with different superscripts are significantly (0.05) different.

Table (60): Least square means and standar errors for the effect of different initial sizes on feed utilization of Nile tilapia.

Items	**Small initial size (22.87g) Mean ± SE**	**Large initial size (39.82g) Mean ± SE**
Feed intake (g)	211.95 ± 6.17 b	323.32 ± 18.89 a
Protein intake (g)	49.85 ± 3.88 b	81.20 ± 7.14 a
Energy intake (g)	637.50 ± 37.28 b	979.13 ± 85.61 a
Feed conversion ratio	2.46 ± 0.10 b	3.22 ± 0.25 a
Protein efficiency ratio	1.78 ± 0.15 a	1.39 ± 0.14 b
Protein productive value	34.80 ± 2.35 a	24.76 ± 2.40 b
Energy retention	19.26 ± 0.95 a	16.12 ± 0.81 b
Profit index	1.79 ± 0.103 a	1.45 ± 0.08 b

a and b means in the same row with different superscripts are significantly (0.05) different.

Table (61): Least square means and standard errors for the effect of different dietary protein and energy levels on nutrients digestibility of the experimental diets used through the first and second experiments.

Items	No.	Digestibility (%)				
		DM	CP	EE	NFE	GE
Protein level (PL)						
20% CP (PL1)	30	54.62±1.93 a	77.65±0.98 b	74.52±2.66 b	56.00±2.53 a	70.42±3.17 b
25% CP (PL2)	30	51.45±1.93 b	80.40±0.98 a	81.10±2.66 a	54.33±2.53 a	71.47±3.17 b
30% CP (PL3)	30	48.47±1.93 c	80.43±0.98 a	77.24±2.66 b	45.11±2.53 b	73.91±3.17 a
Energy level (EL)						
2500 kcal ME/kg (EL1)	30	51.68±1.93 ab	82.66±0.98 a	83.21±2.66 a	51.12±2.53 b	69.16±3.17 c
3000 kcal ME/kg (EL2)	30	53.05±1.93 a	79.02±0.98 b	76.90±2.66 b	54.74±2.53 a	72.48±3.17 b
3500 kcal ME/kg (EL3)	30	49.82±1.93 b	76.81±0.98 b	72.74±2.66 c	49.58±2.53 b	74.16±3.17 a
PL×EL						
PL1×EL1	10	53.96±2.99 ab	80.71±1.71 b	79.15±4.60 c	56.60±4.39 c	67.72±5.49 d
PL1×EL2	10	55.88±2.99 a	76.91±1.71 c	73.25±4.60 cd	69.10±4.39 a	72.73±5.49 b
PL1×EL3	10	54.02±2.99 a	75.32±1.71 c	71.15±4.60 d	42.31±4.39 e	70.81±5.49 c
PL2×EL1	10	52.62±2.99 b	84.62±1.71 a	87.77±4.60 a	55.05±4.39 c	69.15±5.49 c
PL2×EL2	10	51.95±2.99 b	79.53±1.71 bc	78.82±4.60 c	48.81±4.39 d	71.81±5.49 b
PL2×EL3	10	49.79±2.99 c	77.05±1.71 c	76.71±4.60 c	59.13±4.39 b	73.44±5.49 b
PL3×EL1	10	48.45±2.99 c	82.64±1.71 a	82.72±4.60 b	41.70±4.39 e	70.61±5.49 c
PL3×EL2	10	51.31±2.99 b	80.61±1.71 b	78.63±4.60 c	46.32±4.39 d	72.91±5.49 b
PL3×EL3	10	45.65±2.99 d	78.05±1.71 c	70.36±4.60 d	47.30±4.39 d	78.22±5.49 a

a, b, c, d and e: means in the same column with different superscripts are significantly ($P<0.05$) different.

Table (62): Analysis of variance for the effect of different dietary protein and energy levels on nutrients digestibility of the experimental diets used through the first and second experiments.

SOV	F-ratios					
	df	DM	CP	EE	NFE	GE
Protein level (PL)	2	14.51*	8.63*	9.76*	16.21*	13.51*
Energy level (EL)	2	10.50*	6.74*	3.20	7.71*	8.92*
PL×EL	4	13.00*	11.12*	10.54*	18.40*	14.16*
Remainder df	81					
Remainder MS		89.16	29.16	211.70	192.40	301.30

* = $P<0.05$

dietary CP level from 20 to 25 and 30% increased CP and GE digestibility, but decreased DM ($P<0.05$) and NFE ones. However, digestibility of EE significantly ($P<0.05$) increased with increasing dietary CP level from 20 to 25%, but decreased with the higher level (30% CP).

With regard to the effect of dietary EL on nutrients digestibility, results in Table (61) cleared that the diet with 2500 kcal ME/kg showed the highest ($P<0.05$) CP and EE digestibilities and lowest ($P<0.05$) GE one. While the diet contained 3000 kcal ME/kg recorded the highest DM and NFE ($P<0.05$) digestibilities. The higher dietary energy level (3500 kcal ME/kg) achieved the highest ($P<0.05$) GE digestibility and lowest DM, CP, EE ($P<0.05$) and NFE digestibilities. However, it is clear that increasing the dietary energy level from 2500 to 3000 kcal ME/kg increased DM, NFE ($P<0.05$) and GE ($P<0.05$) digestibilities, but decreased ($P<0.05$) CP and EE ones. The diet contained the higher dietary energy level (3500 kcal ME/kg) recorded the lowest digestibility values for all nutrients except for GE digestibility.