RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1. First Experiment:

4.1.1. Growth performance of Nile tilapia:

4.1.1.1. Body weight and body length:

Results of fish BW of Nile tilapia as affected by dietary fat and L-carnitine levels are shown in Tables (3 and 4). As described in these tables, there were no significant differences effect of fat, L-carnitine and their interactions in the initial BW of fish indicating the random distribution of the experimental fish. After three months of the experimental start (end of the experimental), regardless of dietary L-carnitine level, dietary fat had no significant effect on final BW Table (4).

The low dietary fat 5% is considered healthy and suitable for normal growing of Nile tilaoa as shown in Table (3). This result is in accordance with the statement of **Anwer and Jafri (2001)** who stated that the low percentage of dietary fat in fish diets achieved normal growth and prevented fatty fish that has a deleterious effect on storage life. The present result also was in accordance with the results of **Meurer *et al.* (2002).** They reported that, dietary lipids ranged from 3 to 12% in Nile tilapia diets had no significant effect on growth performance. Also, **Azab *et al.* (2002)** found no significant differences in BW of Nile tilapia fed diets contained 10 or 15% dietary fat. However, **Chou and Shiau (1996)** concluded that optimal dietary lipid for

Table (3): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on body weight and body length of Nile tilapia.

Item	No.	Body weight (g)		Body length (cm)	
		Initial	Final	Initial	Final
Fat (F)					
5% (F5)	360	5.91±0.12	24.59±0.31	7.15±0.05	11.51±0.06 b
10% (F10)	360	6.04±0.12	25.19±0.31	7.12±0.05	11.71±0.06 a
L-carn. mg/kg diet (C)					
0 (C0)	120	5.81±0.21	19.83±0.54 b	7.11±0.09	10.64±0.11 b
300 (C300)	120	5.97±0.21	25.64±0.54 a	7.16±0.09	11.98±0.11 a
600 (C600)	120	5.98±0.21	25.73±0.54 a	6.95±0.09	11.75±0.11 a
900 (C900)	120	6.04±0.21	26.23±0.54 a	7.22±0.09	11.84±0.11 a
1200 (C1200)	120	6.01±0.21	25.89±0.54 a	7.15±0.09	11.66±0.11 a
1500 (C1500)	120	6.05±0.21	26.03±0.54 a	7.21±0.09	11.79±0.11 a
Fat × L-carnitine					
F5 C0	60	5.84±0.29	19.60±0.77 b	7.08±0.13	10.75±0.15 c
F5 C300	60	5.88±0.29	25.48±0.77 a	7.17±0.13	11.62±0.15 b
F5 C600	60	5.91±0.29	25.23±0.77 a	6.99±0.13	11.69±0.15 b
F5 C900	60	5.95±0.29	26.03±0.77 a	7.27±0.13	11.73±0.15 b
F5 C1200	60	5.90±0.29	25.31±0.77 a	7.20±0.13	11.53±0.15 b
F5 C1500	60	5.96±0.29	25.92±0.77 a	7.17±0.13	11.74±0.15 b
F10 C0	60	5.78±0.29	20.05±0.77 b	7.15±0.13	10.54±0.15 c
F10 C300	60	6.07±0.29	25.81±0.77 a	7.15±0.13	12.35±0.15 a
F10 C600	60	6.04±0.29	26.23±0.77a	6.90±0.13	11.81±0.15 b
F10 C900	60	6.13±0.29	26.44±0.77 a	7.16±0.13	11.94±0.15 ab
F10 C1200	60	6.12±0.29	26.46±0.77 a	7.11±0.13	11.79±0.15 b
F10 C1500	60	6.13±0.29	26.15±0.77 a	7.24±0.13	11.85±0.15 b

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

Table (4): Analysis of variance for the effect of dietary fat and L-carnitine levels on body weight and body length of Nile tilapia.

SOV	df	F-ratio			
		Body weight		Body length	
		Initial	Final	Initial	Final
Replicates	1	0.014	0.003	0.007	0.009
Fat (F)	1	0.693	1.824	0.130	5.201*
L-carnitine (C)	5	0.186	21.078***	0.980	20.090***
F × C	5	0.060	0.126	0.160	2.005
Remainder df	707				
Remainder MS		5.051	35.327	1.184	1.407

* P<0.05 *** P<0.001

maximal growth of *O. niloticus* X *O. aureus* hybrid was about 12%. Moreover studies showed that providing adequate energy with dietary lipids can minimize the use of more protein as energy source **(Ringrose, 1971; Lee and Putnam, 1973 and Watanabe, 1977).**

With regard to the effect of dietary L-carnitine on BW, results of Table 3 revealed that, compared to the control group, all L-carnitine levels (300 to 1500 mg/kg) significantly increased the final BW of Nile tilapia.

The improvement of energy production in mitochondria through β. oxidation of fatty acids led to belief that exogenous administration of L-carnitine could enhance the performance of fish by improving energy utilization efficiency from lipid oxidation **(Torreele *et al.,* 1993 and Chatzifotis *et al.*, 1995).**

Dietary L-carnitine also showed to increase in growth rates of juvenile hybrid striped bass **(Twibell and Brown, 2000),** rohu **(Keshavanth and Renuka, 1998),** carp **(Focken *et al.,* 1997),** red sea bream **(Chatzifotis *et al.*, 1995 and 1996),** tilapia, **(Jayaprakas *et al.,* 1996 and Azab *et al.,* 2002),** European sea bass **(Santulli and D'Amelio, 1986)** and African catfish **(Torreele *et al.,* 1993 and Twibell and Brown, 2000).**

With respect to the effect of interaction between dietary fat and L-carnitine levels on BW of Nile tilapia, results of Tables 3 and 4 show that, within each dietary fat level (5 and 10%) all L-carnitine levels (300-1500 mg/kg) significantly ($P<0.001$) increased final BW of Nile tilapia. Similar results were obtained by **Azab *et al*, (2002)** who found that, increasing dietary. L-carnitine levels from 300 to 900 mg L-carnitine / kg diet significantly increased final BW of Nile tilapia fed diets contained 10 or 15 % dietary fat.

Results of BL of Nile tilapia as affected by dietary fat and L-carnitine and their interactions are shown in Tables 3 and 4. As shown in these tables the average BL of Nile tilapia ranged from 6.90 to 7.27 cm with no significant differences Table (4) at the start of the experimental.. At the end of experimental (after 3 months). The high dietary fat (10%) significantly ($P<0.05$) increased final BL of Nile tilapia. Regardless of dietary fat, all dietary L-carnitine studied (300 to 1500 mg/kg diet) significantly ($P<0.001$) increased body length and the same trend was observed for the effect of the interaction of dietary fat and L-carnitine level on BL whereas all levels of L-carnitine increased BL for fish fed the two fat levels 5 and 10%.

4.1.1.2. Weight gain and specific growth rate:

Results of Table (5) illustrate the effect of dietary fat and L-carnitine levels on weight gain of Nile tilapia. As described in this table increasing dietary fat from 5 to 10% significantly ($P<0.05$) increased WG of Nile tilapia. **Takeuchi *et al.* (1983)** found that body WG and FE of tilapia *O. niloticus* were improved when fed on diet containing corn oil or soybean oil. **Meurer *et al.* (1999)** fed male tilapia on diets containing 3.0, 4.8, 6.6, 8.4, 10.2 and 12% fats. They found that a quadratic effect ($P<0.01$) was observed for WG. **Wille *et al.* (2002)** reported that feeding blue tilapia on diet containing dietary lipid

Table (5): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on weight gain and specific growth rate of Nile tilapia.

Item	No.*	Weight gain (g)/fish	Specific growth rate %/d
Fat (F)			
5% (F5)	12	18.69±0.02 b	1.69±0.01 a
10% (F10)	12	19.15±0.02 a	1.70±0.01 a
L-carn. mg/kg diet (C)			
0 (C0)	4	14.02±0.03 e	1.47±0.02 b
300 (C300)	4	19.67±0.03 d	1.74±0.02 a
600 (C600)	4	19.76±0.03 d	1.74±0.02 a
900 (C900)	4	20.20±0.03 a	1.75±0.02 a
1200 (C1200)	4	19.88±0.03 c	1.75±0.02 a
1500 (C1500)	4	20.00±0.03 b	1.74±0.02 a
Fat × L-carnitine			
F5 C0	2	13.76±0.05 g	1.45±0.03 b
F5 C300	2	19.66±0.05 d	1.75±0.03 a
F5 C600	2	19.32±0.05 e	1.73±0.03 a
F5 C900	2	20.08±0.05 bc	1.76±0.03 a
F5 C1200	2	19.41±0.05 e	1.74±0.03 a
F5 C1500	2	19.96±0.05 c	1.75±0.03 a
F10 C0	2	14.27±0.05 f	1.49±0.03 b
F10 C300	2	19.74±0.05 d	1.73±0.03 a
F10 C600	2	20.20±0.05 ab	1.74±0.03 a
F10 C900	2	20.31±0.05 a	1.74±0.03 a
F10 C1200	2	20.34±0.05 a	1.75±0.03 a
F10 C1500	2	20.02±0.05 c	1.73±0.03 a

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

* Average of 2 replicates for each treatment.

Table (6): Analysis of variance for the effect of dietary fat and L-carnitine levels on weight gain and specific growth rate of Nile tilapia.

SOV	df	F-ratio	
		Weight gain	Specific growth rat
Replicates	1	4.01	0.46
Fat (F)	1	286.3***	0.00
L-carnitine (C)	5	5290.6***	25.06***
F × C	5	32.4***	30.30***
Remainder df	11		
Remainder MS		0.00438	0.002

*** P<0.001

(8 and 17%) increased BW and WG ($P<0.05$). On the contrary, **Hanley (1991)** found that increasing the dietary lipid level for young male tilapia produced a non significant effect on growth rate and FCR. The present study revealed that, dietary lipid at level of 10% causes a significant increase in WG. **Takeuchi *et al.* (1978)** also reported that, when the lipid content exceeded 18% in a 35% protein in the diet, no further growth was observed in rainbow trout.

With respect to the effect of L-carnitine levels, results of Table (5) also show that, compared to the control, all dietary L-carnitine levels studied (300-1500 mg/kg diet) significantly ($P<0.001$) increased weight gain of Nile tilapia (Table 6) whereas the diet contained 900 mg/kg L-carnitine released the higher weight gain. Results of the effect of interaction between dietary fat and L-carnitine (Table 5) also indicated that, within each fat level (5 or 10%) increasing dietary L-carnitine significantly ($P<0.001$) increased WG of Nile tilapia whereas the dietary level of L-carnitine 900 mg/kg gained the highest WG of tilapia fish. Similar results were also obtained by **Azab *et al.* (2002)** who revealed that WG of Nile tilapia, *O. niloticus* was significantly increased in fish groups fed diets contained L-carnitine at levels of 300, 600 or 900 mg/kg at dietary lipid levels of 10 or 15% compared to the control. On contrast, dietary L-carnitine did not affect WG of channel catfish **(Burtle and Liu, 1994),** rainbow trout **(Rodehuts-cord, 1995)** or Atlantic salmon **(Ji *et al.*, 1996).** This variation in the effect of L-carnitine in different species of fish as recorded by several authors is not attributed to the concentration in L. carnitine in the diet, because low carnitine concentration (150 mg/kg diet) caused an increase in WG of tilapia **(Jayaprakas *et al.,* 1996),** while high concentrations of 3700, 1000 and 230 mg/kg diet had no significant effect on growth rates of Atlantic salmon **(Ji *et al.,* 1996),** channel catfish **(Burtle and Liu, 1994)** or rainbow trout **(Rodehuts-cord, 1995).** However, **Harpaz *et al.* (1999)** observed that L-carnitine at the level of 500mg/kg diet caused a better growth rate in ornamental cichlid fish while L-carnitine at the levels of 1000 and 2000 mg/kg diet reduced growth performance.

SGR of Nile tilapia as affected by dietary fat and L-carnitine and their interactions are illustrated in Tables (5 and 6). As shown in these tables, dietary fat had no significant affect on SGR of Nile tilapia while all L-carnitine levels significantly ($P<0.001$) improved SGR of Nile tilapia and the same trend was also observed for the effect of the interaction between dietary fat and L carnitine, where dietary L. carnitine levels studied improved SGR compared to the control for the two dietary fat levels 5 and 10%. These results confirmed the findings of **Jayaprakas *et al.* (1996)** who stated that, increasing dietary L-carnitine in male of *O. mossambicus* diets significantly enhanced growth performance. In this respect, **Azab *et al.* (2002)** pointed out that, L-carnitine caused a significant increase in SGR of Nile tilapia fed diets contained L-carnitine levels of 300, 600 or 900 mg/kg diet and two fat levels 5 or 10%. Also, **Dikel *et al.* (2003)** found that, addition of L-carnitine at a level of 500 mg/kg diet significantly increased growth rate of Nile tilapia fingerlings by 7.9% compared to the control.

4.1.2. Feed utilization:

Results of the effect of dietary fat, L-carnitine levels and their interactions on feed intake (FI), feed conversion ratio (FCR) and protein efficiency ratio (PER) are shown in Tables (7 and 8). As described in these tables, increasing dietary fat from 5 to 10 % significantly ($P<0.001$) increased feed intake and feed conversion value had no significant effect on PER and these results are in accordance with the statement reported by **De-Silva *et al.* (1991)** who found that feed consumption is related to the digestible energy content of diets and both the dietary protein and lipid levels could influence FCR , PER and apparent net protein utilization. On the other hand, **Meurer *et al.* (1999)** found that protein efficiency and feed conversion of tilapia fish decreased as the dietary fat levels increased from 3 to 12% (in 1.8 increments).

With regard to the effect of L-carnitine levels on FI, FCR and PER of Nile tilapia, results of Table (7) indicated that, compared to the control, all dietary L-carnitine levels significantly ($P<0.001$) increased FI and improved ($P<0.001$) FCR but had no significant effect on PER.

The obtained results showed a significant improvement in FCR in all fish groups fed L-carnitine. Similarly, several researchers have speculated that increasing growth rates of fish fed supplemental carnitine were due to improving FCR via increasing fatty acid oxidation and increasing utilization of dietary energy as observed by **Becker *et al.* (1999) and Azab *et al.* (2002)** in tilapia, **Becker and Focken (1995)** and **Torreele**

Table (7): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on feed utilization of Nile tilapia.

Item	No.*	Feed intake (g)/fish	Feed conversion ratio	Protein efficiency ratio
Fat (F)				
5% (F5)	12	51.54±0.15 b	2.58±0.02 b	1.20±0.12
10% (F10)	12	52.59±0.15 a	2.76±0.02 a	1.21±0.12
L-carn. mg/kg diet (C)				
0 (C0)	4	43.64±0.25 c	3.12±0.03 a	1.07±0.20
300 (C300)	4	53.39±0.25 b	2.41±0.03 c	1.23±0.20
600 (C600)	4	53.54±0.25 ab	2.71±0.03 b	1.23±0.20
900 (C900)	4	53.45±0.25 ab	2.35±0.03 c	1.26±0.20
1200 (C1200)	4	54.12±0.25 ab	2.73±0.03 b	1.22±0.20
1500 (C1500)	4	54.26±0.25 a	2.71±0.03 b	1.23±0.20
Fat × L-carnitine				
F5 C0	2	43.32±0.36 e	3.15±0.05 a	1.05±0.29
F5 C300	2	52.33±0.36 d	2.06±0.05 c	1.25±0.29
F5 C600	2	52.74±0.36 cd	2.72±0.05 b	1.22±0.29
F5 C900	2	53.00±0.36 bcd	2.04±0.05 c	1.26±0.29
F5 C1200	2	53.89±0.36 abc	2.78±0.05 b	1.19±0.29
F5 C1500	2	53.98±0.36 ab	2.70±0.05 b	1.23±0.29
F10 C0	2	43.96±0.36 e	3.08±0.05 a	1.08±0.29
F10 C300	2	54.45±0.36 a	2.75±0.05 b	1.21±0.29
F10 C600	2	54.34±0.36 a	2.69±0.05 b	1.23±0.29
F10 C900	2	53.89±0.36 abc	2.65±0.05 b	1.25±0.29
F10 C1200	2	54.34±0.36 a	2.67±0.05 b	1.24±0.29
F10 C1500	2	54.54±0.36 a	2.72±0.05 b	1.22±0.29

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

* Average of 2 replicates for each treatment.

Table (8): Analysis of variance for the effect of dietary fat and L-carnitine levels on feed utilization of Nile tilapia.

SOV	df	F-ratio		
		Feed intake	Feed conversion ratio	Protein efficiency ration
Replicates	1	1.194	1.803	1.000
Fat (F)	1	25.434***	50.365***	0.001
L-carnitine (C)	5	267.816***	74.498***	0.113
F × C	5	1.740	32.431***	0.006
Remainder df	11			
Remainder MS		0.256	0.0041	0.167

*** P<0.001

et al. **(1993)** in carp and African catfish. on contrast, other researchers observed a significant increase in feed consumption and growth rates without significant improvement in feed efficiency **(Twibell and Brown 2000)** in hybrid striped bass and **Chatzifotis *et al.* (1996)**. in red sea bream, *Pagrus major*.

The present study showed that the interactions between dietary fat levels and L-carnitine levels in fish diet were significant for FCR ($P < 0.01$) which led to reduction in these ratios due to improving energy utilization efficiency **(Santulli and D'Amelio, 1986; Torreele *et al.*, 1993 and Ji *et al.* (1996)** as L-carnitine doses have a wider metabolic role in fish which reflect on the overall, metabolic rate and energy retention. The important role of L-carnitine on metabolic rate is derived both from endogenous synthesis and diet, as carnitine is synthesised from lysine and methionine **(Bremer, 1961 and Tanphaichitr *et al.*, 1971).**

4.1.3. Carcass traits:

As shown in Tables 9 and 10 dietary fat (5 or 10%) had no significant effect on the percentages of dress-out, flesh and by- products of Nile tilapia but the level of 10% fat significantly ($P < 0.05$) increased the percentage of viscera.

With respect to the effect of incorporation of L-carnitine in tilapia diets, on carcass traits results of Tables (9 and 10) referred to that incorporation of 1200 mg/kg L- carnitine in tilapia diets significantly ($P < 0.05$) increased the percentage of dress out, while the low doses (300 or 600 mg/kg L-carnitine)

Table (9): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on carcass traits of Nile tilapia.

Item	No.	Dress-out %	Viscera %	Flesh %	By-products %
Fat (F)					
5% (F5)	36	49.95±0.42 a	9.07±0.32 b	34.71±0.48 a	57.44±0.48 a
10% (F10)	36	49.06±0.42 a	10.35±0.32 a	34.77±0.48 a	56.31±0.48 a
L-carnitine mg/kg diet (C)					
0 (C0)	12	47.54±0.73 b	9.46±0.55	32.95±0.83 b	59.16±0.84 a
300 (C300)	12	49.84±0.73 ab	8.99±0.55	36.22±0.83 a	55.53±0.84 b
600 (C600)	12	49.45±0.73 ab	9.55±0.55	35.96±0.83 a	55.37±0.84 b
900 (C900)	12	49.64±0.73 ab	9.92±0.55	33.91±0.83 ab	57.96±0.84 ab
1200 (C1200)	12	51.06±0.73 a	10.40±0.55	35.27±0.83 ab	56.82±0.84 ab
1500 (C1500)	12	49.52±0.73 ab	9.93±0.55	34.14±0.83 ab	56.42±0.84 b
Fat × L-carnitine					
F5 C0	6	49.33±1.04 a	8.19±0.78 de	34.96±1.17 ab	57.31±1.19 abc
F5 C300	6	50.29±1.04 a	9.11±0.78 bcde	34.65±1.17 ab	57.57±1.19 abc
F5 C600	6	48.84±1.04 ab	8.44±0.78 cde	35.68±1.17 ab	57.34±1.19 abc
F5 C900	6	49.50±1.04 a	11.06±0.78 ab	34.95±1.17 ab	57.48±1.19 abc
F5 C1200	6	51.43±1.04 a	9.94±0.78 abcde	35.18±1.17 ab	56.26±1.19 bcd
F5 C1500	6	50.33±1.04 a	7.67±0.78 e	32.84±1.17 bc	58.70±1.19 ab
F10 C0	6	45.75±1.04 b	10.72±0.78 abcd	30.95±1.17 c	61.02±1.19 a
F10 C300	6	49.38±1.04 a	8.87±0.29 bcde	37.78±1.17 a	53.49±1.19 d
F10 C600	6	50.06±1.04 a	10.66±0.78 abcd	36.24±1.17 ab	53.39±1.19 d
F10 C900	6	49.79±1.04 a	8.79±0.78 bcde	32.86±1.17 bc	58.45±1.19 ab
F10 C1200	6	50.70±1.04 a	10.87±0.78 abc	35.36±1.17 ab	57.38±1.19 abc
F10 C1500	6	48.71±1.04 ab	12.20±0.78 a	35.44±1.17 ab	54.15±1.19 cd

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

Table (10): Analysis of variance for the effect of dietary fat and L-carnitine levels on carcass traits of Nile tilapia.

SOV	df	F-ratio			
		Dress-out %	Viscera %	Flesh %	By-products %
Replicates	1	0.011	0.012	0.028	0.527
Fat (F)	1	2.165	7.988**	0.008	2.700
L-carnitine (C)	5	2.339*	0.763	2.359*	3.025**
F × C	5	1.247	4.533***	2.693*	4.322**
Remainder df	59				
Remainder MS		6.587	3.709	8.332	8.509

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

significantly increased the percentage of flesh and decreased the percentage of by-products but the percentage of viscera did not affected by all L-carnitine levels in tilapia diets.

Results of Table (9) indicated that, there was no clear trend for the effect of the interaction between dietary fat and L-carnitine levels on all carcass traits studied (dress-out, viscera, flesh and by-products).

4.1.4. Proximate analysis of Nile tilapia fish:

4.1.4.1. Proximate analysis of whole fish:

Results of proximate analysis of whole tilapia fish at the end of the experiment are illustrated in Table (11). As described in this table, increasing dietary fat from 5 to 10% significantly ($P < 0.001$) decreased the percentages of moisture and ash and the opposite trend was observed for fat content of tilapia fish while protein was not significantly affected Table (12). **Winfree and Stickney (1981)** reported that, carcass moisture of *O. aurea* was inversely related to carcass fat. Also, **Zeitler *et al.* (1984)** found that high fat content inversely correlated with high water, protein and mineral contents. They added that tilapia are able to store significant quantities of lipids in the carcass and viscera.

Meurer *et al.* (1999) with male tilapia fed diets containing different levels of fat ranging from 3 to 12%, revealed that the whole body fat content increased linearly ($P < 0.05$) as dietary fat was increased. Recent investigations by **Wille *et al.* (2002)** showed that feeding blue tilapia with diets contained 8-12% fat increased ($P< 0.01$) body lipid level.

Table (11): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on proximate analysis of Nile tilapia whole fish.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	36	76.18±0.25 a	69.79±0.20	12.92±0.06 b	17.04±0.06 a
10% (F10)	36	74.40±0.25 b	69.23±0.20	14.47±0.06 a	13.83±0.06 b
L-carnitine (mg/kg diet) (C)					
0 (C0)	12	75.09±0.44	68.21±0.35 d	14.78±0.10 a	15.20±0.11 b
300 (C300)	12	75.92±0.44	69.06±0.35 cd	14.37±0.10 b	15.80±0.11 a
600 (C600)	12	75.27±0.44	68.19±0.35 cd	13.92±0.10 c	15.28±0.11 b
900 (C900)	12	74.68±0.44	69.74±0.35 bc	13.50±0.10 d	15.31±0.11 b
1200 (C1200)	12	75.60±0.44	70.31±0.35 ab	12.89±0.10 e	15.76±0.11 a
1500 (C1500)	12	75.17±0.44	70.84±0.35 a	12.71±0.10 e	15.30±0.11 b
Fat × L-carnitine					
F5 C0	6	76.12±0.62 ab	67.71±0.50 e	13.57±1.14 d	17.40±0.15 a
F5 C300	6	76.84±0.62 a	69.10±0.50 bcde	13.13±1.14 e	17.82±0.15 a
F5 C600	6	75.87±0.62 ab	69.75±0.50 bc	12.88±1.14 ef	16.88±0.15 b
F5 C900	6	75.29±0.62 abc	69.96±0.50 bc	12.68±1.14 ef	16.61±0.15 b
F5 C1200	6	75.99±0.62 ab	70.62±0.50 ab	12.68±1.14 ef	16.64±0.15 b
F5 C1500	6	76.96±0.62 a	71.59±0.50 a	12.57±1.14 f	16.88±0.15 b
F10 C0	6	74.06±0.62 bc	68.71±0.50 cde	15.99±1.14 a	13.00±0.15 e
F10 C300	6	75.01±0.62 abc	69.03±0.50 bcde	15.62±1.14 a	13.70±0.15 d
F10 C600	6	74.67±0.62 bc	68.06±0.50 de	14.95±1.14 b	13.67±0.15 d
F10 C900	6	74.07±0.62 bc	69.52±0.50 bcd	14.31±1.14 c	14.01±0.15 d
F10 C1200	6	75.20±0.62 abc	70.00±0.50 bc	13.11±1.14 ef	14.88±0.15 c
F10 C1500	6	73.38±0.62 c	70.08±0.50 bc	12.85±1.14 f	13.73±0.15 d

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

Table (12): Analysis of variance for the effect of dietary fat and L-carnitine levels on proximate analysis of Nile tilapia whole fish.

SOV	df	F-ratio			
		Moisture %	Protein %	Fat %	Ash %
Replicates	1	0.038	1.903	1.043	0.013
Fat (F)	1	24.436***	3.778	359.182***	1288.825***
L-carnitine (C)	5	0.951	7.778***	66.268***	5.449***
F × C	5	1.274	1.987	23.671***	19.656***
Remainder df	59				
Remainder MS		2.332	1.467	0.121	0.144

*** $P<0.001$

As described in Table (11) incorporation of L-carnitine in tilapia diets significantly (P < 0.001) increased protein and decreased fat contents of tilapia fish but there was no significant effect on the percentage of moisture (Table, 12) and the same trend was also observed for the effect of interaction between fat and L-carnitine whereas, protein content was significantly increased and fat decreased for fish fed diets contained all L-carnitine within each dietary fat content.

Azab *et al.* (2002) found no significant effect of dietary L-carnitine on tissue composition at low fat level (10%), while in high level of dietary fat (15%), L-carnitine caused a significant increase in tissue protein. In the same respect, dietary L-carnitine reduced lipid content of rohu **(Keshavanath and Renuka, 1998)**, tilapia **(Jayaprakas *et al.*, 1996)**, channel catfish **(Burtle and Liu, 1994)** and Atlantic salmon **(Je *et al.*, 1996)**. In contrast, several authors found that, dietary carnitine did not alter tissue composition of hybrid striped bass **(Twibell and Brown, 2000)**, rainbow trout **(Rodehuts-cord, 1995)** or hybrid tilapia **(Becker *et al.*, 1999)**.

4.1.4.2. Proximate analysis of fish flesh and by-products:

As described in Table (13) decreasing dietary fat level from 5 to 10% significantly (P < 0.001) increased fat content of fish flesh, while moisture, protein and ash did not affected by increasing dietary fat.

Table (13): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on proximate analysis of Nile tilapia flesh.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	36	78.80±0.21	82.65±0.10	7.86±0.10 a	6.33±0.08
10% (F10)	36	78.59±0.21	82.81±0.10	6.33±0.10 b	6.36±0.08
L-carnitine (mg/kg diet) (C)					
0 (C0)	12	78.27±0.36 ab	82.18±0.17 c	7.67±0.17 a	5.58±0.13 c
300 (C300)	12	79.29±0.36 a	82.40±0.17 bc	7.56±0.17 ab	6.10±0.13 b
600 (C600)	12	77.63±0.36 b	82.73±0.17 ab	7.10±0.17 bc	6.44±0.13 ab
900 (C900)	12	79.35±0.36 a	82.75±0.17 ab	7.02±0.17 c	6.58±0.13 a
1200 (C1200)	12	78.96±0.36 a	83.08±0.17 a	7.08±0.17 bc	6.54±0.13 a
1500 (C1500)	12	78.68±0.36 ab	83.24±0.17 a	6.13±0.17 d	6.83±0.13 a
Fat × L-carnitine					
F5 C0	6	79.07±0.51 abc	81.92±0.24 d	8.33±0.24 a	5.34±0.19 d
F5 C300	6	78.91±0.51 abc	82.64±0.24 bcd	8.47±0.24 a	6.08±0.19 bc
F5 C600	6	76.57±0.51 d	83.36±0.24 ab	7.97±0.24 a	6.46±0.19 b
F5 C900	6	80.42±0.51 a	82.11±0.24 d	7.80±0.24 a	6.49±0.19 b
F5 C1200	6	79.11±0.51 abc	82.50±0.24 cd	8.23±0.24 a	6.49±0.19 b
F5 C1500	6	78.76±0.51 abc	83.39±0.24 ab	6.34±0.24 bc	7.09±0.19 a
F10 C0	6	77.48±0.51 cd	82.45±0.24 cd	7.01±0.24 b	5.81±0.19 cd
F10 C300	6	79.66±0.51 ab	82.16±0.24 d	6.66±0.24 bc	6.13±0.19 bc
F10 C600	6	78.70±0.51 bc	82.10±0.24 d	6.23±0.24 c	6.42±0.19 b
F10 C900	6	78.29±0.51 bc	83.38±0.24 ab	6.23±0.24 c	6.67±0.19 ab
F10 C1200	6	78.82±0.51 abc	83.67±0.24 a	5.93±0.24 c	6.58±0.19 ab
F10 C1500	6	78.61±0.51 bc	83.08±0.24 abc	5.93±0.24 c	6.56±0.19 ab

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

Table (14): Analysis of variance for the effect of dietary fat and L-carnitine levels on proximate analysis of Nile tilapia flesh.

SOV	df	F-ratio			
		Moisture %	Protein %	Fat %	Ash %
Replicates	1	0.617	0.429	0.55	0.006
Fat (F)	1	0.498	1.251	116.067***	0.111
L-carnitine (C)	5	3.242**	5.332***	9.854***	11.194***
F × C	5	4.498**	8.510**	3.324**	1.519
Remainder df	59				
Remainder MS		1.598	0.354	0.361	0.211

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

The findings of **Hanley (1991)** and **Meurer *et al.* (1999)** were not in accordance with the present result as they reported that increasing the dietary lipid level for young male tilapia significantly increased carcass and visceral fat.

Results of Table (13) showed also that incorporation of L-carnitine in tilapia diets significantly ($P < 0.001$) increased protein and ash content of fish flesh and decreased fat content of fish flesh while moisture content had no clear trend Table (14).

With respect to the effect of interaction between dietary fat and L-carnitine on flesh proximate analysis, results of Table (13) indicated that at 5% fat level, the high level of L-carnitine (1500 mg/kg diet) significantly ($P < 0.05$) increased protein and ash content of fish flesh while fat content was decreased. At 10% dietary fat levels with the moderate level of L-carnitine (1200 mg/kg) released the same effect. Proximate carcass analysis of flesh is in line with the aim of present experiment which encourage oxidation of fatty acids for producing energy and reducing lipid deposition. These results are in accordance with those observed by **Jayoprakas *et al.* (1996).**

Proximate analysis of tilapia by-products is outlined in Tables (15 and 16). As described in these Tables increasing, dietary fat levels was followed by significant in fat content and significant decreased in both moisture and protein content of fish by-products while ash was not significantly altered.

Results of proximate analysis of fish by-products as affected by L - carnitine levels are relatively similar to those

4.2 Second Experiment

4.2.1 Growth performance of common carp:

4.2.1.1. Body weight and body length:

Results of BW and BL of common carp, *Cypreinus carpio* as affected by dietary fat, L-carnitine levels and their interactions are shown in Tables (17 and 18). As described in Table (17), the average initial BW of common carp ranged between 11.85 ± 0.78 and 12.96 ± 0.78 and initial BL ranged between 8.50 ± 0.23 and 9.01 cm with no significant differences among fish groups attributed to dietary fat, L-carnitine and their interactions.

At experiment termination (3 months from start) results indicated that, increasing dietary fat, from 5 to 10% significantly ($P<0.001$) increased final BW from 40.74 to 44.46g but had not any significant effect on BL.

The high dietary fat 10% was important to provide common carp both essential fatty acids and energy and assist in absorption of fat soluble nutrients **(Sargent *et al* 1999). Trzebiatowski and Kotlowski (1991)** found that increasing dietary fat up to 8% improved daily live weight gain for carp fry when water temperature exceeded 27°C. Also, **Filipiak and Trzebiatowski (1992)** reported that supplementation of poultry fat and fish oil to diets of common carp improved fish growth rate at water temperature above 25°C.

Table (17): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on body weight and body length of common carp.

Item	No.	Body weight (g)		Body length (cm)	
		Initial	Final	Initial	Final
Fat (F)					
5% (F5)	150	12.45±0.35	40.74±0.77 b	8.76±0.10	13.30±0.13
10% (F10)	150	12.30±0.35	44.46±0.77 a	8.69±0.10	13.57±0.13
L-carn. Mg/kg diet (C)					
0 (C0)	60	12.31±0.55	37.85±1.22 b	8.88±0.17	12.78±0.21 b
300 (C300)	60	12.05±0.55	45.96±1.22 a	8.81±0.17	13.82±0.21 a
600 (C600)	60	12.40±0.55	42.29±1.22 a	8.82±0.17	13.51±0.21 a
900 (C900)	60	12.69±0.55	42.84±1.22 a	8.72±0.17	13.55±0.21 a
1200 (C1200)	60	12.44±0.55	44.07±1.22 a	8.50±0.17	13.54±0.21 a
Fat × L-carnitine					
F5 C0	30	12.51±0.78	36.62±1.72 d	8.90±0.23	12.80±0.30 b
F5 C300	30	11.97±0.78	44.07±1.72 abc	8.69±0.23	13.62±0.30 ab
F5 C600	30	12.94±0.78	41.74±1.72 bcd	9.01±0.23	13.49±0.30 ab
F5 C900	30	12.42±0.78	39.43±1.72 cd	8.69±0.23	13.32±0.30 ab
F5 C1200	30	12.44±0.78	41.86±1.72 bcd	8.50±0.23	13.29±0.30 ab
F10 C0	30	12.11±0.78	39.07±1.72 cd	8.86±0.23	12.75±0.30 b
F10 C300	30	12.12±0.78	47.85±1.72 a	8.72±0.23	14.01±0.30 a
F10 C600	30	11.85±0.78	42.85±1.72 abc	8.64±0.23	13.52±0.30 ab
F10 C900	30	12.96±0.78	46.25±1.72 ab	8.75±0.23	13.77±0.30 a
F10 C1200	30	12.43±0.78	46.29±1.72 ab	8.50±0.23	13.79±0.30 a

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

Table (18): Analysis of variance for the effect of dietary fat and L-carnitine levels on body weight and body length of common carp.

SOV	df	F-ratio			
		Body weight		Body length	
		Initial	Final	Initial	Final
Replicates	1	0.06	1.03	0.10	0.61
Fat (F)	1	0.11	11.70***	0.20	2.00
L-carnitine (C)	4	0.18	6.13***	0.76	3.47**
F × C	4	0.32	0.78	0.28	0.36
Remainder df	289				
Remainder MS		18.16	88.69	1.63	2.63

** P<0.01 *** P<0.001

Manjappa ***et al*****, (2002)** reported that increasing fish oil from zero to 9% produced significant effect ($P< 0.05$) on growth of common carp, feed conversion and protein efficiency ratio.

Results of the same Tables (17 and 18) also indicated that, incorporation of L-carnitine in carp diets at all levels studied (300, 600, 900 and 1200 mg/kg diet) significantly ($P<0.001$ and $P<0.01$) increased fish BW and BL, respectively.

Table (17) also showed the effect of the interaction between dietary fat and L-carnitine levels on BW and BL of common carp. Results of this table revealed that, there was a significant increase in BW and BL of carp in fish group fed L-carnitine at 300 mg/kg diet with dietary fat of 10% or 5%, respectively the effect of L-carnitine was not detected and the same trend was also observed for fish BL.

4.2.1.2. Weight gain and specific growth rate:

Values of WG and SGR of common carp fish were significantly higher in case of 10% dietary fat level than 5% fat Table (19).

The WG and SGR of common carp fish fed diets supplemented with different L-carnitine levels fluctuated in values as WG ranged from 25.24 to 33.92 g/fish, SGR from 1.25 to 1.49 and obviously both traits were significantly higher in carnitine supplemented groups than the body gain and specific growth rate of the control fish fed the diet supplemented with 0% carnitine Tables (19 and 20). The low level of L-carnitine (300 mg/kg)

Table (19): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on weight gain and specific growth rate of common carp.

Item	No.*	Weight gain (g)/fish	Specific growth rate %/d
Fat (F)			
5% (F5)	10	28.29±0.18 b	1.31±0.03 b
10% (F10)	10	32.17±0.18 a	1.43±0.03 a
L-carn. mg/kg diet (C)			
0 (C0)	4	25.54±0.28 d	1.25±0.04 c
300 (C300)	4	33.92±0.28 a	1.49±0.04 a
600 (C600)	4	29.90±0.28 c	1.37±0.04 abc
900 (C900)	4	30.15±0.28 c	1.35±0.04 bc
1200 (C1200)	4	31.64±0.28 b	1.41±0.04 ab
Fat × L-carnitine			
F5 C0	2	24.11±0.40 g	1.19±0.06 c
F5 C300	2	32.10±0.40 cd	1.45±0.06 ab
F5 C600	2	28.80±0.40 e	1.30±0.06 bc
F5 C900	2	27.00±0.40 f	1.28±0.06 bc
F5 C1200	2	29.42±0.40 e	1.35±0.06 abc
F10 C0	2	26.96±0.40 f	1.30±0.06 bc
F10 C300	2	35.73±0.40 a	1.53±0.06 a
F10 C600	2	31.00±0.40 d	1.43±0.06 ab
F10 C900	2	33.29±0.40 bc	1.41±0.06 ab
F10 C1200	2	33.86±0.40 b	1.46±0.06 ab

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

* Average of 2 replicates for each treatment.

Table (20): Analysis of variance for the effect of dietary fat and L-carnitine levels on weight gain and specific growth rate of common carp.

SOV	df	F-ratio	
		Weight gain	Specific growth rate
Replicates	1	1.98	3.97
Fat (F)	1	234.26***	9.73**
L-carnitine (C)	4	117.28***	4.95*
F × C	4	7.83**	0.07
Remainder df	9		
Remainder MS		0.322	0.006

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

released the highest WG and SGR. Similar results were obtained by **Focken *et al.* (1997).** They found that carp fish fed diets contained 400 or 600 mg L-carnitine/kg diet grew faster than the control group.

The differences among means of WG and SGR due to the effect of fat levels and L-carnitine and interaction between these two factors were significant ($P<0.01$) except the interaction of SGR was non significant Table (20).

Murthy and Naik (2000) evaluated the effect of diets containing various levels of protein and two levels of lipid (12 and 18%) on growth performance Indian major carp. They stated that the best growth and the maximum specific growth rate (2.6%) were recorded with diet having 35% protein and 12% lipid.

The highest WG (33.73 g/fish) was achieved in fish group fed on L-carnitine 300 mg/kg diet at 10% dietary fat followed by fish fed on 1200 mg/kg diet (33.86 g/fish) the lowest feeding quotient was observed in group fed on L-carnitine supplements of 600 mg/kg. The same trend of the effect of L-carnitine was also observed with respect to SGR.

4.2.2. Feed utilization:

Results of the effect of dietary fat, L-carnitine and their interactions on feed intake (FI), feed conversion ratio (FCR) and protein efficiency ratio (PER) are shown in Tables (21 and 22). As shown in table (21) increasing dietary fat in carp diets from 5

Table (21): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on feed utilization of common carp.

Item	No.*	Feed intake (g)/fish	Feed conversion ratio	Protein efficiency ratio
Fat (F)				
5% (F5)	10	64.81±0.11 b	2.30±0.02 a	1.45±0.01 b
10% (F10)	10	72.06±0.11 a	2.25±0.02 a	1.49±0.01 a
L-carn. mg/kg diet (C)				
0 (C0)	4	65.02±0.17 d	2.55±0.04 a	1.31±0.01 c
300 (C300)	4	73.76±0.17 a	2.18±0.04 b	1.54±0.01 a
600 (C600)	4	66.93±0.17 c	2.24±0.04 b	1.49±0.01 b
900 (C900)	4	66.90±0.17 c	2.22±0.04 b	1.50±0.01 ab
1200 (C1200)	4	69.59±0.17 b	2.20±0.04 b	1.52±0.01 ab
Fat × L-carnitine				
F5 C0	2	63.17±0.25 g	2.62±0.05 a	1.27±0.02 d
F5 C300	2	69.99±0.25 c	2.18±0.05 b	1.53±0.02 a
F5 C600	2	65.66±0.25 f	2.28±0.05 b	1.46±0.02 b
F5 C900	2	60.23±0.25 h	2.23±0.05 b	1.49±0.02 ab
F5 C1200	2	65.02±0.25 f	2.21±0.05 b	1.51±0.02 ab
F10 C0	2	66.86±0.25 e	2.48±0.05 a	1.34±0.02 c
F10 C300	2	77.53±0.25 a	2.17±0.05 b	1.54±0.02 a
F10 C600	2	68.20±0.25 d	2.20±0.05 b	1.52±0.02 a
F10 C900	2	73.57±0.25 b	2.21±0.05 b	1.51±0.02 ab
F10 C1200	2	74.15±0.25 b	2.19±0.05 b	1.52±0.02 a

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

* Average of 2 replicates for each treatment.

Table (22): Analysis of variance for the effect of dietary fat and L-carnitine levels on feed utilization of common carp.

SOV	df	F-ratio		
		Feed intake	Feed conversion ratio	Protein efficiency ratio
Replicates	1	0.37	0.21	3.000
Fat (F)	1	144.58***	2.57	11.36**
L-carnitine (C)	4	375.54***	16.81***	68.33***
F × C	4	154.24***	0.54	1.631
Remainder df	9			
Remainder MS		0.13	0.01	0.001

** P<0.01 *** P<0.001

to 10% significantly ($P<0.001$ and $P<0.01$) increased feed intake and improved PER, respectively while FCR did not affect by the level of dietary fat in the present experiment. In this respect, **Anwer and Jafri (2001)** showed that the common carp fingerlings exhibited maximum live weight gain, specific growth rate, best FCR and PER (1.66) at 5.1% dietary lipid, they added that maximum protein deposition (31.6%) was noticed at 7.4% dietary lipid. **Manjappa *et al.* (2002)** reported that increasing fish oil from zero to 9% had a significant effect on growth common carp with the diet containing 6% fish oil. FCR and PER were improved with increasing dietary lipid levels.

With regard to the effect of L-carnitine on FI, FCR and PER, results of Table (21) indicated that, compared to the control fish group, all L-carnitine levels incorporated in carp diets significantly ($P<0.001$) improved FI, FCR and PER Table (22), and this leads to the recommendation that the possibility of using the low dose (300mg/kg diet) of L-carnitine in fish diets to improve feed utilization parameters. **Chatzifotis *et al*, (1995)** reported that feed efficiency was positively correlated with growth rate and remarkably improved as the amount of L-carnitine in the diet increased.

As shown in table (21), within each dietary fat levels tested (5 or 10%), increasing dietary L-carnitine improved FI, FCR and PER. Analysis of variance (Table, 22) indicated that interaction between dietary fat and L-carnitine had a significant effect on FI while had no significant effect on FCR and PER.

4.2.3. Carcass traits :

Least square means for the effect of dietary fat, L-carnitine levels and their interactions on carcass traits are shown in table (23). Analysis of variance for the effect of dietary fat and L-carnitine levels on carcass traits are also presented in Table (24). As described in these tables (23 and 24), increasing dietary fat from 5 to 10% in carp diets significantly ($P<0.05$ and $P < 0.001$) decreased dress-out and by-products significantly increased viscera, but had no significant effect on the percentages of flesh.

With respect to the effect of L-carnitine, results of table (23) also show that, increasing dietary L-carnitine levels (from 0 to 1200 mg/kg diet) in carp diets significantly dress-out and by-products percentages and significantly ($P< 0.001$) increased flesh percentage. There was no clear trend for the effect on dress-out percentage while viscera did not significantly affected by L-carnitine levels and the same trend was also observed for L-carnitine levels in the diet contained 5 or 10% dietary fat.

The effect of the interactions among dietary fat levels and carnitine levels were significant ($P<0.001$) in dressing-out, flesh, viscera and by- product percentage. The last result indicates the influence of dietary lipid and its estrification by L-carnitine for producing energy and protein sparing action in carcass composition.

Table (23): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on carcass traits of common carp.

Item	No.	Dress-out %	Flesh %	Viscera%	By-products %
Fat (F)					
5% (F5)	30	62.26±0.37 a	45.82±0.19	11.90±0.10 b	52.90±0.14 a
10% (F10)	30	60.15±0.42 b	46.27±0.15	12.09±0.10 a	52.16±0.14 b
L-carnitine mg/kg diet (C)					
0 (C0)	12	61.72±0.58 ab	44.13±0.29 c	12.58±0.16	55.31±0.22 a
300 (C300)	12	62.17±0.58 a	46.07±0.29 b	12.13±0.16	52.68±0.22 b
600 (C600)	12	60.41±0.58 ab	46.56±0.29 b	12.63±0.16	51.72±0.22 c
900 (C900)	12	59.83±0.58 b	46.04±0.29 b	12.36±0.16	51.50±0.22 c
1200 (C1200)	12	61.88±0.58 a	47.43±0.29 a	12.23±0.16	51.43±0.22 c
Fat × L-carnitine					
F5 C0	6	64.47±0.82 a	41.48±0.41 e	11.04±0.23 e	56.98±0.30 a
F5 C300	6	62.99±0.82 abc	44.96±0.41 d	10.94±0.23 e	53.47±0.30 b
F5 C600	6	60.06±0.82 d	46.51±0.41 c	12.33±0.23 cd	51.79±0.30 c
F5 C900	6	60.47±0.82 cd	47.99±0.41 ab	12.77±0.23 bc	51.17±0.30 c
F5 C1200	6	63.30±0.82 ab	48.15±0.41 a	12.44±0.23 cd	51.09±0.30 c
F10 C0	6	58.97±0.82 d	46.78±0.41 bc	14.12±0.23 a	53.63±0.30 b
F10 C300	6	61.36±0.82 bcd	47.17±0.41 abc	13.32±0.23 b	51.89±0.30 c
F10 C600	6	60.77±0.82 bcd	46.61±0.41 c	12.93±0.23 bc	51.65±0.30 c
F10 C900	6	59.20±0.82 d	44.08±0.41 d	11.94±0.23 d	51.83±0.30 c
F10 C1200	6	60.46±0.82 cd	46.72±0.41 bc	12.03±0.23 d	51.77±0.30 c

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

Table (24): Analysis of variance for the effect of dietary fat and L-carnitine levels on carcass traits of common carp.

SOV	df	F-ratio			
		Dress-out %	Flesh%	Viscera %	By-products %
Replicates	1	0.27	0.02	1.22	0.32
Fat (F)	1	6.33*	3.01	43.17***	14.95***
L-carnitine (C)	4	3.08*	17.05***	1.72	57.56***
F × C	4	3.85**	35.92***	26.96***	15.92***
Remainder df	49				
Remainder MS		4.07	1.03	0.32	0.56

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

4.2.4. Proximate analysis of common carp fish:

4.2.4.1. Proximate analysis of whole fish:

Results of proximate analysis of whole fish are illustrated in tables (25 and 26). As shown in these tables, increasing dietary fat in carp diets significantly ($P<0.001$) decreased moister, protein and ash content and increased fat content of carp whole body. These results are in accordance with those reported by **Zeitler *et al.* (1984)** who found that the high fat inversely correlated with high water, protein and mineral contents. **Abdelhamid (1988)** came to the same conclusion with common carp. **Hanley (1991)** found that increasing dietary lipid level significantly increased the level of carcass and visceral lipid. **Manjappa *et al,* (2002)** reported that dietary lipid had a positive impact on carcass lipid level ($P<0.05$). They added that moisture and crude protein didn't vary from that of the control.

The low level 5% of dietary fat is considered important in fish diet achieve normal growth and prevent fatty fish which has a deleterious effect on storage life **(Anwer and Jafri, 2001).** This conclusion reference is also in accordance with that previously published reference by **Sinnhuber (1969)** who found that fatty acids composition of fish carcass are most clearly reflected by dietary lipids.

As described in table (25), increasing L-carnitine level in carp diets significantly ($P<0.001$) decreased moisture and fat content of whole fish while protein content significantly ($P<0.001$) increased.

Table (25): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on proximate analysis of common carp whole fish.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	30	74.34±0.20 a	59.04±0.30 a	24.91±0.22 b	9.29±0.13 a
10% (F10)	30	72.22±0.20 b	55.77±0.30 b	33.70±0.22 a	7.57±0.13 b
L-carnitine (mg/kg diet (C)					
0 (C0)	12	73.44±0.32 a	52.51±0.47 b	33.16±0.35 a	8.29±0.21
300 (C300)	12	73.75±0.32 a	59.39±0.47 a	27.49±0.35 c	8.44±0.21
600 (C600)	12	73.94±0.32 a	58.59±0.47 a	28.06±0.35 c	8.41±0.21
900 (C900)	12	72.35±0.32 b	58.45±0.47 a	29.33±0.35 b	8.43±0.21
1200 (C1200)	12	72.92±0.32 b	58.06±0.47 a	28.48±0.35 b	8.60±0.21
Fat × L-carnitine					
F5 C0	6	74.98±0.46 a	52.18±0.66 f	31.19±0.49 c	8.84±0.29 ab
F5 C300	6	75.40±0.46 a	60.10±0.66 bc	21.71±0.49 f	9.59±0.29 a
F5 C600	6	74.77±0.46 a	60.85±0.66 ab	23.24±0.49 e	8.60±0.29 bc
F5 C900	6	73.09±0.46 bc	59.78±0.66 bc	25.25±0.49 d	9.73±0.29 a
F5 C1200	6	73.46±0.46 b	62.27±0.66 a	23.18±0.49 e	9.71±0.29 a
F10 C0	6	71.91±0.46 cd	52.85±0.66 f	35.14±0.49 a	7.73±0.29 cde
F10 C300	6	72.11±0.46 bcd	58.67±0.66 cd	33.28±0.49 b	7.28±0.29 e
F10 C600	6	73.12±0.46 bc	56.33±0.66 e	32.88±0.49 b	8.22±0.29 bcd
F10 C900	6	71.60±0.46 d	57.13±0.66 de	33.42±0.49 b	7.13±0.29 e
F10 C1200	6	72.37±0.46 bcd	53.85±0.66 f	33.78±0.49 b	7.50±0.29 de

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

Table (26): Analysis of variance for the effect of dietary fat and L-carnitine levels on proximate analysis of common carp whole fish.

SOV	df	F-ratio			
		Moisture %	Protein %	Fat %	Ash %
Replicates	1	0.56	0.04	0.12	0.08
Fat (F)	1	53.99***	60.62***	792.55***	86.97***
L-carnitine (C)	4	4.10***	34.96***	41.82***	0.30
F × C	4	2.38	13.43***	18.25***	5.19***
Remainder df	49				
Remainder MS		1.24	2.65	1.46	0.51

*** P<0.001

4.2.4.2. Proximate analysis of fish flesh and by-products:

Results of proximate analysis of fish flesh and by-products as affected by dietary fat, L-carnitine levels and their interactions are outlined in tables 27, 28, 29 and 30. As described in these tables increasing dietary fat from 5 to 10% significantly ($P<0.001$) decreased moisture, protein, ash and increased fat content of fish flesh (Table 27) and fish by-products (Table 29). Analysis of variance (Tables 28 and 30) shows that dietary fat levels studied (5 or 10%) had a significant effect on proximate analysis of flesh and by-products of common carp fish.

Results of tables (27 and 29) also showed that, increasing L-carnitine levels in carp diets significantly ($P<0.05$) decreased moisture and fat ($P<0.001$), but increased ($P<0.001$) protein content of carp flesh while ash content is not significantly affected. the same trend was also observed for proximate analysis of fish by-products, except for protein content.

With regard to the effect of interaction between dietary fat and L-carnitine, levels results of Tables (27 and 29) indicated that, within each fat level studied (5 or 10%) increasing L-carnitine in carp diets from 0 to 1200 mg/kg diet significantly reduced moisture and fat content and increased protein, fat and ash contents of fish flesh Table (27). Analysis of variance Table (28) indicated that the interactions between fat and L-carnitine levels in carp diets had a significant effect on protein and fat content of fish flesh.

Table (27): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on proximate analysis of fish flesh.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	30	75.05±0.20 a	61.01±0.21 a	26.71±0.18 b	5.47±0.06 a
10% (F10)	30	72.79±0.20 b	59.94±0.21 b	29.89±0.18 a	4.50±0.06 b
L-carnitine (mg/kg diet) (C)					
0 (C0)	12	74.70±0.32 a	56.56±0.33 c	31.74±0.28 a	5.07±0.10
300 (C300)	12	73.86±0.32 ab	60.81±0.33 b	29.26±0.28 b	5.03±0.10
600 (C600)	12	73.97±0.32 ab	60.85±0.33 b	29.28±0.28 b	5.11±0.10
900 (C900)	12	73.20±0.32 b	61.27±0.33 b	28.31±0.28 c	4.82±0.10
1200 (C1200)	12	73.88±0.32 ab	62.86±0.33 a	24.42±0.28 d	4.92±0.10
Fat × L-carnitine					
F5 C0	6	76.12±0.46 a	59.46±0.47 d	28.61±0.40 c	5.41±0.14 ab
F5 C300	6	74.79±0.46 ab	61.91±0.47 b	26.13±0.40 e	5.52±0.14 ab
F5 C600	6	74.75±0.46 ab	61.01±0.47 bc	27.31±0.40 d	5.82±0.14 a
F5 C900	6	74.61±0.46 b	61.17±0.47 b	25.91±0.40 e	5.25±0.14 b
F5 C1200	6	75.00±0.46 ab	61.49±0.47 b	23.59±0.40 f	5.35±0.14 b
F10 C0	6	73.28±0.46 c	53.67±0.47 e	33.88±0.40 a	4.71±0.14 c
F10 C300	6	72.93±0.46 cd	59.71±0.47 cd	32.39±0.40 a	4.55±0.14 c
F10 C600	6	73.19±0.46 cd	60.71±0.47 bcd	31.25±0.40 b	4.39±0.14 c
F10 C900	6	71.79±0.46 d	61.36±0.47 b	30.71±0.40 b	4.39±0.14 c
F10 C1200	6	72.75±0.46 cd	64.24±0.47 a	25.25±0.40 e	4.50±0.14 c

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

Table (28): Analysis of variance for the effect of dietary fat and L-carnitine levels on proximate analysis of common carp fish flesh.

SOV	df	F-ratio			
		Moisture %	Protein %	Fat %	Ash %
Replicates	1	0.26	0.26	0.37	0.02
Fat (F)	1	61.37***	13.21***	280.14***	119.50***
L-carnitine (C)	4	2.70*	50.31***	51.28***	1.38
F × C	4	0.77	23.12***	8.92***	2.01
Remainder df	49				
Remainder MS		1.26	1.31	0.94	0.12

* P<0.05 *** P<0.001

Results of Table (29) showed that, for each dietary fat levels (5 or 10%) increasing L-carnitine levels significantly reduced moisture and fat contents of by-products but increased protein content of common carp fish by-products.

Zhang *et al.* (2002) fed common carp on diets containing different protein levels with supplmentation of carnitine (0, 50, 100, 150, 200 and 250 mg/kg diet) they reported that L-carnitine supplementation increased the average muscle protein content by 13% and reduced muscle fat content by 11.45% compared with controls.

As previously mentioned, these result are in line with the aim of the present experiment which encourage oxidation of fatty acids for producing energy and reducing lipid deposition.

Table (29): Least square means and standard errors for the effect of dietary fat and L-carnitine levels on proximate analysis of common carp fish by-products.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	30	72.39±0.23 a	45.29±0.35 a	37.68±0.25 b	12.41±0.17 a
10% (F10)	30	68.91±0.35 b	43.41±0.35 b	40.85±0.25 a	10.09±0.17 b
L-carnitine mg/kg diet (C)					
0 (C0)	12	71.56±0.36 a	43.41±0.56	41.56±0.39 a	11.13±0.26
300 (C300)	12	70.06±0.36 b	44.35±0.56	39.80±0.39 b	11.10±0.26
600 (C600)	12	70.75±0.36 ab	44.63±0.56	38.74±0.39 bc	11.01±0.26
900 (C900)	12	70.38±0.36 b	45.02±0.56	38.46±0.39 c	11.32±0.26
1200 (C1200)	12	70.50±0.36 ab	45.01±0.56	37.79±0.39 c	11.68±0.26
Fat × L-carnitine					
F5 C0	6	73.04±0.51 a	44.61±0.79 abc	39.82±0.56 bc	11.74±0.40 b
F5 C300	6	72.17±0.51 a	44.49±0.79 abc	38.18±0.56 cde	11.84±0.40 b
F5 C600	6	71.88±0.51 a	45.13±0.79 ab	36.60±0.56 de	12.20±0.40 b
F5 C900	6	72.65±0.51 a	46.66±0.79 a	36.49±0.56 e	12.86±0.40 ab
F5 C1200	6	72.19±0.51 a	45.57±0.79 ab	37.33±0.56 a	13.39±0.40 a
F10 C0	6	70.08±0.51 b	42.20±0.79 c	43.30±0.56 b	10.51±0.40 c
F10 C300	6	67.94±0.51 d	44.22±0.79 abc	41.41±0.56 b	10.35±0.40 c
F10 C600	6	69.62±0.51 bc	44.14±0.79 abc	40.08±0.56 b	9.82±0.40 c
F10 C900	6	68.10±0.51 cd	43.39±0.79 bc	40.43±0.56 b	9.77±0.40 c
F10 C1200	6	68.80±0.51 bcd	44.45±0.79 abc	38.24±0.56 cd	9.98±0.40 c

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

Table (30): Analysis of variance for the effect of dietary fat and L-carnitine levels on proximate analysis of common carp fish by-products.

SOV	Df	F-ratio			
		Moisture %	Protein %	Fat %	Ash %
Replicates	1	0.03	0.02	0.13	0.01
Fat (F)	1	114.93***	10.55**	81.52***	98.70***
L-carnitine (C)	4	2.45*	1.43	14.51***	1.05
F × C	4	1.64	1.18	2.85*	3.34*
Remainder df	49				
Remainder MS		1.58	3.70	1.85	0.82

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

4.3. Third Experiment:

Table (31), shows the growth performance and survival rate of Nile tilapia fish fed diets supplemented by different levels of L-carnitine (from 0 to 1200 mg/kg diet) under the effect of cold water temperature (ranged from 9.4 to 11.5°C)

Final BW and BL of Nile tilapia fish were not affected by supplementing fish diet with different levels of dietary L. carnitine in the presence of low water temperature. This result may be due to that energy production through β. oxidation of fatty acids was utilized to withstand lower water temperature and protect fish against exposure to cold. This interpretation may be supported by the findings of **Harpaz *et al,* (1999)** who found that addition of L-carnitine to diets of *Pelvicachromis plusher* at a level of 900 or 1000 mg/kg diet seems to yield the best production against exposure to cold. Accordingly percentages of survival rates of tilapia fish were significantly higher, in case of diets supplemented with L-carnitine levels compared with the diet having 0% L-carnitine Table (32). Survival percentages increased gradually, in parallel with increasing the levels of L-carnitine as the percentages exceeded from 75.81 to 87.32%. Fish groups fed diets supplemented with L-carnitine at a level of 900 or 1200 mg/kg diet exhibited the higher survival rates. Similar result was obtained by **Harpaz *et al.* (1999).**

It could be concluded that, although Nile tilapia fish is considered sensitive to low water temperature which may lead to mass mortality, dietary supplementation with L-carnitine, gave tilapia fish reared in low water temperature, hardness and protection against cold water.

Table (31): Least square means and standard errors for the effect of L-carnitine levels on body weight, body length and survival rate of Nile tilapia reared in cold water.

	L-carnitine level				
	Control (0 mg/kg)	300 mg/kg	600 mg/kg	900 mg/kg	1200 mg/kg
Body weight					
Initial	3.63±0.17	3.70±0.17	3.72±0.17	3.71±0.17	3.73±0.17
Final	7.51±0.76	8.01±0.67	8.36±0.67	8.96±0.67	9.01±0.65
Body length					
Initial	6.58±0.08	6.45±0.08	6.37±0.08	6.52±0.08	6.58±0.08
Final	8.18±1.77	8.01±1.57	7.88±1.57	7.81±1.51	8.21±1.65
Temperature °C					
December	11.38	11.20	11.28	11.40	11.45
January	10.42	10.51	11.50	10.91	11.30
February	10.25	9.35	9.40	9.75	9.90
Average °C	10.70	10.40	10.60	10.70	10.90
Survival rate	64.52±0.26 d	75.81±0.26 c	82.26±0.26 b	87.10±0.26 a	87.32±0.26 a

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

Table (32): Analysis of variance for the effect of dietary L-carnitine levels on body weight and body length and survival rate of Nile tilapia reared in cold water.

SOV	Body weight (g)				Body length (cm)				Survival rate	
	Initial		Final		Initial		Final			
	df	F-ratio	df	F-ratio	df	F-ratio	df	F-ratio	df	F-ratio
Replicates	1	0.10	1	0.02	1	0.97	1	2.82	1	0.65
Treatment	4	0.07	4	0.77	4	1.29	4	1.49	4	1219.75***
Remainder df	413		332		413		332		4	
Remainder MS		1.85		23.05		0.41		125.89		0.1377

*** $P < 0.001$