Effect of feed supplementation with L-carnitine on growth and cold tolerance of the Nile tilapia, *Oreochromis niloticus*

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ABSTRACT

The effect of dietary L-carnitine and lipid on growth performance, feed utilization and body composition of Nile tilapia, *Oreochromis niloticus* were evaluated in two separate 2×5 factorial experiments as well as the effect of dietary L-carnitine on cold tolerance of Nile tilapia was evaluated in another experiment of the present study. The effect of L-carnitine was evaluated in five levels, 0, 300, 600, 900 and 1200 mg/kg diet at each of two lipid levels (5 and 10%), therefore ten isonitrogenous (30% CP) and isocaloric (3000 kcal ME/kg) diets were formulated and tested in three replicates with Nile tilapia (First experiment). Another experiment was applied by using the same previous diets (30% CP, 5% fat, 3000 kcal ME/kg diet) which formulated to contain increasing levels of L-carnitine, 0, 300, 600, 900 and 1200 mg/kg diet to study the effect of L-carnitine on cold tolerance of Nile tilapia (second experiment).

In the present study, dietary L-carnitine at any level significantly increased all growth parameters (body weight, body length, weight gain, specific growth rate) and improved feed conversion and protein efficiency ratio of Nile tilapia. Compared to control group dietary L-carnitine supplementation significantly ($P<0.05$) increased the percentage of dress-out and flesh and decreased the percentage of by-products of Nile tilapia Also, increased dietary L-carnitine level decreased ($P<0.05$) fat content and increased ($P<0.05$) protein content of Nile tilapia.

Results of the second experiment of the present study clearly showed that, the addition of L-carnitine to the diet of tilapia fish can substantially reduce their mortality during winter season. Fish fed the diet supplemented with 900 or 1200 mg/kg exhibited the best tolerance to cold water.

In conclusion, dietary L-carnitine supplementation at all studied levels (300 to 1200 mg/kg diet) improved growth and feed utilization, decrease tissue fat and increased tissue protein and also increased survival rate of tilapia fry reared during cold season.

Keywords: L-carnitine, lipids, growth performance, feed utilization Nile tilapia

INTRODUCTION

L-carnitine (γ- trimethyl-amino-β-hydroxybutyrate) is synthesized in vivo from lysine and methionine and is essential for the transport of long-chain fatty acids from the cytosol into the mitochondria where the β-oxidation of these fatty acids occurs (Dunn, 1981). Fish biologists first became interested in L-carnitine when Bilinski and Jonas (1970) observed that addition of L-carnitine to their incubation media enhanced transport and oxidation of long chain fatty acids in isolated trout mitochondria.

The improved energy production in mitochondria through B-oxidation of fatty acids may be suggest that exogenous administration of L-carnitine could enhance the performance of fish by improving energy utilization efficiency from lipid oxidation (Torreele *et al.,* 1993; Chatzifotis *et al.*, 1995).

It has also been found that there is an increased tolerance of ammonia (Tremblay and Bradley 1992) that can not be directly explained by the effect of L-carnitine. It also increases the rate of protein synthesis (Santulli *et al.*, 1990) and enhancing the generation of metabolic energy.

This could stimulate some specific cell functions and may influence several biochemical and physiological process, i.e., cell protection against xenobiotics (Torreele *et al.,* 1993; Chatzifotis *et al.*, 1995).

Lipid nutrition of fish produced in aquaculture has attracted considerable interest both historically from the standpoint of satisfying essential fatty acid requirements (NRC, 1993) and more recently for the protein-sparing capability. Most warmwater species are typically fed diets with less than 10% lipid due to their ability to utilize higher levels of carbohydrates as energy source, the high cost of lipid relative to carbohydrates, and unwanted accretion of lipid depots (Soltan *et al.,* 2002 & 2006). To improve utilization of dietary lipids by fish, L-carnitine has shown promise by improving growth and feed efficiency and reducing lipid deposition in some fish species (Torreele *et al.*, 1993; Chatzifotis *et al*., 1995 and Ji *et al*., 1996)

Chichlids such as tilapia, are amongst the most popular and promising fish for warm water aquaculture and/or ornamental fish production. One of the most serious drawbacks to growing this specie in temperate zones is their sensitivity to low ambient temperature, leading in extreme cold temperature to mass mortality (Soltan *et al.,* 2015). Overwintering therefore presents a serious problem. Therefore, the purpose of the present study was to determine if Nile tilapia could utilize elevated levels of dietary lipid, and if supplemental L-carnitine could enhance utilization of dietary lipid. Also the effect of dietary L-carnitine on cold tolerance of Nile tilapia was evaluated.

MATERIALS AND METHODS

The experimental work of the present study was carried out at Fish Nutrition Laboratory, Faculty of Agriculture, Benha University.

Growth performance experiments:

Fish: Nile tilapia, *O. niloticus* fingerlings were obtained from Abbassa hatchery, Sharkia Governorate. The experimental fish were transported in a 50-liter plastic bags filled with water and oxygen to the fish laboratory. Fish were adapted for two weeks and then distributed randomly into twenty glass aquaria (100×40×50 cm). Each fish was taken out by a net and weighed then transferred randomly to the experimental aquaria. Twenty tanks were randomly stocked with 30 tilapia fish for each tank (first experiment).

Fish grouping: For each experiment fish were grouped into control group (0 L-carnitine) and four dietary L-carnitine (Arab Company For Pharmaceuticals & Medical Plants – MEPACO - Egypt) at concentrations of 300, 600, 900 and 1200 mg/kg diet in two dietary lipid levels, 5 and 10%. Therefore, the experimental diets designated as F5C0, F5C300, F5C600, F5C900, F5C1200, F10C0, F10C300, F10C600, F10C900 and F10C1200, respectively. All these fish groups were arranged in two replicates.

Feed and feeding: Composition and proximate analysis of basal diets used in the two experiments are presented in Table 1. Two basal diets were formulated to contain 5 or 10% dietary lipid. Each basal diet was divided into 5 diets and L-carnitine was added with five levels, 0, 300, 600, 900 and 1200 mg/kg diet, therefore 10 isonitrogenous (30% CP) and isocaloric (3000 kcal ME/kg) diets were formulated. Fish were given the diets at a daily rate 5% of total biomass. Fish were fed twice daily at 9:00 am and 2:00 pm. Records of live body weight (g) and body length (cm) of individual fish were measured at the start and the end of each experiment. Growth performance and feed utilization parameters were measured by using the following equations:

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

Where:- Ln = the natural log, W1 = initial fish weight; W2 = the final fish weight in "grams" and t = period in days.

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

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

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

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

Cold tolerance experiment:

The second experiment of the present study aimed to study the effect of dietary L-carnitine on cold tolerance of Nile tilapia, therefore, 10 glass aquaria (100×40×50 cm) were stocked with 40 tilapia for each aquarium and the aquaria were divided into five groups (in two replicates). During the experimental period (from 1December to 1 March 2004) fish were fed five isonitrogenous (30% CP) and isocaloric (3000 ME/kg diet) diets at a rate of 1% of fish body weight (6 days/week). The experimental diets formulated to contains, 0, 300, 600, 900 and 1200 mg L-carnitine/kg diet. Temperature was weekly recorded in all aquaria.

Statistical analysis: Statistical analysis of the obtained data was analyzed according to SAS (1996). Differences between means were tested for significance according to Duncan's multiple rang test as described by Duncan (1955).

Table 1: Composition and proximate analysis of basal diets.

Ingredient	5% lipid	10% lipid
Fish meal	28.0	28.0
Soybean meal	18.0	18.0
Yellow corn	24.0	16.5
Wheat flour	13.0	9.0
Wheat bran	9.0	15.5
Corn oil	4.0	9.0
Vit.&Min. mix.[1]	4.0	4.0
Sum	100.0	100.0
Proximate analysis (Dry matter basis)		
Dry matter	95.34	95.78
Protein	30.12	30.23
Lipid	5.32	10.11
Ash	7.96	8.11
Crude fiber	9.87	9.55
NFE[2]	46.73	42.00
ME (Kcal/kg diet)[3]	3019	3028
P/E ratio[4]	99.77	99.83

[1] Vitamin & mineral mixture/kg premix:: Vitamin D3, 0.8 million IU; A, 4.8 million IU; E, 4 g; K, 0.8 g , B1, 0.4 g; Riboflavin, 1.6 g; B6, 0.6 g, B12, 4 mg; Pantothenic acid, 4 g; Nicotinic acid, 8 g; Folic acid, 0.4 g Biotin,20 mg , Mn, 22 g; Zn, 22 g; Fe, 12 g; Cu, 4 g; I, 0.4 g, Selenium, 0.4 g and Co, 4.8 mg.

[2] Nitrogen free extract (NFE) =100-(CP+EE+CF+Ash)

[3] Metabolizable energy was calculated from ingredients based on NRC (1993) values for tilapia.

[4] Protein to energy ratio: mg protein/kcal ME.

RESULTS AND DISCUSSION

First experiment

I-Growth performance, feed intake and feed utilization

Table 2 showed the effect of L-carnitine on growth performance and feed utilization of Nile tilapia, it revealed that, at the experiment start body weight (BW) ranged between 5.78 to 6.13 g and body length (BL) ranged between 6.90 to 7.27 cm with no significant differences between fish groups in BW and BL indicating the random distribution of fish around the different treatments. At the end of the experimental period (90 days) results of Table 2 indicated that, dietary factors had dramatic effects on growth and feed utilization. Dietary lipid levels studied (5 and 10%) had no significant effect on all growth and feed utilization parameters while all dietary L-carnitine levels significantly (P<0.05) increased BW, BL, WG, SGR, feed intake (FI) and improved FCR and PER. The obtained results follow the trend as those obtained by Abdel-Hakim *et al.,* (2001 a & b); Hassaan *et al.,* (2013 and 2014 a & b).

Table 2: Least square means and standard error for the effect of dietary fat and L-carnitine on growth performance and feed utilization of Nile tilapia.

Item	No.	Body weight (g)		Body length (cm)		Weight gain (WG)	Specific growth rate (SGR)	Feed intake (g)/fish (FI)	Feed conversion ratio (FCR)	Protein efficiency ratio (PER)
		Initial	Final	Initial	Final					
Fat (F)										
5% (F5)	300	5.91± 0.12	24.59± 0.31	7.15± 0.05	11.51± 0.06	18.69± 0.02	1.69± 0.01	51.54± 0.15	2.76± 0.02	1.20± 0.12
10% (F10)	300	6.04± 0.12	25.19± 0.31	7.12± 0.05	11.71± 0.06	19.15± 0.02	1.70± 0.01	52.59± 0.15	2.75± 0.02	1.21± 0.12
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	14.02± 0.03 e	1.47± 0.02 b	43.64± 0.25 b	3.12± 0.03 a	1.07± 0.20 b
300 (C300)	120	5.97± 0.21	25.64± 0.54 a	7.16± 0.09	11.98± 0.11 a	19.67± 0.03 d	1.74± 0.02 a	53.39± 0.25 a	2.71± 0.03 b	1.23± 0.20 a
600 (C600)	120	5.98± 0.21	25.73± 0.54 a	6.95± 0.09	11.75± 0.11 a	19.76± 0.03 d	1.74± 0.02 a	53.54± 0.25 a	2.71± 0.03 b	1.23± 0.20 a
900 (C900)	120	6.04± 0.21	26.23± 0.54 a	7.22± 0.09	11.84± 0.11 a	20.20± 0.03 a	1.75± 0.02 a	53.45± 0.25 a	2.65± 0.03 b	1.26± 0.20 a
1200 (C1200)	120	6.01± 0.21	25.89± 0.54 a	7.15± 0.09	11.66± 0.11 a	19.88± 0.03 c	1.75± 0.02 a	54.12± 0.25 a	2.72± 0.03 b	1.22± 0.20 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	13.76± 0.05 g	1.45± 0.03 b	43.32± 0.36 b	3.15± 0.05 a	1.05± 0.29 b
F5 C300	60	5.88± 0.29	25.48± 0.77 a	7.17± 0.13	11.62± 0.15 b	19.66± 0.05 d	1.75± 0.03 a	52.33± 0.36 a	2.66± 0.05 b	1.25± 0.29 a
F5 C600	60	5.91± 0.29	25.23± 0.77 a	6.99± 0.13	11.69± 0.15 b	19.32± 0.05 e	1.73± 0.03 a	52.74± 0.36 a	2.73± 0.05 b	1.22± 0.29 a
F5 C900	60	5.95± 0.29	26.03± 0.77 a	7.27± 0.13	11.73± 0.15 b	20.08± 0.05 bc	1.76± 0.03 a	53.00± 0.36 a	2.64± 0.05 b	1.26± 0.29 a
F5 C1200	60	5.90± 0.29	25.31± 0.77 a	7.20± 0.13	11.53± 0.15 b	19.41± 0.05 e	1.74± 0.03 a	53.89± 0.36 a	2.78± 0.05 b	1.19± 0.29 a
F10 C0	60	5.78± 0.29	20.05± 0.77 b	7.15± 0.13	10.54± 0.15 c	14.27± 0.05 f	1.49± 0.03 b	43.96± 0.36 b	3.08± 0.05 a	1.08± 0.29 b
F10 C300	60	6.07± 0.29	25.81± 0.77 a	7.15± 0.13	12.35± 0.15 a	19.74± 0.05 d	1.73± 0.03 a	54.45± 0.36 a	2.76± 0.05 b	1.21± 0.29 a
F10 C600	60	6.04± 0.29	26.23± 0.77 a	6.90± 0.13	11.81± 0.15 b	20.20± 0.05 ab	1.74± 0.03 a	54.34± 0.36 a	2.69± 0.05 b	1.23± 0.29 a
F10 C900	60	6.13± 0.29	26.44± 0.77 a	7.16± 0.13	11.94± 0.15 ab	20.31± 0.05 a	1.74± 0.03 a	53.89± 0.36 a	2.65± 0.05 b	1.25± 0.29 a
F10 C1200	60	6.12± 0.29	26.46± 0.77 a	7.11± 0.13	11.79± 0.15 b	20.34± 0.05 a	1.75± 0.03 a	54.34± 0.36 a	2.67± 0.05 b	1.24± 0.29 a

Means followed by the same letter in each column for each factor are not significantly different (P<0.05).

The present study revealed that, L-carnitine caused a significant increase in BW, WG and SGR of Nile tilapia, *O. niloticus* and these results in accordance with those observed by Jayaprakas *et al*., (1996) and Azab *et al*., (2002) who found that, supplementation of L-carnitine to Nile tilapia diets significantly increases WG and improves FCR. In the same respect, Jayaprakas and Sambhu (1998) found significant increase in growth of Pearlspot, *Etroplus suratensi* when treated with 750 mg carnitine/kg diet.

With regard to the interaction between dietary lipid and L-carnitine, results of Table 2 indicated that, within each lipid level; the lower L-carnitine level (300 mg/kg diet) improved significantly BW, BL, WG, SGR, FI, FCR and PER but did not significantly different from the higher L-carnitine levels (600, 900 and 1200 mg/kg diet). The lack of a strong L-carnitine effect on tilapia growth at the higher levels (600, 900 or 1200 mg/kg diet) in the present experiment may due to the ability of fish to synthesize adequate quantities of L-carnitine for lipid metabolism. The diets were limited in lysine or methionines which are precursors for L-carnitine synthesis. If a limited precursor pool was available for metabolism, the higher L-carnitine levels may have had more dramatic influences on growth and/or proximate composition of gain. Azab *et al*., (2002) found that, growth rate of Nile tilapia improved when L-carnitine was supplemented at a level of 900 mg/kg diet. However, Kheyyali and Tahari (1998) found that, L-carnitine supplementation to the level 250 mg/kg improved weight gain of rainbow trout, *Oncorhynchus mykiss* to 83% of the control and further supplementation of L-carnitine gave lower performance and 100 mg L-carnitine/kg diet resulted in the lowest gain with 61% of the control.

II-Carcass traits and body composition of Nile tilapia:

Results of Table 3 indicated that, dietary lipids (5 and 10%) had no significant effect on carcass traits of Nile tilapia. Compared to control all L-carnitine levels significantly increase the percentage of dress-out and flesh while the percentage of by-products significantly ($P<0.05$) decreased. With regard to the effect of interaction between dietary lipid and L-carnitine, results of Table 3 revealed that, the diet contained 10% lipid and 0 L-carnitine (F10 C0) recorded the lowest dress-out and flesh and the higher by-products percentages.

Table 3: Least square means and standard error for the effect of dietary fat and L-carnitine on carcass analysis of Nile tilapia.

Item	No.	Dress-out %	Flesh %	By-products %
Fat (F)				
5% (F5)	30	49.95±0.42	34.71±0.48	57.44±0.48
10% (F10)	30	49.06±0.42	34.77±0.48	56.31±0.48
L-carnitine mg/kg diet (C)				
0 (C0)	6	47.54±0.73 b	32.95±0.83 b	59.16±0.84 a
300 (C300)	6	49.84±0.73 a	36.22±0.83 a	55.53±0.84 b
600 (C600)	6	49.45±0.73 a	35.96±0.83 a	55.37±0.84 b
900 (C900)	6	49.64±0.73 a	33.91±0.83 a	56.96±0.84 b
1200 (C1200)	6	51.06±0.73 a	35.27±0.83 a	56.82±0.84 b
Fat × L-carnitine				
F5 C0	3	49.33±1.04 a	34.96±1.17 ab	57.31±1.19 ab
F5 C300	3	50.29±1.04 a	34.65±1.17 ab	57.57±1.19 ab
F5 C600	3	48.84±1.04 a	35.68±1.17 ab	57.34±1.19 ab
F5 C900	3	49.50±1.04 a	34.95±1.17 ab	57.48±1.19 ab
F5 C1200	3	51.43±1.04 a	35.18±1.17 ab	56.26±1.19 bc
F10 C0	3	45.75±1.04 b	30.95±1.17 c	61.02±1.19 a
F10 C300	3	49.38±1.04 a	37.78±1.17 a	53.49±1.19 c
F10 C600	3	50.06±1.04 a	36.24±1.17 ab	53.39±1.19 c
F10 C900	3	49.79±1.04 a	32.86±1.17 bc	58.45±1.19 ab
F10 C1200	3	50.70±1.04 a	35.36±1.17 ab	57.38±1.19 ab

Means followed by the same letter in each column for each factor are not significantly different ($P<0.05$).

Proximate analysis of tilapia fish as affected by dietary lipid and L-carnitine outlined in Table 4. As described in this table, the lower lipid level (5%) released the higher ($P<0.05$) moisture and ash and the lower fat content. Also it was found that, as dietary L-carnitine increased fat content of tilapia fish significantly ($P<0.05$) decreased and protein content significantly increased, while moisture and ash content did not significantly affected. The higher protein content and lower fat content were recorded with fish fed the diet contained the higher L-carnitine level (1200 mg/kg diet).

With regard to the effect of interaction between dietary lipid and L-carnitine, results of Table 4 show that, within each dietary lipid level, increased L-carnitine level from 0 to 1200 mg/kg diet significantly decreased fat and relatively increased protein content of tilapia fish while moisture and ash had no clear trend. These results similar to those obtained by Jayaprakas and Sambhu (1998), they found that, body protein content increased while body lipid decreased ($P<0.01$) with carnitine administration to pearlspot, *Ertoplus suratensis*. In contrast with our results, some authors found that, dietary L-carnitine did not alter tissue composition of hybrid tilapia (Becker *et al*., 1999) and Nile tilapia, *O. niloticus* (Azab *et al*., 2002).

From these results, it can be concluded that, L-carnitine at concentrations ranged from 300 to 1200 mg/kg diet in dietary lipid 5 or 10% improve growth performance, feed efficiency, carcass traits and increase tissue protein and decrease tissue fat percentages of Nile tilapia.

Table 4: Least square means and standard error for the effect of dietary fat and L-carnitine on proximate analysis of tilapia fish.

Item	No.	Moisture %	Protein %	Fat %	Ash %
Fat (F)					
5% (F5)	30	76.18±0.25 a	69.79±0.20	12.92±0.06 b	17.04±0.06 a
10% (F10)	30	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)	6	75.09±0.44	68.21±0.35 b	14.78±0.10 a	15.20±0.11
300 (C300)	6	75.92±0.44	69.06±0.35 ab	14.37±0.10 a	15.80±0.11
600 (C600)	6	75.27±0.44	68.91±0.35 b	13.92±0.10 ab	15.28±0.11
900 (C900)	6	74.68±0.44	69.74±0.35 ab	13.50±0.10 ab	15.31±0.11
1200 (C1200)	6	75.60±0.44	70.31±0.35 a	12.89±0.10 b	15.76±0.11
Fat × L-carnitine					
F5 C0	3	76.12±0.62 ab	67.71±0.50 e	13.57±1.14 d	17.40±0.15 a
F5 C300	3	76.84±0.62 a	69.10±0.50 bc	13.13±1.14 e	17.82±0.15 a
F5 C600	3	75.87±0.62 ab	69.75±0.50 bc	12.88±1.14 e	16.88±0.15 b
F5 C900	3	75.29±0.62 abc	69.96±0.50 bc	12.68±1.14 e	16.61±0.15 b
F5 C1200	3	75.99±0.62 ab	70.62±0.50 ab	12.68±1.14 e	16.64±0.15 b
F10 C0	3	74.06±0.62 bc	68.71±0.50 cd	15.99±1.14 a	13.00±0.15 e
F10 C300	3	75.01±0.62 abc	69.03±0.50 bc	15.62±1.14 a	13.70±0.15 d
F10 C600	3	74.67±0.62 bc	68.06±0.50 de	14.95±1.14 b	13.67±0.15 d
F10 C900	3	74.07±0.62 bc	69.52±0.50 bc	14.31±1.14 c	14.01±0.15 d
F10 C1200	3	75.20±0.62 abc	70.00±0.50 bc	13.11±1.14 e	14.88±0.15 c

Means followed by the same letter in each column for each factor are not significantly different ($P<0.05$)

Second experiment

During the period between December to March 2004 water temperature in the experimental aquaria ranged between 9.35 and 11.50°C (Table 8). Final BW and BL of tilapia fish did not significantly affected by dietary L-carnitine. Results of cold tolerance challenge showed a significant advantage of all treatment groups which received the diets

supplemented with L-carnitine compared to control group (had no L-carnitine supplementation). This was evident by the high survival rate for all L-carnitine supplemented groups. Fish group received L-carnitine at a level of 900 or 1200 mg/kg diet exhibited the best survival rate. Similar results were obtained by Harpaz *et al*., (1999). They found that, addition of L-carnitine to diets of *Pelvicachromis pulcher* at a level of 900 or 1000 mg/kg diet seems to yield the best protection against exposure to cold. Also, Soltan *et al.,* (2015) found that, supplementation of *O. niloticus* with 350 mg/kg diet L-carnitine significantly increased survival rate from 16% (control group) to 73% for treated fish.

The major goal in the over-wintering of tilapia fingerlings is to obtain a high survival rate of the fish and to keep them in good condition for future growth in the production ponds (Bakeer *et al.,* 2005). Crab *et al.,* (2009) demonstrated that, temperature in the covered ponds with polyethylene sheets could easily be controlled and was 0.4-4.9°C higher than the influent water. Hybrid tilapia fingerlings (*O. niloticus* × *O. aureus*) survival levels were excellent being 97± 6% for 100 g fish and 80±4% for 50 g fish and these findings can help to overcome over-wintering problems, particularly mass mortality of fish due to low temperatures in the ponds. Therefore, the obtained results indicated the possibility of improving *O. niloticus* survival by supplementing tilapia diets with 350 mg/kg diet L-carnitine.

Table 5: Effect of L-carnitine levels in diets on cold tolerance of *O. niloticus*.

Growth traits	L-carnitine level				
	0 mg/kg	300 mg/kg	600 mg/kg	900 mg/kg	1200 mg/kg
Initial BW (g)	3.63±0.17	3.70±0.17	3.72±0.17	3.71±0.17	3.73±0.17
Final BW (g)	7.51±0.76	8.01±0.67	8.36±0.67	8.96±0.67	9.01±0.65
Initial BL(cm)	6.58±0.08	6.45±0.08	6.37±0.08	6.52±0.08	6.58±0.08
Final BL(cm)	8.18±1.77	8.01±1.57	7.88±1.57	7.81±1.51	8.21±1.65
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
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

Means followed by the same letter in each column for each factor are not significantly different ($P<0.05$)

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ARABIC SUMMARY

تأثير إضافة الكارنيتين للعلف على النمو وتحمل البرودة فى أسماك البلطى النيلى

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أجريت هذه الدراسة لتقييم تأثير الكارنيتين على النمو والإستفادة من الغذاء وتكوين الجسم فى أسماك البلطى النيلى ولتقييم تأثير إضافة الكارنيتين بعد اضافته للعلف على كفاءة النمو واالغذاء فى أسماك البلطى النيلى أجريت تجربه عامليه (2 x 5) كما أجريت تجربة ثانية لتقييم تأثير إضافة الكارنيتين إلى العلف على زيادة مقاومة أسماك البلطى لبرودة الماء فى الشتاء. وقد تم استخدام الكارنيتين بمستويات صفر, 300, 600 , 900 1200 مجم/علف وفى كل مستوى تم اختبار مستويين من الدهن (5 ، 10 %) وبذلك تم تكوين 10 علائق متساوية فى محتواها من البروتين (30% بروتين) ومتساوية فى محتواها من الطاقة (3000 كيلو كالورى طاقة ممثلة/كجم علف) وقد تم اختبار كل عليقة فى 3 مكررات على أسماك البلطى (التجربة الأولى). كما تم تكوين 5 علائق أخرى متساوية فى محتواها من البروتين (30% بروتين) ومتساوية فى محتواها من الطاقة (3000 كيلو كالورى/كجم علف) ومتساوية كذلك فى محتواها من الدهن (5 %) كما أضيف إليها نفس مستويات الكارنيتين السابقة وذلك لدراسة تأثير إضافة الكارنيتين إلى العلف على زيادة مقاومة أسماك البلطى على تحمل البرودة (التجربة الثانية) وقد استغرقت كل تجربة ثلاثة أشهر.

أدت إضافة الكارنيتين إلى علائق الأسماك إلى زيادة معنوية فى كل مقاييس النمو (وزن الجسم ، طول الجسم، الزيادة فى وزن الجسم ، معدل النمو) كما أدت إلى زيادة معدل تحويل الغذاء وكفاءة الاستفاده من البروتين فى أسماك البلطى (التجربة الأولى). ومقارنة بمجموعة المقارنة أدت إضافة الكارنيتين إلى علائق أسماك البلطى إلى زيادة نسبة الذبيحة واللحم ونقص نسبة المخلفات فى الذبيحة كما أدت زيادة مستوى الكارنيتين إلى نقص معنوى فى محتوى الجسم من الدهن وزيادة محتواه من البروتين فى البلطى.

وبصفة عامة يمكن إستنتاج أن إضافة الكارنيتين بمستويات من 300 إلى 1200 مجم/كجم علف قد أدى إلى تحسين كفاءة النمو والإستفادة من الغذاء وكذلك إنخفاض فى محتوى الجسم من الدهن وزيادة محتواه من البروتين وذلك فى أسماك البلطى والمبروك كما أدت إضافة الكارنيتين إلى علائق البلطى إلى زيادة نسبة الحيوية لأسماك البلطى النيلى فى درجات الحرارة المنخفضة اثناء شهور الشتاء.