Global Journal of Fisheries and Aquaculture.

Vol. 2 (2)
pp. 139-147, March, 2014. ©
Global Science Research Journals

Full Length Research paper

Effect of cysteine and dietary protein levels on striped mullet (*Mugil cephalus*) performance

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Accepted 8th March, 2014

This experiment was conducted to study the effect of cysteine (CYS) and different dietary protein levels on growth performance, survival rate, feed utilization and body composition of striped mullet (*Mugil cephalus*) fry (2.1g initial body weight). Six experimental diets were formulated to contain three levels of protein (16, 20 and 24%) each supplemented with or without 1% cysteine. Diets were isocaloric (4.25 kcal gross energy/g diet). Each diet was fed in triplicate groups of 10 fish each twice daily to apparent satiation for 10 weeks. The results showed that growth performance was significantly affected by increasing dietary protein level and supplemented cysteine in the fish diet (P<0.05). Fish fed CYS-diets showed significantly higher growth performance parameters and better feed utilization than fish fed on other diets. Moreover, fish fed CYS-diets containing 24% protein were significantly higher in growth performance values compared to other treatments. Survival rate increased significantly (P< 0.05) with increasing dietary protein level and supplemented cysteine in the fish diet. These results suggest that balancing fish diets containing 24% crude protein supplemented with 1% cysteine level, has significant impacts on growth performance and the feed utilization outcomes of striped mullet (*Mugil cephalus*) fry.

Keywords: Striped mullet; *Mugil cephalus*; cysteine; protein levels; growth performance; feed utilization.

INTRODUCTION

Mullet (*Mugillidae*) are considered as one of the important fish species for mono and polyculture systems in Egypt. They represent some of the most promising species for commercial aquaculture and have strong market demand and high price in many countries (El Dahhar *et al.*, 2011). Also, mullets are good candidates and play an important role in the fisheries and fish farms of tropical and subtropical countries of the world (Nash and Shehadeh, 1980).

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The cost of the fish production depends mainly on the cost of feed which constitutes most of the economical expenses. Dietary protein is the most expensive component in fish feeds and also the most important factor affecting growth performance of fish. Accurate information on the protein requirement of fish is critical for any new aquaculture initiative (Ng *et al.*, 2008). Higher protein utilization may be obtained by increasing protein digestibility, improving amino acid balance and reducing

the amount of protein used for energetic purposes (Nordrum *et al.*, 2000; Kim *et al.*, 2010). Few of the nutritional researches have focused on minimizing crude protein in the diet for mullet. Papaparaskeva and Alexis (1986) found that 24% dietary crude protein level was required for maximum growth for young grey mullet *Mugil capito* of 2.5 g initial body weight. While, El-Dahhar *et al.* (2011) found that diet containing 28% crude protein is the optimal level for striped mullet (*Mugil cephalus*) fry for maximum growth and feed efficiency during nursing period (1.62 g).

Recent evidence shows that some amino acids and their metabolites are important regulators of key metabolic pathways that are necessary for maintenance, growth, feed intake, nutrient utilization, immunity, as well as resistance to environmental stressors in various fishes (Li *et al.*, 2009). However, specific amino acids deficiencies are a limiting factor of the complete replacement of fish meal in fish feeds, and supplementation feeds with them have improved growth in some cases (Cheng *et al.*, 2003). Gaylord *et al.* (2006) reported that even when all the indispensable amino acid requirements are met in a plant-based fish feed, growth rate remains low relative to a fish-meal-based feed.

Cysteine and methionine are classified as sulfur-containing amino acids and adequate amounts of both (cysteine and methionine) are needed for proper protein synthesis and other physiological functions of the fish. When methionine is fed without cysteine, a portion of the methionine is used for protein synthesis, and a portion is converted to cysteine for incorporation into protein (Griffin *et al.*, 1994; Nordrum *et al.*, 2000). There is limited information about nutritional essentiality of cysteine for fish. It has been estimated that cysteine can spare 40–60% of dietary methionine needed for various fishes (Wilson, 2002). Takeuchi (2007) stated that taurine is synthesized from methionine after it is oxidized to cysteine. In fish, it has been recently clarified that taurine is also an essential nutrient for larva. Some species can synthesize taurine from methionine and cysteine, Yokoyama *et al.* (1997) reported that rainbow trout can synthesize taurine from cysteine. However, there are limited data on using amino acids as feed supplement in striped mullet diets and especially the use of dietary cysteine to enhance fish performance is rarely evaluated. Also no more information is available about the optimum protein requirements of this species. This study was conducted to evaluate the effect of cysteine supplementation in practical diets and different dietary protein levels on growth performance, feed utilization, survival and body composition of striped mullet (*Mugil cephalus*) fry.

MATERIALS AND METHODS

The Experimental Fish

This experiment was carried out at the fish production laboratory, Faculty of Agriculture (Saba Bacha), Alexandria University, Egypt. Striped mullet (*Mugil cephalus*) used in this study were obtained from a private fish farm in Kafr El-Shikh Government, Egypt. Fish were acclimatized in tanks of 1 m^3 capacity to laboratory conditions and fed on artificial diets for two weeks until the beginning of experiment. Fish with an initial body weight of (2.1 ± 0.06 g) were divided randomly to 6 groups in triplicate of 10 fish in each group per aquarium. Glass aquaria of dimensions 100 x 34 x 50 cm were filled with 100 L of water and supplemented with continuous aeration. Nearly half of the water was exchanged daily by freshly stocked dechlorinated tap water and aquaria were cleaned every day before feeding. Fish were fed twice daily at 9.00 and 14.00h to apparent satiation. Fish were weighed at the beginning of the experiment and then biweekly for 10 weeks experimental period. Fish mortality was recorded daily and the dead fish were removed.

Diet formulation and preparation

Six practical diets were formulated to contain three levels of protein (16, 20 and 24%) each supplemented with or without 1% cysteine. Diets were isocaloric (4.25 kcal gross energy/g diet). The composition and chemical analysis of the experimental diets are presented in Table (1). Diets were formulated from commercial ingredients containing both animal and plant protein sources. Fish oil emulsified with equal amount of water using 0.7% phosphatediyl choline (lecithin) according to (El-Dahhar and El-Shazly, 1993) was added to the diets. Mixtures were homogenized in a food grinder mixer attachment model NFGA (Kitchen Aid St. Goseph, MI 49085 USA). Then, water was blended into the mixture at the ratio of 50% for pelleting. The diets were pelleted using meat grinder of Kitchen Aid with a 1.5 mm diameter and kept dry until they were used. Diets were heat treated by an autoclave with a maximum pressure of 1.2 kg /cm^2 G, for 15 minutes after adding water. Diets were dried in a drying oven model (Fisher oven 13 – 261 – 28A) for 24 hours on 65 °C. Vitamins and minerals mixture and amino acid were added to the diets after heat treatment.

Parameters of growth performance and feed utilization

Growth performance and feed utilization efficiency parameters were calculated using the following equations:

Table (1): Composition and proximate analysis of experimental diets used in the present experiment.

Ingredients	non CYS-diets			CYS-diets		
	Protein level in diet			Protein level in diet		
	16 %	20 %	24 %	16 %	20 %	24 %
Wheat flour	27	22	18	27	22	18
Wheat bran	34.5	30.5	27	33.5	29.5	26
Soybean meal	8	16	23	8	16	23
Yellow corn	20	17	14	20	17	14
Fish meal	4	8	11.5	4	8	11.5
Fish oil	3.5	3.5	3.5	3.5	3.5	3.5
Vit &Min Mix*	1	1	1	1	1	1
Bone meal	2	2	2	2	2	2
Cysteine**	0	0	0	1	1	1
Total	100	100	100	100	100	100
Proximate analyses:						
Dry matter	89.68	89.54	89.28	89.52	89.73	89.89
Crude protein	15.81	19.7	23.89	15.73	19.62	23.66
Crude fat	11.52	11.84	11.04	10.77	11.49	10.84
Crude fiber	7.87	8.71	9.07	7.13	8.75	9.07
NFE***	55.32	49.58	45.12	57.94	49.86	46.31
Ash	9.48	10.17	10.88	9.43	10.28	10.12
GE (kcal/g)	4.25	4.26	4.24	4.24	4.24	4.26

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

**Sigma-Aldrich Co., St. Louis, Missouri, USA.

***NFE is nitrogen free extract is calculated by difference = 100- (protein+ fat+ fiber+ ash).

Growth performance parameters:

Weight gain (WG) = W_1-W_0.
Relative growth rate (RGR%) = $[(W_1 - W_0) / W_0] \times 100$.
Specific growth rate (SGR%/day) = $[(\ln W_1 - \ln W_0)/T] \times 100$.

Where, Ln = natural log, W_0 = Initial body weight (g), W_1= Final body weight (g) and T= Time (day).

Feed utilization efficiency parameters:

Feed conversion ratio (FCR) = feed intake (g)/body weight gain (g).
Protein efficiency ratio (PER) = total weight gain (g)/protein intake (g).
Protein productive value (PPV%) = 100 (protein gain/protein intake).
Energy retention (ER%) = 100 (gross energy gain/gross energy intake).

Survival rate (%) = 100 × (fish No. at the end/ fish No. stocked at the beginning).

Chemical analysis of diets and fish

Twenty five fish at start and three from each aquarium at the end of the experiment were taken randomly and were frozen for whole body composition analysis. Frozen samples were dried at 70°C for 72 h and passed through a meat grinder into one composite homogenate per aquarium. Chemical analysis of homogenized fish and experimental diets were carried out according to the methods of (Association of Official Analytical Chemists AOAC, 1990) for protein (macro-keldahl method), fat (ether extract method), moisture (oven drying), crude fiber (fritted-glass crucible method) and ash (muffle furnace).

The nitrogen free extract (NFE) was calculated as:

NFE (%) = 100 − (% crude protein + % crude lipid + % crude fiber +% ash).

Gross energy (GE) was calculated according to (NRC, 1993) as crude protein, crude fat and carbohydrate to be 5.65, 9.44 and 4.11kcal/g respectively.

Water quality

Water quality parameters were monitored to ensure that water quality remained well within limits recommended for striped mullet culture. Water temperature and dissolved oxygen were measured daily using a YSI Model 58 oxygen meter (Yellow Springs Instrument, Yellow Spring, OH, USA). Total ammonia, nitrite, and nitrate were measured twice weekly using a DREL 2000 spectrophotometer by the method of (Golterman *et al.*, 1978), pH was monitored daily using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH, USA). Water temperature ranged from 26.5 to 27.5 °C, dissolved oxygen from 4.2 to 5.5 mg/ L, total ammonia from 0.21 to 0.28 mg/L, pH from 7.5 to 7.7, and alkalinity from 176 to 180 mg/L. There were no significant differences in the water quality parameters among the treatments during the experimental period. All the previous water quality parameters were within the acceptable range for fish growth (Boyd, 1984).

Statistical analysis

A (2 x 3) factorial design was used in this experiment with two levels of cysteine (0 and 1%) and three levels of dietary crude protein (16, 20, and 24%). Differences between means were tested using Duncan's new multiple range test. Treatment effects were considered significant at $P < 0.05$. All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, USA) as described by (Dytham, 1999).

RESULTS

Growth performance

Data of Table (2) show that final body weight (FBW), weight gain (WG), survival%, relative growth rate (RGR%) and specific growth rate (SGR% /day) of striped mullet (*Mugil cephalus*) were significantly ($P< 0.05$) improved with increasing protein level in the diets. Fish maintained on diets containing 24% protein diet exhibited significantly ($P< 0.05$) the greatest FBW, WG, RGR% and SGR compared to other treatments. Also, the results showed that fish fed CYS-diets showed significantly ($P< 0.05$) higher growth performance parameters than fish fed on non CYS-diets.

Survival rate presented in Table (2) at the end of the experiment showed that there were significant differences ($P< 0.05$) among treatments. In addition, fish fed diet containing 24% crude protein recorded the highest ($P< 0.05$) value of survival rate 96.67%, while the lowest values were obtained when fish given diets containing 16% crude protein 76.67%. Also, fish fed CYS-diets were significantly higher ($P< 0.05$) in survival rate 88.89% compared with the fish fed non CYS-diets 81.11%, regardless of protein level.

Feed utilization

Values of feed conversion ratio (FCR), protein efficiency ratio (PER), protein productive value (PPV%) and energy retention (ER%) of striped mullet (*Mugil cephalus*) are shown in Table (3). Data showed that with increasing the protein content in the fish diet from 16 to 24%, FCR values of fish improved significantly ($P< 0.05$). The best value of FCR was found in fish groups maintained diet containing 24% protein level (1.61), while the worst FCR was found with fish maintained diet containing 16% crude protein (1.73). Moreover, results indicated that fish given CYS-diets were significantly improved ($P< 0.05$) in FCR values (1.64) than fish given non CYS-diets (1.70). On the other side, PER improved significantly ($P < 0.05$) by decreasing dietary protein level in the diets. Fish fed diet containing 16% crude protein gave better PER value than fish fed on 20 or 24% crude protein, values were 3.61, 3.02 and 2.60 respectively. However, irrespective of supplemental cysteine, results did not show any significant ($P > 0.05$) effect of supplemental cysteine on PER. Also, results show that PPV% decreased significantly ($P< 0.05$) with increasing dietary protein level. The best values ($P< 0.05$) of PPV% (60.70 and 65.69%) were obtained with fish fed on diets containing at 16% crude protein with or without supplemental cysteine, respectively.

Table (2): Growth performance parameters (means ± SE) of striped mullet (*Mugil cephalus*) fed on diets containing different dietary protein and cysteine levels.

Treatments		FBW	WG	RGR%	SGR	Survival %
non CYS-diets	**16 %**	5.95±0.12 d	3.82±0.13 d	179.19±6.77 e	1.22±0.03 e	76.67±3.33 d
	20 %	6.62±0.11 cd	4.49±0.12 cd	211.62±5.83 cd	1.35±0.02 d	80.00±0.00 cd
	24 %	7.47±0.21 b	5.35±0.21 b	252.52±11.58 b	1.50±0.04 bc	86.67±8.82 bc
CYS-diets	**16 %**	6.98±0.22 c	4.85±0.22 c	227.54±10.54 c	1.41±0.04 cd	83.33±6.67 c
	20 %	7.88±0.26 b	5.75±0.26 b	270.53±11.98 b	1.56±0.04 ab	86.67±3.33 bc
	24 %	8.57±0.11 a	6.43±0.10 a	301.56±3.34 a	1.65±0.01 a	96.67±3.33 a
Cysteine	**non-CYS**	6.68±0.11 h	4.55±0.11 h	214.38±5.28 h	1.36±0.02 h	81.11±1.67 h
	CYS	7.81±0.12 g	5.68±0.12 g	266.56±5.73 g	1.55±0.02 g	88.89±1.73 g
Protein	**16 %**	6.46±0.16 z	4.33±0.16 z	203.36±8.08 z	1.32±0.03 z	80.00±2.89 y
	20 %	7.25±0.11 y	5.12±0.11 y	241.10±5.51 y	1.46±0.02 y	83.33±1.67 xy
	24 %	8.02±0.08 x	5.89±0.08 x	277.12±4.93 x	1.58±0.02 x	91.67±1.67 x

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

With respect to energy retention (ER%) results shows that ER% was insignificantly affected by different dietary protein levels or cysteine supplementation in the fish diet.

Body composition

With respect to body composition of striped mullet, results in Table (4) revealed no significant differences ($P>0.05$) between treatments in fish body moisture contents, it ranged between 70.96 and 72.58%. Concerning protein contents of the fish, results show that protein contents increased significantly ($P< 0.05$) with increasing protein level in fish diets. The fish fed diets containing 24% protein had significantly ($P< 0.05$) higher body protein than those of fish fed at 16 or 20% protein. Moreover, fish given CYS-diets showed significantly ($P< 0.05$) higher fish body protein contents than fish fed non-CYS-diets. On the other side, results revealed no significant differences ($P>0.05$) between treatments in fish body lipid contents, it ranged between 9.69 and 10.04%.

Table (3). Feed and nutrient utilization parameters (Means ± SE) of striped mullet (*Mugil cephalus*) fed on diets containing different dietary protein and cysteine levels.

Treatments		Feed	FCR	PER	PPV %	ER%
non CYS-diets	**16 %**	6.81±0.11 e	1.78±0.08 a	3.52±0.16 ab	60.70±2.50 ab	30.85±1.41
	20 %	7.71±0.22 d	1.72±0.09 ab	2.96±0.16 cd	51.28±3.03 c	29.81±1.59
	24 %	8.69±0.12 c	1.62±0.05 cd	2.58±0.07 d	45.01±1.18 d	31.85±1.08
CYS-diets	**16 %**	8.20±0.02 c	1.69±0.08 bc	3.70±0.17 a	65.69±2.63 a	29.98±1.56
	20 %	9.37±0.09 b	1.63±0.09 cd	3.09±0.17 bc	54.80±2.70 bc	29.24±1.31
	24 %	10.28±0.11a	1.60 ±0.04 d	2.61±0.07 d	48.12±1.37 cd	30.06±0.37
Cystein	**non-CYS**	7.74±0.14 h	1.70±0.06 g	3.02±0.11	52.33±1.98	30.84±1.18
	CYS	9.29±0.01 g	1.64±0.04 h	3.13±0.08	56.20±1.16	29.76±0.72
Protein	**16 %**	7.51±0.06 z	1.73±0.07 x	3.61±0.15 x	63.20±2.09 x	30.42±1.40
	20 %	8.54±0.08 y	1.67±0.04xy	3.02±0.07 y	53.04±1.46 y	29.52±0.69
	24 %	9.49±0.11 x	1.61±0.02y	2.60±0.04 z	46.56±0.53 z	30.95±0.61

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

DISCUSSION

The results of the present study indicate that diet containing 24% protein and supplemented with 1% cysteine is the optimal lvels for striped mullet (*Mugil cephalus*) fry (2.1 g). These results are nearly similar reported by (El-Dahhar *et al.*, 2011). They found that diet containing 28% crude protein is the optimal for striped mullet (*Mugil cephalus*) fry (1.62g) for maximum growth and feed efficiency during nursing period. In another study (El-Dahhar, 2000) stated that 26% dietary protein level was needed for maximum growth and feed efficiency for striped mullet (*Mugil cephalus*) larvae (0.2 g). While, these results are lower than those observed by (El-Sayed and Teshima, 1992) in their previous study, they found that (*Liza ramada*) reared in fresh water require about 35 to 40% dietary crude protein for optimum growth. Moreover, the results obtained by (Mabrouk, 1991) on striped mullet (*Mugil cephalus*) indicated that fingerlings reared in fresh water required 40% dietary crude protein for optimum growth and best performance. On the other side, (Amer, 2000) indicated that 24% dietary protein was the best level for striped mullet fingerlings reared under polyculture system. However, variation in protein requirements in the previous studies may be due to different reasons: fish size, feeding rates, environmental conditions, protein and energy quality and balance between dietary protein and dietary energy in the diet (Lovell, 1989).

Table (4): Body composition (Means ± SE) of striped mullet (*Mugil cephalus*) fed on diets containing different dietary protein and cysteine levels.

	Treatments	Moisture %	Crude protein %	Fat %
non CYS-diets	**16 %**	72.58±0.06	14.52±0.01 cd	9.73±0.12
	20 %	72.42±0.08	14.94±0.14 c	10.04±0.02
	24 %	71.97±0.32	15.72±0.05 b	9.84±0.17
CYS-diets	**16 %**	71.78±0.34	15.26±0.08 bc	9.91±0.30
	20 %	71.69±0.30	15.54±0.01 b	9.69±0.07
	24 %	70.96±0.31	16.20±0.16 a	9.75±0.30
Cystein	**non-CYS.**	72.33±0.07	14.85±0.06 h	9.87±0.09
	CYS.	71.48±0.29	15.67±0.05 g	9.78±0.11
Protein	**16 %**	72.18±0.20	14.89±0.04 y	9.82±0.20
	20 %	72.06±0.18	15.19±0.07 y	9.86±0.03
	24 %	71.47±0.17	15.70±0.06 x	9.79±0.22

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

In the present study, results indicated that there were significant differences in FBW, WG, RGR and SGR among treatments. Fish fed on CYS-diets were significantly (P< 0.05) higher in growth performance than fish fed other diets. These positive effects of cysteine may be due to its effect on nutrient digestibility. Nordrum *et al.* (2000) demonstrated that cysteine influence the digestive processes considerably. The effect may involve both increased enzyme secretion and increased stability. These results are in agreement with those reported by (Abimorad *et al.*, 2009) where pacu (*Piaractus mesopotamicus*) fed plant protein based diets containing 23% dietary protein supplemented with both amino acids (lysine and methionine) or methionine alone showed satisfactory growth and nitrogen retention results when compared with fish fed 30% dietary protein diet only. Also, Gaylord *et al.* (2006) found that taurine supplementation improved growth, feed conversion ratios, protein and energy retention efficiencies of rainbow trout fed at plant protein diets. However, Nguyen (2007) determined that the total sulfur amino acid (TSAA) requirement of juvenile Nile tilapia in semipurified diets was 0.85% of the diet and cysteine could replace up to 49% of methionine requirement based on an equimolar sulfur basis. Kim *et al.* (2003) noted an improvement in growth of Japanese flounder with supplemental taurine up to 1.4% in the diet, which could only be partially compensated by supplemental cysteine. While (Li and Robinson, 1998) found that there were no differences in weight gain between fish fed diets contained 24% protein with or without lysine supplementation. Takeuchi (2007) explained that the effect of dietary supplementation of amino acids on fish is complex, varying with species and growth stages as related to their ability to synthesize it.

In the present study, survival rate at the end of the experimental period was higher with increasing dietary protein level. Also, fish fed CYS-diets were significantly higher in survival rate compared with fish fed non CYS-diets. These results are in accordance with those reported by (El Dahhar *et al.*, 2011) for striped mullet (*Mugil cephalus*) fry. They found that survival rate increased significantly with increasing dietary crude protein from 16 to 28%. Also, Takeuchi (2007) reported that amino acids and their related compounds, peptides and peptide hormones have improving effects on growth and survival of living organisms.

In the present study, results indicated that fish fed CYS-diets improved significantly FCR than fish fed non CYS-diets. This agrees with results of major carp (*Catla catla*) fingerling obtained by (Zehra and Khan, 2013). They found that maximum weight gain, protein efficiency ratio, protein deposition, high carcass protein and best feed conversion ratio were recorded in the fish fed diets supplemented with amino acid (1.75% arginine). Li and Robinson (1998) indicated that feed efficiency of fish fed diet supplemented with lysine was higher than fish fed diet without lysine supplementation. Also, these results confirm with the finding of Hernández *et al.* (2012). They indicated that addition of 1% citric acid and amino acid to a low fishmeal diet enhanced rainbow trout growth. Trosvik *et al.* (2012) in previous study showed that there were no significant differences in final weight, weight gain and specific growth rate between Nile tilapia fry fed control diet containing 20% fishmeal and fry fed diet containing 45% yeast extract and 36% soybean meal with amino acid supplementation (methionine and lysine).

In the present study, values of protein efficiency ratio and protein productive value of striped mullet (*Mugil cephalus*) were affected significantly by different dietary protein levels or cysteine supplementation in fish diets. Fish fed diet containing 20% crude protein with CYS-diets were equal or significantly better than those fed on diet containing 24% crude protein with non CYS-diets. These results indicate that cysteine can spare the dietary crude protein needed for striped mullet. It decreased dietary protein level from 24 to 20% without any significant differences in growth performance or feed efficiency. Moreover, it may be enhanced significantly nutrient utilization. These results are in agreement with what were found by (Hernández *et al.*, 2012) who indicated that addition of 1% citric acid and amino acid to a diet formulated with a low fish meal concentration enhanced rainbow trout growth. Also, Abimorad *et al.* (2009) stated that there were insignificant differences between fish fed diet containing 30% dietary protein and fish fed plant protein based diets containing 23% dietary protein supplemented with both amino acids (lysine and methionine) or methionine alone. On the other side, energy retention results show that, ER% was insignificantly affected by different dietary protein levels or cysteine supplementation in the fish diets. Similar results were obtained by Gaylord *et al.* (2006). They demonstrated that supplementation of the fishmeal diets with taurine had no effect on energy retention efficiencies of rainbow trout.

In the present study, results revealed no significant differences between treatments in fish body fat contents but protein contents increased significantly as protein level of the diets increased and CYS-diets was significantly higher in fish body protein contents than fish fed non CYS-diets. Similar results were obtained by Li and Robinson (1998). They reported that, there were no differences in fillet fat of young channel catfish (*Ictalurus punctatus*) between fish fed diets contained 24% protein with or without supplemental lysine. Also, Zehra and Khan (2013) stated that maximum carcass protein was recorded in the fish fed diets supplemented with 1.75% arginine than other treatments.

CONCLUSION

Amino acids have a wide variety of effects on living organisms, their effects and mechanisms have not been completely clarified to date. The results of the present work indicates that growth performance, survival rate and the feed utilization of striped mullet (*Mugil cephalus*) fry can be improved by using the potentially positive effects of balancing fish diets containing 24% crude protein supplemented with 1% cysteine level. Moreover, using of individual amino acid availability values would improve the ability to formulate nutritious least cost diets for fish. Further research progress in this field (utilize the amino acids as direct supplements) can be expected.

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