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Original Article

Effect of dietary supplementation of Yeast, Garlic and Enzymes on growth performance and economic evaluation in European Eel (*Anguilla anguilla*) fry

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ABSTRACT

This study was conducted to investigate the effect of feeding three commercial feed additives Tonilisat® (Saccharomyces cerevisiae), Garlin® (26% allicin), Enziver® (Multi-enzymes) and different mixtures of them on growth performance, feed utilization, body composition and cost benefit of European eel (Anguilla anguilla) fry. A total of 160 European eel fry (3.0±0.2 g/fish) were divided into 8 groups (10 fish/tank in two replicates) for 120 days. Eight dietary treatments were conducted as follow: the first diet considered to be the control without any additives. The second and third diets contain 0.2% of Tonilisat® and Garlin®, respectively. The fourth diet contains 0.1% of Enziver®, The fifth diet contains a mixture of 0.1% Tonilisat® with 0.1% Garlin®, the sixth diet contains a mixture of 0.1% e Tonilisat® with 0.05% Enziver®, the seventh diet contains a mixture of 0.1% Garlin® with 0.05% Enziver®, and the eighth diet contains a mixture of 0.1% Tonilisat® , 0.1% Garlin® and 0.05% Enziver®, respectively. The obtained results indicated that growth performance, feed conversion ratio and nutrient utilization were significantly improved in eels fed diet supplemented with multi-enzymes and different mixtures of feed additives. The survival rate (%) and whole body proximate composition didn't differ significantly among different experimental groups. Meanwhile, the profit index improved significantly with multi-enzyme supplementation and the combinations of yeast, garlic and multi-enzyme increased diets benfits. Therefore, it's reasonable to incorporate exogenous multi-enzymes or combination of yeast, garlic and multi-enzyme in the diets of European eels.

Keyword: Feed additives, Eel (Anguilla anguilla), Growth performance, feed utilization, economic evaluation.
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1. INTRODUCTION

Eel are migrant fish found in marine, brackish and fresh waters worldwide (Nandlal, 2005). Eels classified as tropical and subtropical fish, and it includes 19 species distributed throughout the world (Arai, 2014). Four eel species are commercially important such as European eel (*Anguilla anguilla*), Asian eel, (*A. japonica*), North American eel, (*A. rostrata*) and Australian eel (*A. australis*).

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The European eel, *A. Anguilla*, has long been an important economic resource for fishermen in the Atlantic and Mediterranean coasts (Melia et al., 2006). Meanwhile, in East-Asian countries more than 90% of Anguilla production is based on eel farming, which requires wild-caught glass eels for stocking, as the captive reproduction and raising of larvae to glass eel stage is not commercially viable yet (Shiraishi and Crook, 2015). The eels farming going to grow from extensive to intensive culture in several regions of the world (Genç et al., 2005). Whereas, may much attention for culturing fish with high global market has been paid off. In Egypt, *A. anguilla* is one of the most important and valuable commercial species with a wide market and great customer appeal. *A. anguilla* is distributing along the Nile river specially the north Delta region and costal lagoons (Hamza, 1996*)*. Eels farms will be success in Egypt because of the Egyptian climate is very suitable for eels farming and the production cost in Egypt is lower than the main producer countries (Hamza, 1996). Whereas, the total Egyptian production of eels increased from 466 tons in 2004 to 636 tons in 2017. However, the aquaculture contributes by 5.80% of this production (GAFRD, 2018). Moreover, the Egyptian aquaculture is concentrated on inland farms with the main species culture being tilapia and mullets. Due to the high productivity of the typical culture species which in turn led to an oversupply of the two species with a consequent decline in market prices. Hence, there is interest to investigate new species amenable for culture under the existing conditions as a strategy for diversifying marketing opportunities for the cultured species in local and global markets, thus will be increase eel production (El Shebly et al., 2007).

Eels fish rearing have many management problems as acceptance of artificial feed, feed costs (Ghonimy, 2013), escaping behavior and high mortality rate occurs during the weaning to an artificial diet, whereas survival rate to marketable size is only 25-40 % (Larkin, 2000). The commercialization of eel aquaculture still need more study especially the feeding cost, which constitutes 30-70% of total expenditure in fish culture and for this reason, different methods have been essayed to gain benefit from every kind of feed source especially in the developed countries (Yildirim et al., 1999). The overall goal of the aquaculture is to maximize production, increase profitability and reduce production costs (Yildirim et al., 1999). The increasing of commercial aquaculture intensification, encourage the invention of many products as feed additives (microbes, animals, plants and chemicals origin) for aquaculture with varying success rate. Yeast is one of the most used probiotic feed additive in the animal nutrition. It could be improved growth performance and diet utilization (Li and Gatlin, 2003, Abdel-Tawwab et al.,2008, Zhao et al., 2017, Abdel-Aziz et al., 2020 and 2021) antioxidant system and stimulate the immune response (Ortuño et al., 2002); Choudhury et al., 2005 and Vetvicka et al., 2013) of several fish species. Garlic (*Allium sativum*) has had an important dietary and medicinal role for centuries and has long been known to have broad antibacterial properties (Guo et al., 2012). Garlic (*Allium sativum*) also has been reported to produce various beneficial effects, including anti-stress protection, growth promotion, appetite stimulation, immuno-stimulation and anti-microbial properties in finfish and shrimp larvae culture (Aly et al., 2010, Guo et al., 2011 and Millet et al., 2011).

Moreover, the exogenous enzyme supplementation to fish diet specially in larval stage or with plant-based protein diets becomes common practice (Kolkovski et al., 1993, Farhangi and Carter 2007 and Cao et al., 2007). Enzymes supplementation enhance the nutritional value of fish diet via transforming the complex components to absorbable nutrients (Soltan, 2009). They can improve fish growth, feed intake, feed and nutrients utilization and reduce the cost of fish production and the release of nutrients to the environment (Kolkovski et al., 1993, Debnath et al., 2005, Farhangi and Carter 2007 and Dawood et al., 2014). However, the available literature regarding the application of feed additives in eel culture is very rare. Therefore, this study was conducted to determine the effect of feeding three commercial feed additives Tonilisat®, Garlin®, Enziver® and different mixtures of them on growth performance, feed utilization, body composition and cost benefit of European Eel (*A. anguilla*) fry.

2. Materials and Methods

2.1. Experimental fish and culture technique:

The study was carried out at privet fish farm, Kafr El-Sheikh Governorate in cooperation with the Department of Fish and Animal Production at Faculty of Agriculture (Saba Basha), Alexandria University. A total of 160 *A. anguila* fry (3.0±0.2 g/fish) were obtained from Brollos Lake, Kafr El-Sheikh governorate. The fish caught were transported in a small bucket (30 L capacity) to circular plastic tanks filled with freshwater. The transport acclimation was done immediately after arrival to fish farm by adding water gradually to the buckets contained the caught fish, in order to acclimate it to rearing water temperature. Then eels were acclimated to rearing condition for two weeks prior to start the experiment. The fish was randomly assigned to sixteen plastic tanks (0.2 m^3 water capacity) to represent the eight treatments each in duplicate. The tanks were covered with nylon net (1 mm mesh). Experimental fish were reared in fresh water at a temperature (27±1º C), pH (8.5±0.2), dissolved oxygen (6 ppm) and a photoperiod of 12 H light: 12 H dark. Water was changed daily at the rate of 25% of the total volume before the first feeding.

2.2. Experimental diets and feeding regime:

Eight isonitrogenous 47% protein and isocaloric 502.26 kcal/100gm energy experimental diets were formulated as the following: The first diet without any additives (D_1, control diet). The rest of the seven diets are the basil control diet supplemented with the various feed additives as follow: The second diet contains 0.2% of Tonilisat® (D_2), the third diet contains 0.2% of Garlin® (D_3), the fourth diet contains 0.1% of Enziver® (D_4), The fifth diet contains a mixture of 0.1% Tonilisat® with 0.1% Garlin® (D_5), the sixth diet contains a mixture of 0.1% Tonilisat® with 0.05% Enziver® (D_6), the seventh diet contains a mixture of 0.1% Garlin® with 0.05% Enziver® (D_7), and the eighth diet contains a mixture of 0.1% Tonilisat® , 0.1% Garlin® and 0.05% Enziver® , respectively (D_8). The experimental diets were prepared by grinding all the ingredients, mixed with vitamins and minerals before adding the respect feed additive dissolved in oil. Warm water (40°C) was added slowly until the diets began clumping. The resultant dough was placed in plastic pages and store frozen at - 20°C until use.

Fish were fed the experimental diets at (6% of their live body weight) at two times a day (10.00 a.m. and 3.00 p.m.) in six days a week. Fish were weighted at every month intervals and feed amounts were adjusted on the basis of live fish weight.

Table (1): Formulation and proximate composition of basal diet diets (% on DM basis).

Ingredients	%
Fish meal (67%)	50
Soybean meal (47%)	18
Yellow corn	10
Wheat bran	10
Corn oil	5
Fish oil	5
Vitamin & Mineral mix.[1]	2
Proximate composition (%) on DM[2] basis	
Moisture	10.99
Crude Protein	47.1
Ether extract	15.3
Crude fiber	8.95
Ash	6.37
NFE[3]	22.28
GE kcal/100g[4]	502.26
P/E ratio[5]	93.89

[1]Vitamin and mineral mixture each kg contains: 4800 I.U. Vit. A, 2400 IU cholecalciferol (Vit. D), 40 g Vit. E, 8 g Vit. K,4.0 g Vit. B12, 4.0 g Vit. B2, 6 g Vit. B6, 4.0 g Pantothenic acid, 8.0 g Nicotinic acid, 400 mg Folic acid, 20 mg Biotin, 200 gm Choline, 4 g Copper, 0.4 g Iodine, 12 g Iron, 22 g Manganese, 22 g Zinc, 0.04 g Selenium. Folic acid, 1.2 mg; niacin, 12 mg; d-calcium pantothenate, 26 mg; pyridoxine. HCl, 6 mg; riboflavin, 7.2 mg; thiamin. HCl, 1.2 mg; sodium chloride (NaCl, 39% Na, 61% Cl), 3077 mg; ferrous sulfate ($FeSO_4 \cdot 7H_2O$, 20% Fe), 65 mg; manganese sulfate ($MnSO_4$, 36% Mn), 89 mg; zinc sulfate ($ZnSO_4 \cdot 7H_2O$, 40% Zn), 150 mg; copper sulfate ($CuSO_4 \cdot 5H_2O$, 25% Cu), 28 mg; potassium iodide (KI, 24% K, 76% I), 11 mg; Celite AW521 (acid-washed diatomaceous earth silica), 1000 mg.
[2]DM: dry matter.
[3]NFE: Nitrogen free extract
[4]GE= Gross energy (kcal/100g DM): Calculated using gross calorific values of 5.65, 9.45 and 4.11 kcal/100g for protein, fat and carbohydrate, respectively NRC, 1993).
[5]P/E ratio: Protein to energy ratio = mg crude protein/Kcal GE.

2.3.Feed additive composition:

1. Tonilisat®: Active live yeast, *Saccharomyces cerevisiae*, contain 8 × 10^9 cells/gram (China Way Corporation, Taiwan).
2. Garlin®: Garlic contains 26% allicin loaded on white silica and starch as a carrier in powder form (Jinan Tiantianxiang Co., Ltd., China).
3. Enziver®: Exogenous multi-enzymes contain phytase (1000 FTU), xylanase (5000 IU), amylase (7500 IU), pectinase (900 IU), protease (5500 IU), glucanase (800 IU), cellulase (10000 IU) (Zoetis Philippines, Inc., Philippines).

2.4.Measured parameters:

Growth performance:

Mean final body weight (FBW) of each experimental treatment was determined by dividing total fish weight in each tank by the number of fish. Weight gain (WG), specific growth rate (SGR%), Average daily gain (ADG) and survival rate (%) were determined as follow:

Body weight gain (g/fish): BWG = $W_2 – W_1$.

Where; W_1: Initial weight of fish in grams and W_2: Final weight of fish in grams.

Average daily gain (g/fish/day): ADG = $W_2 - W_1$/days. Where; W_1: Initial weight of fish in grams; W_2: Final weight of fish in grams, and n=days.

Specific growth rate (%/day): SGR = 100 × (ln W_2 - ln W_1)/days. Where; ln is the natural log.

Survival rate (%) = 100 × (final number of fish/initial number of fish).

Feed and nutrient utilization:

Feed intake (g/kg fish) was determined by dividing total feed intake by fish number after exclusion of the part eaten feed by dead fish. Feed conversion ratio (FCR), protein efficiency ratio (PER), protein productive value (PPV), fat retention (FR) and energy retention (ER) were calculated by using the following equations:

FCR = feed intake (g)/weight gain (g).

PER = weight gain (g)/protein intake (g).

PPV (%) = protein gain (g)/protein intake (g) × 100.

Energy utilization (EU %) = 100 × (E_T - E_I)/ Energy intake (kcal)

Where: E_T: Energy in fish carcass (kcal) at the end and E_I: Energy in fish carcass at the start.

2.5.Diets and whole body proximate chemical composition:

The chemical composition of fish and diet samples were assessed according to procedures of (AOAC 2010). Dry matter was determined after drying the samples in an oven (105°C) for 24 h. Ash was measured following incineration at 550°C for 12 h. Crude protein was determined by the micro-Kjeldhal method, with N% × 6.25 (using a Kjeltech autoanalyzer, Model VELP Scientifica, UDK 127), and crude fat was assessed by Soxhlet extraction (Model VELP Scientifica, SER 148) with diethyl ether (40-60°C). Crude fiber was determined after 5% sulfuric acid and 5% sodium hydroxide digestion for 15 min. then the residues dried and ashed. Nitrogen free extract calculated using the following equation: NFE = 100- (crude protein + ether extract + crude fiber + ash). Table (1).

2.6. Economic evaluation:

Economic evaluation of the experimental diets has been calculated by evaluating the feed cost in Egyptian pound (LE) needed to produce 1 kg of live weight of fish.

Feed costs/kg weight gain (Incidence cost) = FCR × costs of kg feed.

Profit index = value of fish /cost of feed consumed

2.7.Statistical analysis:

Data were expressed as mean ± SE values. The data were analyzed by one-way analysis of variance (ANOVA) followed by TUKEY test multiple comparison tests for the means ($P < 0.05$). Statistical analyses were performed using Rapid publication-ready MS-Word tables for one-way ANOVA (Assaad et al., 2014).

3. RESULTS

3.1.Growth performance and survival:

The growth performance parameters and survival (%) of European eel (*A. anguilla*) fry which fed on diets supplemented with different feed additives of yeast, garlic and multi-enzymes are shown in Table (2). The results showed that the growth performance (FBW, gain, ADG and SGR) of eel fed diets supplemented with multi-enzymes (D_4) and the combination of garlic and multi-enzymes (D_7) or yeast, garlic and multi-enzymes (D_8) significantly increased than fish fed the control diet (non-supplemented diets). Whereas, the final weight of these treatments outperforms the control group by 14%, 21% and 30%, respectively. The survival rate (%) in the present study ranged between 55-60%

without any significant differences among different groups.Moreover, the total length was increased significantly with enzyme mixture supplementation (D_4) and different combinations of enzyme, garlic and yeast (D_5-D_8) than the control and other treatments (Table,3). Meanwhile, conditionfactor increased significantly with diet supplemented the mixture of the three supplementations (D_8: enzyme, garlic and yeast) than other experimental diets (Table, 3).

Table (2): Effect of dietary supplementation of yeast, garlic and enzymes on growth performance and survival (%) European eel (*Anguilla anguilla*) fry.

Items[1]	Experimental diets[2]							
	D_1	**D_2**	**D_3**	**D_4**	**D_5**	**D_6**	**D_7**	**D_8**
IBW (g/fish)	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005	3.01 ± 0.005
FBW (g/fish)	4.86^{de} ± 0.042	4.78^{e} ± 0.005	4.70^{e} ± 0.209	5.45^{bc} ± 0.079	5.38^{bcd} ± 0.105	5.22^{ce} ± 0.0165	5.88^{ab} ± 0.0685	6.33^{a} ± 0.108
BWG (g/fish)	1.84^{de} ± 0.037	1.76^{e} ± 0.01	1.68^{e} ± 0.214	2.43^{bc} ± 0.084	2.36^{bcd} ± 0.10	2.2^{ce} ± 0.0215	2.87^{ab} ± 0.0735	3.31^{a} ± 0.113
ADG (g/fish/day)	0.015^{de} ± 0.0003	0.015^{e} ± 0.0001	0.014^{e} ± 0.002	0.02^{bc} ± 0.0001	0.02^{bcd} ± 0.0008	0.02^{ce} ± 0.0002	0.024^{ab} ± 0.0006	0.03^{a} ± 0.0009
SGR (%/day)	0.397^{de} ± 0.006	0.383^{e} ± 0.0023	0.369^{e} ± 0.04	0.493^{bc} ± 0.014	0.482^{bcd} ± 0.015	0.457^{ce} ± 0.004	0.557^{ab} ± 0.01	0.618^{a} ± 0.016
Survival (%)	60 ± 0.00	55 ± 5.00	55 ± 5.00	55 ± 5.00	60 ± 0.00	60 ± 0.00	60 ± 0.00	60 ± 0.00

Means in the same row without a common superscript letter differ significantly ($P < 0.05$).

[1] IBW: initial body weight, FBW: final body weight, BWG: body weight gain, ADG: average daily gain, SGR: specific growth rate.

[2]D_1: control diet; D_2: supplemented with 0.20% of Tonilisat®; D_3: supplemented with 0.20% of Garlin®; D_4: supplemented with 0.1% of Enziver®; D_5: supplemented with mixture of 0.1% of Tonilisat® with 0.1% of Garlin®; D_6: supplemented with mixture of 0.1% of the Tonilisat® with 0.05% of Enziver®; D^7: supplemented with 0.1% of Garlin® with 0.05% of Enziver®; D_8: supplemented with mixture of 0.1% of Tonilisat® with 0.1% of Garlin® with 0.05% of Enziver® (D_8).

Table (3): Effect of dietary supplementation of yeast, garlic and enzymes on length and condition factor European eel (*Anguilla anguilla*) fry.

Items	Experimental diets							
	D1	D_2	**D_3**	**D_4**	**D_5**	**D_6**	**D_7**	**D_8**
Initial length (cm/fish)	12.73 ± 0.18	12.44 ± 0.45	12.06 ± 0.17	12.17 ± 0.05	12.11 ± 0.24	12.05 ± 0.27	12.68 ±0.23	12.80 ± 0.10
Final length (cm/fish)	14.05^{d} ± 0.05	14.10^{d} ± 0.00	14.00^{d} ± 0.10	14.45^{c} ± 0.05	14.40^{c} ± 0.10	14.30^{c} ±0.00	14.85^{b} ±0.05	15.15^{a} ± 0.05
Length gain (cm/fish)	1.33 ± 0.13	1.67 ± 0.45	1.94 ± 0.07	2.28 ± 0.10	2.30 ± 0.14	2.25 ± 0.27	2.18 ±0.18	2.35 ± 0.15
Condition Factor (K value)	0.18^{b} ± 0.00	0.17^{b} ± 0.00	0.18^{b} ± 0.00	0.18^{b} ± 0.00	0.18^{b} ± 0.00	0.18^{b} ± 0.00	0.18^{b} ±0.00	0.20^{a} ±0.01

Means in the same row without a common superscript letter differ significantly ($P < 0.05$).

3.2.Feed and nutrient utilization:

Results of feed and nutrient utilization in terms of feed intake, FCR, PER, PPV and EU of fish fed diets supplemented with different feed additives were presented in Table (4). The results indicated that feed intake was significantly increased with different combinations of feed additives (D_6-D_8) which reflect the increasing of diet acceptability. Moreover, feed additives (yeast, garlic and enzyme) exhibited a significant effect on all estimated feed and nutrient utilization traits. The FCR and PER were significantly improved with enzyme mixture supplementation (D_4) and the different combination of yeast and garlic (D_5) garlic and enzyme (D_7) or yeast, garlic and multi-enzymes (D_8). Furthermore, the PPV, energy gain and energy utilization were significantly increased with the combination of the three additives (D_8; yeast, garlic and multi-enzymes) compared to the control and other supplemented diets.

Table (4): Effect of dietary supplementation of yeast, garlic and enzymes on feed and nutrients utilization of European eel (*Anguilla anguilla*) fry.

Items	Experimental diets							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
FI (gm/fish)	11.59^{b} ± 0.19	12.56^{a} ± 0.55	11.48^{b} ± 0.30	12.33^{ab} ± 0.41	12.18^{ab} ± 0.01	12.78^{a} ± 0.11	12.74^{a} ± 0.02	13.17^{a} ± 0.13
FCR (g)	6.19^{ab} ± 0.09	6.88^{a} ± 0.39	6.70^{a} ± 1.16	4.97^{cde} ± 0.04	4.97^{cde} ± 0.13	5.71^{abc} ± 0.07	4.38^{cd} ± 0.09	3.54^{d} ± 0.03
PER (g)	0.35^{c} ± 0.00	0.31^{c} ± 0.02	0.33^{c} ± 0.06	0.43^{ab} ± 0.01	0.43^{ab} ± 0.01	0.38^{bc} ± 0.01	0.49^{b} ± 0.01	0.60^{a} ± 0.01
PPV (%)	6.07^{bcde} ±0.53	4.29^{e} ± 0.25	5.12^{de} ± 0.81	7.31^{bc} ± 0.53	7.11^{bcd} ± 0.19	5.76^{cde} ± 1.23	8.13^{ab}± 0.04	9.88^{a} ± 0.44
EU (%)	5.96^{bcde} ± 0.45	4.45^{d} ± 0.26	5.18^{cd} ± 0.65	6.88^{bc} ± 0.35	6.60^{bcd} ± 0.14	5.51^{cde} ± 0.92	7.50^{b} ± 0.06	9.21^{a} ± 0.23

Means in the same row without a common superscript letter differ significantly ($P < 0.05$).

FI: feed intake; FCR: feed conversion ratio; PER: protein efficiency ratio; PPV: protein productive value, EU: Energy utilization.

3.3. Whole body composition:

Whole body compositions of European eel at the end of the feeding trial are presented in Table (5). The proximate composition of fish body for all fish groups fed supplemented diets with yeast, garlic and multi-enzymes revealed that no significantly ($P > 0.05$) differences were observed in dry matter, protein, total lipid and ash contents among all treatments.

Table (5): Effect of dietary supplementation of yeast, garlic and enzymes on whole-body proximate chemical composition (on a wet weight basis) of European eel (*Anguilla anguilla*) fry.

Items	Experimental diets							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Dry matter (%)	27.70 ± 1.04	25.70 ± 0.01	26.80 ± 0.39	27.00 ± 0.72	26.70 ± 0.01	26.20 ± 2.09	26.70 ± 0.41	26.30 ± 0.25
Protein (%)	19.50 ± 0.71	18.00 ± 0.02	18.70 ± 0.27	19.00 ± 0.52	18.80 ± 0.01	18.40 ± 1.53	18.70 ± 0.23	18.30 ± 0.32
Lipid (%)	6.47 ± 0.23	6.10 ± 0.024	6.30± 0.122	6.29 ± 0.046	6.20 ± 0.028	6.09 ± 0.39	6.28 ± 0.11	6.23 ± 0.01
Ash (%)	1.76 ± 0.11	1.56 ± 0.01	1.79 ± 0.02	1.76 ± 0.16	1.73 ± 0.02	1.76 ± 0.17	1.78 ± 0.08	1.73 ± 0.06
Carcass energy (Kcal/100gm)	617.11± 1.03	620.04 ±0.67	615.65 ±1.37	615.84 ±4.01	615.88 ±0.75	614.42 ±2.13	615.86 ±1.00	617.0± 0.56

Means in the same row without a common superscript letter differ significantly ($P < 0.05$).

3.4. Economic evaluation

Calculations of economic efficiency of the testeddiets based on the cost of feed, costs of one Kg gain in weight and its ratio with the control group are shown in Table (6). The results showed that feed cost per kg gain (L.E) significantly decreased with the combination of garlic and enzyme (D_7) and yeast, garlic and enzyme (D_8). Meanwhile, the profit index improved significantly with enzyme supplementation (D_4) and the combination of yeast and garlic (D_5), garlic and enzyme (D_7), and yeast garlic and enzyme (D_8).

Table (6): Effect of dietary supplementation of yeast, garlic and enzymes on cost-profit analysis of European eel (*Anguilla anguilla*) fry.

Items	Experimental diets							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
Cost (L.E/kg diet)[1]	16.59	16.59	16.69	16.69	16.75	16.72	16.72	16.74
FCR	6.185	6.875	6.695	4.965	4.97	5.71	4.38	3.535
Feed cost / Kg gain	102.62	114.73	112.06	83.03	83.17	95.42	73.35	59.42
Relative to control	100.00	111.80	109.21	80.91	81.05	83.17	65.46	71.56
Changes in feed cost / kg gain	0.00	-11.80	-9.21	19.09	18.95	16.83	34.54	28.44
Fish price (L.E / kg diet)	120	120	120	120	120	120	120	120
Profit index	1.17	1.05	1.10	1.45	1.44	1.26	1.64	2.02
Changes in profit index	0.00	-27.50	-25.37	6.650	6.44	7.69	22.95	55.76

[1]Cost of 1 kg ingredients used were 23 L.E for fish meal, 6.25 L.E for soybean meal, 3.50 L.E for yellow corn, 3.50 L.E for wheat bran,14 L.E for oil, 8 L.E for Vit. and Min., 45 L.E for yeast, 55 L.E for garlic powder and 120 L.E enzymes. Egypt Feed Ingredients Price at the start of 2016.

4. Discussion

The feeding of eel on artificial diets is the bottleneck of these species culture. Whereas, glass eels started a fasting stage during metamorphosis from *leptocephalus* larvae to glass eel, then started to be fed on small prey including copepods, *polychaetes* (bristle worms), oligochaetes (smooth worms), amphipods and aquatic insect larvae (Anon, 2000). After catching the adaptation of eels to artificial diets is a challenge and cause high mortality (Larkin, 2000). Moreover, as eel a carnivore fish with protein requirement ranged between (45 and 47 %) (Satoh, 2002), the feeding cost is very expensive which sharply affect the total production cost (Watene, 2003). Therefore, the improvement of growth and feed utilization is a prime of importance to reduce production cost and more commercialize the culture of these species. The results of the present study revealed that growth performance and feed utilization of eels fed diets supplemented with exogenous multi-enzymes or the different combinations of yeast, garlic and multi-enzymes significantly higher than the control group. In accordance, Yildirim and Turan (2010) reported that African Catfish, *Clarias gariepinus*, fed diets supplemented with exogenous enzyme (containing fungal xylanase, β-glucanase, pentosonase, β-amilase, fungal β-glucanase, hemicellulase, pectinase, cellulase, cellubiase) had significantly higher growth rate, FCR, PER and PPV in dose dependent manner without any changes in survival rate. Moreover, presence of pancreatic digestive enzyme in the micro-diet of sea bream, *Sparus auratus*, enhanced its assimilability by 30% (Kolkovski et al., 1993). Also, Dawood et al. (2014) reported that exogenous digestive enzymes improved growth, feed utilization of rabbitfish, *Siganus rivulatus*.

The positive effects of exogenous enzymes may be attributed to the stimulation of own animal production such as amylases, proteases and lipases to improve the digestion of starch, protein and lipid, respectively (Lin et al., 2007 and Zhou et al., 2009). Also, Enzymes supplementation enhances the nutritional value of fish diet via transforming the complex components to absorbable nutrients (Soltan, 2009). Moreover, there are synergistic effects of yeast, garlic and multi-enzymes supplementation on growth and feed utilization. These findings are in agreement with Tewary and Patra (2011) who found a superior growth performance in terms of weight gain percentage and SGR in *Labeo rohita* fed dietary supplemented with 5% *S. cerevisiae* compared to the control group. Tolan, (2006) reported that increasing total gain of Nile tilapia, *Oreochromis niloticus* by increasing level of dry yeast supplementation from 1 up to 3 g/kg diet. Moreover, Diab et al. (2002) stated that dietary dried yeast fed for Nile tilapia, *O. niloticus* from 1% up to 5% recorded high average body weight compared to fish fed the control group (without yeast). The utilization of dried yeast may effectively improve growth (Craig *et al.*, 2006) and non-specific immune responses (Paulsen et al., 2003) in a variety of fish species. In the line with the obtained results, Abdel-Tawwab et al. (2008) showed that yeast supplementation improved FCR and increased feed utilization of Nile tilapia, *O. niloticus*. Also, Lara-Flores et al. (2003) supported these results where the authors demonstrated that yeast is an appropriate growth-stimulating additive in *O. niloticus* practical diet. The better growth performance with yeast supplemented diets may be due to the improvement of nutrients digestibility (De-Schrijver and Ollevier, 2000 and El-Dakar et al., 2007) and accelerate the digestive system maturation (Waché et al., 2006). Also, Tovar-Ramirez et al. (2002) recorded an increase in the digestive enzyme activities of amylase, trypsin and lipase in seabass (*Dicentrachus labrax*) using live yeast. Moreover, yeast reduce the presence of potentially pathogenic bacteria by competitive exclusion and causes intestinal microbial balance of the host organism and confer various beneficial effects include immunostimulation and enhance disease resistance, and antioxidant system (Gatlin et al. 2006, Ortuño et al. 2002, Choudhury et al. 2005 and Vetvicka et al. 2013). Buts et al. (1994) reported that yeast may release spermine and spermidine in the digestive tract, which playing fundamental role in proliferating, fast growth and regenerating tissue (Peulen et al., 2002). It is therefore possible that spermine and spermidine production by yeasts may explain at least partly the effect observed on fish growth and feed utilization. Regarding the improving effects of garlic co-supplementation with yeast and multi-enzymes on growth and feed utilization. The present results agree with the findings of Sasmal et al. (2005) who found that weight gain and FCR of *Carassius auratus* improved significantly with feeding diet supplemented with 1 g garlic/100 g feed. Moreover, Guo et al. (2012) showed a significant increase in weight gain and feed efficiency in grouper fed supplemented diets with 1.3 garlic powder. Similarly, Diab et al. (2008) reported a significantly increased in weight gain of Nile tilapia (*O. niloticus*) after feeding with a 1% garlic. Shalaby et al., (2006) and Yones et al, (2019) also demonstrated that dietary 3% garlic powder enhanced growth, feed intake, SGR, FCR and PER in Nile tilapia. High growth and digestibility were also observed in tilapia fed for 60 days with a diet containing garlic (Xie et al., 2009).

Furthermore, Nya and Austin (2009) reported that growth, FCR and PER of rainbow trout (*Oncorhynchus mykiss*) enhanced via feeding diets containing 0.5 and 1.0% garlic powder.

Beneficial health properties of garlic are attributed to organosulphur compounds, particularly allicin, which an important criterion for evaluating the quality of commercial garlic varieties (Rose *et al.*, 2005). The biological activity of these agents was attributed to either antioxidant activity or thiol-disulfide exchange Rabinkov *et al.* (1998). Moreover, Nya et al. (2010) reported that the mode of action of allicin may well include the inhibition of cysteine protease, the scavenging, and trapping of free radicals (hydroxyl, superoxide anions and hydrogen peroxide) and the initiation of the inhibition of thiol-containing protein in the cells of pathogens. The survival percent ranged between 55-60% in the present study which is higher than the recorded percent of 25-40% during weaning to an artificial diet of European eel (Larkin, 2000). However, the effect of individual supplementation of yeast and garlic didn't t show any improvement in growth performance and feed utilization. This may be in contrast to the most available literature in other species [Abdel-Tawwab et al. (2008); Lara-Flores et al. (2003); De-Schrijver and Ollevier, 2000); Gatlin et al., 2006); Sasmal et al., (2005); Guo et al., (2012); Diab et al. (2002); Diab et al. (2008) and Shalaby et al. (2006)]. These differences may be related to the low level of garlic supplementation in the present study or the ability of yeast to colonize the intestinal wall of eels. However, there are lacks of information on this species of fish. More investigations should be conducted for more explanation of the microbial colonization in eels gut and the physiological changes caused by different feed additives. The whole-body proximate chemical composition of different treated groups didn't differ significantly with different dietary supplementations (yeast, garlic and multi-enzymes) in the present study. In accordance, Zehra and Khan (2016) reported that the crude protein of rainbow trout flesh didn't differ with increasing supplementation of yeast RNA extract. Similarly, Li et al. (2007) showed that supplementing diets of red drum, *Sciaenops ocellatus,* juvenile with a yeast purified nucleotide mixture have insignificant effect on body composition. Also, Lara-Flores *et al.* (2003); EL-Haroun *et al.* (2006) and Ghosh et al. (2008) reported that probiotics supplementation couldn’t significantly affect the body composition of different fish species and do not affect strongly tissue synthesis. Moreover, Diab *et al.* (2002) didn't found significant changes in fish body composition caused by different garlic levels. Abdelhamid et al. (2002) and Khattab et al. (2004), they found that inclusion of Biogen® in the diet increased fish protein content.

On the other hand, protein content was increased in African catfish fed diet supplemented with 0.75 g/kg enzyme complex (Yildirim and Turan, 2010). Also, (Oz´orio, et al., 2012) reported that the body composition of tilapia was affected by supplementing the diet with yeast; hence there was a reduction in body protein. In addition, the effects of administration of probiotic (*Bacillus subtilis*) in the diet on body composition showed that this probiotic improved the fat content of the carcass (Ghosh et al. 2008).

The economic benefit of using yeast, garlic and multi-enzymes supplementation in individual form or in combination clearly showed that the combination of these feed additives reduced the cost of production for one kg fish weight gain and increase the profit index by 55.76% when the eels fed the three additives at the same time compared to the control. These findings agree with Dawood et al. (2014) who reported that exogenous digestive enzymes supplementation improve the economic benefit of rabbitfish, *Siganus rivulatus*, production. El-Haroun et al. (2006) reported an increase of profit index of Nile tilapia fed diets supplemented with probiotic (biogin®) in dose dependent manner. Also, El-Dakar et al. (2007) reported that dietary probiotic/prebiotic appears to reduce feed cost per unit growth of Spinefoot rabbitfish, *Siganus rivulatus.*

5. CONCLUSION

In conclusion the present research revealed that dietary supplements of different feed additives (yeast, garlic and enzyme) in combinations improved growth performance and feed utilization of European eel, *A. anguilla*, fry. However, exogenous multi-enzymes is the only feed additive significantly improved the performance of European eel compared to yeast, garlic and the control group. Also, the co-supplementation of the three feed additives can reduce feed cost per unit growth of European eel.

REFERENCES

Abdel-Aziz, M., Bessat, M., Fadel, A., & Elblehi, S. 2020. Responses of dietary supplementation of probiotic effective microorganisms (EMs) in *Oreochromis niloticus* on growth, hematological, intestinal histopathological, and antiparasitic activities. Aquaculture International, 28(3), 947-963.

Abdel-Aziz, M.F., Abdel-Tawwab Y A., Sadek, M.F. and Yones, A.M. 2021. Evaluation of use effective microorganisms (EM) with different feeding strategies on growth performance, body composition and economic efficiency of mono sex Nile tilapia *Oreochromis niloticus* Juveniles. Aquatic living resources.34. 10.1051/alr/2021021

Abdelhamid, A.M., Khalil, F.F.M., El-Barbary, M.I., Zaki, V.H. & Husien, H.S., 2002. Feeding Nile tilapia Biogen to detoxify aflatoxin diets. In Proceeding of the 1st annual scientific conference of animal and fish production. Mansoura. Pp 208-230.

Abdel-Tawwab, M., Abdel-Rahman, A.M. & Ismael, N.E. 2008. Evaluation of commercial live bakers' yeast, *Saccharomyces cerevisiae* as a growth and immunity promoter for Fry Nile tilapia, *Oreochromis niloticus* (L.) challenged in situ with*Aeromonashydrophila*. Aquaculture, 280(1): 185-189.

Aly, S.M., El Naggar, G.O., Mohamed, M.F. & Mohamed, W.E., 2010. Effect of garlic, echinacea, organic green and vet-yeast on survival, weight gain, and bacterial challenge of overwintered Nile tilapia fry (*Orechromis niloticus*). Journal of Applied Aquaculture, 22:210-215.

Anon, C., 2000. Best practice guidelines for Australian short finned glass eel fishing and aquaculture. Marine and Freshwater Resources Institute, Australia.

O.A.C. 2010. (Official methods of analysis of International agricultural chemicals). Contaminants drugs/edited by William Horwitz. Gaithersburg (Maryland).

Arai, T. 2014. Do we protect freshwater eels or do we drive them to extinction? *SpringerPlus*, *3*(1): 534.

Assaad, H., Zhou, L., Carroll, R.J. & Wu, G., 2014. Rapid publication-ready MS-Word tables for one-way ANOVA. Springer Plus 3: 474.

Buts, J.P., Keser N. & Raedemaeker, L., 1994. *Saccharomyces boulardii* enhance rat intestinal enzyme expression by endoluminal release of polyamines. Pediatric Research, 36: 522-527.

Cao, L., Wang, W., Yang, C., Yang, Y., Diana, J., Yakupitiyage, A. & Luo, Z., Li, D., 2007. Application of microbial phytase in fish feed. Enzyme and Microbial Technology. 40(4): 497-507.

Choudhury, D., Pal, A.K., Sahu, N.P., Kumar, S., Das, S.S. & Mukherjee, S.C., 2005. Dietary yeast RNA supplementation reduces mortality by *Aeromonas hydrophila* in rohu (*Labeo rohita* L.) juveniles. Fish and Shellfish Immunology, 19(3): 281-291.

Craig, S.R. & McLean, E., 2006. Nutrigenomics in aquaculture research: A key in the Aquanomic revolution. In Nutritional Biotechnology in the Food and Feed Industry; Jacques, K., Lyons, P., Eds.; Nottingham University Press: Nottingham, UK.

Dawood, M.A., El-Dakar, A., Mohsen, M., Abdelraouf, E., Koshio, S., Ishikawa, M. & Yokoyama, S., 2014. Effects of using exogenous digestive enzymes or natural enhancer mixture on growth, feed utilization, and body composition of rabbitfish, *Siganus rivulatus*. Journal of Agricultural Science and Technology. B, 4(3B): 180-187

Debnath, D., Pal, A.K., Sahu, N.P., Jain, K.K., Yengkokpam, S. & Mukherjee, S.C. 2005. Effect of dietary microbial phytase supplementation on growth and nutrient digestibility of *Pangasius pangasius* fingerlings. Aquaculture Research, 36(2): 180-187.

De-Schrijver, R. & Ollevier, F. 2000. Protein digestion in juvenile turbot (*Scophthalmus maximus*) and effects of dietary administration of *Vibrio proteolyticus*. Aquaculture, 186: 107-1167.

Diab, A.S., El-Nagar, G.O. & Abd-El-Hady, Y.M., 2002. Evaluation of *Nigella sativa* L. (black seeds, baraka), Allium sativum (garlic) and Biogen as feed additives on growth performance and immunostimulants of *Oreochromis niloticus* fingerlings. Suez Canal Veterinary Medicine Journal, 2: 745-775.

Diab, A.S., Aly, S.M., John, G., Abde-Hadi, Y. & Mohammed, M.F. 2008. Effect of garlic, black seed and Biogen as immunostimulants on the growth and survival of Nile tilapia, *Oreochromis niloticus* (Teleostei: *Cichlidae*), and their response to artificial infection with Pseudomonas fluorescens. African Journal of Aquatic Science 3: 63-68.

El-Dakar, A.Y., Shalaby, S.M. & Saoud, I.P. 2007. Assessing the use of a dietary probiotic/prebiotic as an enhancer of Spinefoot rabbitfish, *Siganus rivulatus*, survival and growth. Aquaculture Nutrition, 13(6): 407-412.

El-Haroun, E.R., Goda, A.S. & Chowdhury, K. 2006. Effect of dietary probiotic Biogen® supplementation as a growth promoter on growth performance and feed utilization of Nile tilapia *Oreochromis niloticus* (L.). Aquaculture Research, 37(14): 1473-1480.

El-Shebly, A.A.; El-Kady, M.A.H. & Hossain, M.d.Y. 2007. A Preliminary observation on the pond culture of European eel, *Anguilla anguilla* (Linnaeus, 1758) in Egypt: Recommendation for Future Studies. Pakistan journal of biological sciences, 10(7): 1050-1055.

Farhangi, M. & Carter, C.G. 2007. Effect of enzyme supplementation to dehulled lupin-based diets on growth, feed efficiency, nutrient digestibility and carcass composition of rainbow trout, *Oncorhynchus mykiss* (Walbaum). Aquaculture Research, 38(12): 1274-1282.

GAFRD .2018. the General Authority for Fishery Resources Development, Fish Statistics Year Book, (2016), Cairo, Egypt, 136 pp

Gatlin III, D.M., Li, P., Wang, X., Burr, G.S., Castille F. & Lawrence, A.L. 2006. Potencial application of prebiotics in aquaculture.En: Editores: L. Elizabeth Cruz Suarez, Denis Ricque Marie, Mireya Tapia Salazar, Martha G. Neito Lopez, David A. Villarreal Cavazos, Ana C. Puello Cruzy Armando Garcia Ortega. Avances en Nutricion Acuicola VIII. VIII Simposium International de Nutricion Acuicola. 15-17 noviembre. Universidad Autonoma de Nuevo Leon, Monterrey, Nuevo Leon, Mexico. ISBN 970-694-333-5.

Genç, E., Şahan, A., Altun, T., Cengizler, İ., & Nevşat, E. 2005. Occurrence of the swimbladder parasite Anguillicola crassus (Nematoda, Dracunculoidea) in European eels (Anguilla anguilla) in Ceyhan River, Turkey. Turkish Journal of Veterinary and Animal Sciences, 29(3), 661-663.

Ghonimy, A.M.A., 2013. Dietary animal protein sources for weaning and early growing eels, *anguilla Anguilla*. MS, Department of Animal Production, Faculty of Agriculture, Cairo University, Egypt

Ghosh, S., Sinha, A. & Sahu, C. 2008 Dietary probiotic supplementation in growth and health of live-bearing ornamental fishes. Aquaculture Nutrition, 14: 289-299.

Guo, J.J., Kuo, C.M., Shen, Y.D., Her, B.Y., Chou, R.L. & Chen, T.I. 2011. Antibacterial activity of garlic against Vibrio parahaemolyticus. In: Wu, M.C., Tseng, C.T., Tseng, H.R., Chen, S.C., Liu, D.C., Su, M.S., Su, W.C. (Eds.), Book of the Abstracts for 2011 International Symposium on Grouper Culture. The Fisheries Research Institute of Council of Agriculture, Pingtung, Taiwan, ROC, p. 19.

Guo, J.J., Kuo, C.M., Chuang, Y.C., Hong, J.W., Chou, R.L. & Chen, T.I., 2012. The effects of garlic-supplemented diets on antibacterial activity against *Streptococcus iniae* and on growth in orange-spotted grouper, *Epinephelus coioides*. Aquaculture, 364: 33-38.

Hamza, A.K. 1996. Aquacutlture in Egypt. World Auqacult., 27(1):14-19.

Khattab, Y.A.E. Shalaby, A.M.E., Sharaf Saffa, M., El-Marakby, H., RizlAlla, E.H., 2004. The physiological changes and growth performance of the Nile Tilapia *Oreochromis niloticus* after feeding with Biogen® as growth promoter. Egypt. J. Aquat. Biol. and Fish., 8(2): 145-158.

Kolkovski, S., Tandler, A., Kissil, G. W. & Gertler, A. 1993. The effect of dietary exogenous digestive enzymes on ingestion, assimilation, growth and survival of gilthead seabream (*Sparus aurata, Sparidae,* Linnaeus) larvae. Fish Physiology and Biochemistry, 12(3): 203-209.

Lara-Flores, M., Olvera-Novoa, M.A., Guzma´n-Me´ndez, B.E. & Lo´pez-Madrid, W. 2003. Use of the bacteria *Streptococcus faecium* and Lactobacillus *acidophilus*, and the yeast *Saccharomyces cerevisiae* as growth promoters in Nile tilapia (*Oreochromis niloticus*). Aquaculture, 216: 193-201.

Larkin, B. 2000. The Weaning and Growth of *Anguilla australis* Glass Eels and Elvers. Thesis, Deakin University, Australia.

Li, P. & Gatlin, D.M., 2003. Evaluation of brewers yeast (*Saccharomyces cerevisiae*) as a feed supplement for hybrid striped bass (*Morone chrysops*× *M. saxatilis*). Aquaculture, 219(1): 681-692.

Li, P., Gatlin, D.M. &Neill, W.H. 2007. Dietary supplementation of a purified nucleotide mixture transiently enhanced growth and feed utilization of juvenile red drum, *Sciaenops ocellatus*. Journal of the World Aquaculture Society, 38(2): 281-286.

Lin, S., Mai, K. & Tan, B., 2007. Effect of exogenous enzyme supplementation in diets on growth and feed utilization in Nile tilapia, *Oreochromis niloticus* x *O. aureus*. Aquaculture research, 38: 1645-1653.

Melia, P., Bevacqua, D., Crivelli, A.J., De Leo, G.A., Panfili, J. & Gatto, M. 2006. Age and growth of *Anguilla anguilla* in the Camargue lagoons. Journal of Fish Biology, 68(3): 876-890.

Millet, C.O.M., Lloyd, D., Williams, C., Williams, D., Evans, G., Saunders, R.A. & Cable, J., 2011. Effect of garlic and allium-derived products on the growth and metabolism of *Spironucleus vortens*. Experimental Parasitology, 127: 490-499.

Nandlal, S. 2005. Catching eels in Pacific island countries and territories. PSC Fish. Newslett., 1: 44-48.

NRC, National Research Council. 1993. Nutrient requirements of fish, National Academy Press, Washington DC.

Nya, E.J. & Austin, B., 2009. Use of garlic, *Allium sativum*, to control *Aeromonas hydrophila* infection in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Journal of Fish Diseases, 32: 963-970.

Nya, E.J., Dawood, Z. & Austin, B. 2010. The garlic component, allicin, prevents disease caused by *Aeromonas hydrophila* in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Journal of Fish Diseases 33: 293-970.

Ortuño, J., Cuesta, A., Rodríguez, A., Esteban, M.A. & Meseguer, J. 2002. Oral administration of yeast, *Saccharomyces cerevisiae,* enhances the cellular innate immune response of gilthead seabream (*Sparus aurata* L.). Veterinary Immunology and Immunopathology, 85(1): 41-50.

Oz´orio R.O.A., Portz, L., Borghesi, R., Cyrino, J.E.P. 2012. Effects of dietary yeast (*Saccharomyces cerevisia*) supplementation in practical diets of tilapia (*Oreochromis niloticus*). Animals, 2(1): 16-24.

Paulsen, S.M., Lunde, H., Engstad, R.E., Robertsen, B. 2003. *In vivo* effects of beta-glucan and LPS on regulation of lysozyme activity and mRNA expression in Atlantic salmon (*Salmo salar* L.). Fish Shellfish Immunol., 14: 39-54.

Peulen, O., Deloyer, P. & Dandrifosse, G. 2002. Maturation of intestinal digestive and immune systems by food polyamines. PP.145-167 In: Zabielski, R., Gregory, P.C., Westrom, B. (Eds.), Biology of the intestine in growing animal, Vol. 1., Elsevier, Amesterdam, The Netherlands.

Rabinkov, A., Miron, T., Konstantinovski, L., Wilchek, M., Mirelman, D. & Weiner, L. 1998. The mode of action of allicin: trapping of radicals and interaction with thiol containing proteins. Biochimica et Biophysica Acta, 1379: 233-244.

Rose, P., Whiteman, M., Moore, P.K. & Zhu, Y.Z. 2005. Bioactive S-alk(en)yl cysteine sulfoxide metabolites in the genus Allium: the chemistry of potential therapeutic agents. Natural Product Reports, 22: 351–368.

Sasmal, D., Babu, C.S. & Abraham, T.J., 2005. Effect of garlic (*Allium sativum*) extract on the growth and disease resistance of *Carassius auratus* (Linnaeus, 1758). Indian J. Fish, 52(2): 207-214.

Shiraishi, H. & Crook, V. 2015. Eel market dynamics: an analysis of Anguilla production, trade and consumption in East Asia. TRAFFIC. Tokyo, Japan.

Shalaby, A.M., Khattab, Y.A. & Abdel Rahman, A.M. 2006. Effects of garlic (*Allium sativum*) and chloramphenicol on growth performance, physiological parameters and survival of Nile tilapia (*Oreochromis niloticus*). Journal of Venomous Animals Including Tropical Diseases, 12: 172-201.

Soltan, M.A. 2009. Effect of dietary fish meal replacement by poultry by-product meal with different grain source and enzyme supplementation on performance, feces recovery, body composition and nutrient balance of Nile tilapia. Pakistan Journal of Nutrition, 8(4): 395-407.

Tewary, A., Patra, B.C. 2011. Oral administration of baker's yeast (*Saccharomyces cerevisiae*) acts as a growth promoter and immunomodulator in *Labeo rohita* (Ham.), J. Aquac. Res. Development, 2 (1),http://dx.doi.org/10.4172/2155-9546.1000109.

Tolan, A.E. 2006. Evaluation of some feed additives at different levels in diets of Nile tilapia, Egypt. J. Agric. Res., 84(18): 385-402.

Tovar-Ramirez, D., Zambonino, J., Cahu, C., Gatesoupe, F.J. & Vázquez-Juárez, R. 2002. Effect of live yeast incorporation in compound diet on digestive enzyme activity in sea bass (*Dicentrarchus labrax*) larvae. Aquaculture, 204: 113-123.

Vetvicka, V., Vannucci, L. & Sima, P. 2013. The effects of β–glucan on fish immunity. North American journal of medical sciences, 5(10): 580.

Waché, Y., Auffray, F., Gatesoupe, F.J., Zambonino, J., Gayet, V., Labbé, L. & Quentel, C. 2006. Cross effects of the strain of dietary *Saccharomyces cerevisiae* and rearing conditions on the onset of intestinal microbiota and digestive enzymes in rainbow trout, *Onchorhynchus mykiss*, fry. Aquaculture, 258: 470- 478.

Watene, E. 2003. Potential for commercial eel aquaculture in northland. national institute of water and atmospheric research. Client Report, March 2003: AKL2003- 032

Xie, L.L., Cao, J.H., Yang, S.X., Zhao, C.Y., Ren, L. 2009. The impact of dietary Chinese herbal medicines on growth performance and muscular composition in juvenile tilapia. Fisheries Science 28: 11-14.

Yildirim, O., Celikkale, M.S., Korkut, A.Y., Hossu, B., 1999. Possibility of feeding rainbow trout (*Oncorhynchus mykiss* W., 1972) with fish longer by-products as an alternative feed source. Ege Univ. Fac. Fish. J. Fish. Aquatic. Sci.: 16: 1-2.

Yildirim, Y. B. & Turan, F., 2010. Effects of exogenous enzyme supplementation in diets on growth and feed utilization in African catfish, *Clarias gariepinus*. Journal of Animal and Veterinary Advances, 9(2): 327-331.

Yones, A.M, Elbattal, A., Elgelany,S.S. & Attia,S. 2019. Incorporation of garlic meal (*Allium sativum*) as natural additive to enhance performance, immunity, gonad and larval survival rate of Nile tilapia (*Oreochromis niloticus*) broodstock. Afr.J.Biol.Sci. 15 (1): 117-135.

Zehra, S. & Khan, M.A. 2016. Total sulphur amino acid requirement and maximum cysteine replacement value for methionine for fingerling Catla catla (Hamilton). Aquaculture Research, 47(1): 304-317.

Zhao, L., Wang, W., Huang, X., Guo, T., Wen, W., Feng, L. & Wei, L. 2017. The effect of replacement of fish meal by yeast extract on the digestibility, growth and muscle composition of the shrimp, *Litopenaeus vannamei*. Aquaculture Research, *48*(1), 311-320.

Zhou, Y., Jiang, L.V.D. & Wang, T. 2009. Improved energy-utilizing efficiency by enzyme preparation supplement in broiler diets with different metabolizable energy levels. Poultry science, 88: 316-322.