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IMPROVING FEED EFFICIENCY OF PLANT DIETS BY EXOGENOUSENZYMES ADDITIVE AND HEAT TREATMENT OF SOYBEAN FOR NILE TILAPIA *OREOCHROMIS NILOTICUS*

N. E. El-Tawil

Department of Fish Nutrition, Central Laboratory for Aquaculture Research CLAR, Agriculture Research Center, Egypt.

*Corresponding author e-mail: nadereltawil@yahoo.com

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SUMMARY

This study was conducted to evaluate the effect of using exogenous digestive enzymes(Zymogen®) and heattreatment of soybean (cooked)in diets on growth performance and feed efficiency of Nile tilapia*Oreochromisniloticus*(4.07g). Six experimental diets were formulated to be isonitrogenous (27% crude protein) and isocaloric**(**4.29kcal/g) and used to feed triplicate groups of fish to apparent satiation for11weeks**.** Treatments were: T1 contain both fish meal and plant protein sourcesas FMcontrol diet (FM), T2 contain only plant protein additivesas a SBMcontrol diet, T3 (SBM +1.0% zymogen) Z^1, T4 (SBM +2.0% zymogen)Z^2, T5 and T6 (SBM +1.0% or2.0% zymogen levelwith cookedsoybean treatment)Z^1C, Z^2C respectively.Results showed that supplemented fish diets with zymogen and cookedsoybean enhanced fish performance over plant diet control. Fish maintained atFM,Z^2, Z^2Cand Z^1Cdiets were significantly higher ($P<0.05$) in all growth performance parameters andsurvival rate values than other treatments.Differences among FM, Z^2, Z^2C and Z^1C treatmentswere not significant ($P>0.05$). Also, feed efficiency parameterswere improved significantly($P<0.05$)atfish maintained on FM, Z^2Cand Z^1Cdiets**.** These results suggest that using exogenous digestive enzymes (zymogen) and cooked soybean treatment in all plant based dietsmayenhancethe growth performance and the feed efficiencyof Nile tilapia. Moreover, theeconomicefficiency in terms of feed utilization has been improved.

Keywords:*Fishmeal, zymogen, cooked soybean, growthperformance, feed efficiency, Nile tilapia.*

INTRODUCTION

With increasing the international prices of the feed ingredients used in aquaculture,there is a great need to enhance feed efficiency, growth performance and disease resistance of cultured fish species. Dietary supplementation of different feed additives usually in small quantities for the purpose of fortifying it with certain nutrients have been found to be beneficial for improving growth performance and feed efficiency of fishes (Ganguly*et al.,* 2012).

Fish meal (FM) represents an ideal nutritional source of dietary protein for fish. Increasing demand, unstable supply, and high prices of FM along with the continuous expansion of aquaculture are reasons for many nutritionists to realize that soon they will no longer be able to afford it as a major protein source in aquatic feeds.A current priority in the aquaculture industry and one of the challenges that fish nutritionists face is the need to partially or totally replace FM with less expensive, non-traditional animal or plant protein sources including plant-based protein ingredientsto ensure its sustainability (Peng*et al.,* 2013, Castillo and Gatlin,2015). Soybean has been recognized as one of the most appropriate alternative protein source for FM in aquatic feed because of high protein content, balanced essential amino acids, availability and its low cost, but its full nutritional value can be obtained only after inactivation of soy anti-nutritional factors such as protease inhibitor, anti-vitamin and lectin(Azarm and Lee, 2012, Storebakken,2000). At present, commercialSBM produced can partially replace fishmeal, andwe need to improve processing methods to develop newproducts that will be suitable for fish consumption and utilization (Mahmoud *et al.,* 2014).Feed ingredients exposed to varying degrees of heating during manufacturing and processing.Barrows *et al.,* (2007) reported that heat treatment of soybean is necessary to de-nature endogenous trypsin inhibitors and maximize nutritional value. Moreover, El-Dahhar (2006) stated that heat treatments and pressure of the dietare expecting to improve product quality and make the best nutritional use of the raw materials. It can also sterilize the product and give the flexibility to utilize a wider range of raw materials while maximizing their nutritional quality.

Addition of exogenous enzymes in fish feeds can improve nutrient utilization, thereby reducing nutrient losses. Exogenous enzymes have been proven to improve nutritional value of feed and decrease environmental pollution.Tacon (1993) stated thatpresence of anti-nutritional factors within plant feed-stuffs limittheir use in aquatic feeds. However, certain enzymes provide an additional powerful tool that can inactivate anti-nutritional factors and enhance the nutritive value of plant based protein in feeds. Nowadays, exogenous enzymes are extensively used all over the world as additives in fish diets to improve the nutritional value of fishfeeds, especially with the raise of using plant proteins in aquafeeds and reduce water pollution (Goda*et al*., 2012).SBM containsalso non-starch polysaccharides that are not efficiently digested by most fish species. Lobo (1999) found that use of exogenous enzymes, such as xylanase, α-galactosidase, β-glucanase and endo-β-mannanase, make the oligosaccharide fraction more digestible in some species. Lin *et al.*,(2007) demonstrated that using of digestive enzyme (protease) in fish diet improved protein digestibility in hybrid tilapia.

The present study was conducted to evaluate the effect of using exogenous digestive enzymes supplementation (zymogen) with heat treatment of soybean (cooked) in fish diets on growth performance and feed efficiencyof Nile tilapia*Oreochromisniloticus*fed on all based plant protein diets.

MATERIALS AND METHODS

Dietsformulation and preparation:

Six practical diets were formulatedfrom commercial ingredients to contain isonitrogenous (27% crude protein) and isocaloric(4.29 kcal/gdiets) based on feedstuff values reported by NRC (1993).The composition and chemical analysis of the experimental diets are presented in Table (1). Treatments were: T1 both fish meal and plant protein sources as a FM control, T2 all plant protein sources without any additives as a SBM control, T3 all plant protein sources supplemented with 1.0% zymogen level(Z^1), T4 all plant protein sources supplemented with 2.0% zymogen level(Z^2), T5 all plant protein sources supplemented with 1.0% zymogen level with cooked soybean(Z^1C)and T6 all plant protein sources supplemented with 2.0% zymogen level with cooked soybean(Z^2C).Cooked soybean was done by using an autoclave with a maximum pressure of 1.2 kg /cm², for 15 minuets according toEl-Dahhar and El-Shazly(1993).Exogenous digestive enzymes(Zymogen®) (manufactured by the Nile co. for pharmaceuticals and chemical industries, Cairo, Egypt) contain Lipase (800 USNF units),amylase(5000 USNF units), protease(5000 USNF units), pepsin100mg, hemicellulase40mg,Ox bileextract20mg, dimethylpolysiloxane 20mg and vitamin B1 25mg. The ingredients of each diet were separately blended with additional 50% of warm water to make a paste of each diet.Vitamins and minerals mixtures were added to the diets after heat treatment. The pastes were separately passed through a grinder, and pelleted in a modified paste extruder to form the tested diets (1-mm diameter). Diets were dried in a drying oven model (Fisher oven 13–261–28A) for 24 hours at 65°C.Zymogen was mixed with some oil and sprayed onto the diets and homogenized well, then dried under room temperature andstored in plastic bags which were kept dry until they were used.

The Experimental Fish:

Nile tilapia fry (*Oreochromisniloticus*) were obtained from the fish hatchery ponds, Central Laboratory for Aquaculture Research (CLAR) Abbassa, Abu-Hammad, SharkiyaGovernorate, Egypt. Fish were kept in indoor tank for 2 weeks as an acclimation period to the laboratory conditions. Fish with an average initial body weight of (4.07 ± 0.03 g) were divided into 6 groups (3 replicates per treatment) each containing 20 fish/ glass aquarium(100 Liter capacity). Aquaria were supplemented with continuous aeration.Water was exchanged partially every day by stocked dechlorinated tap water. Fish were fed twice daily to apparent satiation and aquaria were cleaned every day before feeding. Fish feeding was offered 6 days/week. Fish were weighed at the beginning of the experiment and then biweekly for 11 weeks experimental period.

Table (1). Formulation of feed ingredients and proximate chemical composition (%; on dry matter basis) for the experimental diets.

Ingredients	FM	SBM	Z^1	Z^2	Z^1C	Z^2C
Herring Fish meal	10.00	0.00	0.00	0.00	0.00	0.00
Soybean meal	33.00	51.00	51.00	51.00	51.00	51.00
Corn meal	30.00	25.00	25.00	25.00	25.00	25.00
Wheat bran	18.00	14.00	14.00	13.00	14.00	13.00
Zymogen	0.00	0.00	1.00	2.00	1.00	2.00
Corn oil	4.00	5.00	5.00	5.00	5.00	5.00
Starch	2.00	2.00	1.00	1.00	1.00	1.00
Vitamins premix[1]	2.00	2.00	2.00	2.00	2.00	2.00
Minerals premix[2]	1.00	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100	100
Dry matter%	89.85	89.76	89.74	89.77	89.69	89.71
Protein %	27.16	27.24	27.22	27.19	27.22	27.24
Fat %	8.51	8.24	8.21	8.23	8.32	8.26
Fiber %	6.11	6.32	6.31	6.34	6.28	6.32
Ash %	10.35	10.63	10.56	10.59	10.61	10.49
NFE %[3]	47.87	47.57	47.70	47.65	47.57	47.69
GE (kcal/g)[4]	4.30	4.27	4.27	4.27	4.28	4.28

[1]*Vitamins premix (per kg of premix): thiamine, 2.5 g; riboflavin, 2.5 g; pyridoxine, 2.0 g; inositol, 100.0 g; biotin, 0.3 g; pantothenic acid, 100.0 g; folic acid, 0.75 g; para-aminobenzoic acid, 2.5 g; choline, 200.0 g; nicotinic acid, 10.0 g; cyanocobalamine, 0.005 g; α-tocopherol acetate, 20.1 g; menadione, 2.0 g; retinol palmitate, 100,000 IU; cholecalciferol, 500,000 IU.*

[2]*Minerals premix (g/kg of premix): CaHPO4.2H2O, 727.2; MgCO4.7H2O, 127.5; KCl 50.0; NaCl, 60.0; FeC6H5O7.3H2O, 25.0; ZnCO3, 5.5; MnCl2.4H2O, 2.5; Cu(OAc)2.H2O, 0.785; CoCl3..6H2O,0.477; CaIO3.6H2O, 0.295; CrCl3.6H2O, 0.128; AlCl3. 6H2O, 0.54; Na2SeO3, 0.03.*

[3]*NFE (%) = 100 − (% crude protein + % crude lipid + % crude fiber +% ash)*

[4]*Gross energy (GE) was calculated according to NRC (1993) as 5.65, 9.45, and4.11 kcal/g of protein, lipid, and carbohydrates, respectively.*

Chemical analysis of diets and fish:

The tested diets and whole-fish body from each treatment at the beginning and at the end of the experiment were analyzed according to the methods of AOAC (1990) for moisture, crude protein, total lipids, and ash. Moisture content was estimated by drying the samples to constant weight at 85 °C in a drying oven (GCA, model 18EM, Precision Scientific group, Chicago, Illinois, USA). Nitrogen content was determined using a microkjeldahl apparatus (Labconco Corporation, Kansas, Missouri,USA). Lipid content was determined by ether extraction in a multi-unit extraction Soxhlet apparatus (Lab-Line Instruments, Inc., Melrose Park, Illinois,USA) for 16 h. and ash was determined by combusting dry samples in a muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) at 550 °C for 6 h. Crude fiber was estimated according to Goering and Van Soest(1970). Gross energy was calculated according to NRC (1993).

Parameters of growth performance:

Growth performance was determined, and feed utilization efficiencyparameterswere calculated using the following equations:

Weight gain = W_2 - W_1

Specific growth rate (SGR; % g/day) = 100 (Ln W_2 – Ln W_1) / T

Where W_1 and W_2 are the initial and final fish weights, respectively, and T is the experimental period in days.

Feed conversion ratio (FCR) =feed intake / weight gain.

Protein efficiency ratio (PER) = weight gain/protein intake.

Protein productive value (PPV %) = 100 (protein gain/protein intake).

Energy retention (ER %) = 100 (energy gain/ energy intake).

Water quality:

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 using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, OH, USA). Unionized ammonia was measured using DREL/2 HACH kits (HACH Co., Loveland, Colorado, USA).

Statistical analysis:

The obtained data were subjected to one-way ANOVA (complete randomized design). Differences between means were tested at the 5% probability level using Duncan's new multiple range test by Duncan (1955). All the statistical analyses were done using SPSS program version 10 (SPSS, Richmond, USA) as described by Dytham (1999).

Economical evaluation:

A simple economic analysis was conducted for different experimental treatments to estimate the cost of feed required to produce a unit of fish biomass. The estimation was based on local retail sale market price of all the dietary ingredients at the time of the study. These prices (in LE/kg) were as follows: herring fish meal, 18.00; soybean meal, 4.00; yellow corn meal, 2.50; wheat bran, 2.25; corn oil, 10.00; starch 6.00, vitamins mixture,10; minerals mixture,7.00 and zymogen 48.0LE/kg.

RESULTS AND DISCUSSION

In the present study, water temperature ranged from 26.0 to 27.0°C, dissolved oxygen concentration range was 4.7 to 5.5 mg/L, total ammonia concentration ranged from 0.13 to 0.19 mg/L and pH from7.3 to7.8.These water quality parameters are in acceptable ranges for normal growth of Nile tilapia during the experimental period(Boyd, 1984).

Data of Table (2) show that final body weight (FBW), weight gain (WG), daily weight gain (DWG), specific growth rate (SGR %) and survival rate of Nile tilapia (*Oreochromisniloticus*) were improved significantly (P<0.05) with zymogen supplementation in fish diet.Fish maintained on diets containing zymogen exhibited significantly (P<0.05) the greatest growthperformance parameters comparedto fish fed

Table (2). Growth performance values (means ± SE) of Nile tilapia fed diets containing different levels of zymogen and cooked soybean.

Item	FM	SBM	Z^1	Z^2	Z^1C	Z^2C
IBW, g	4.09±0.31	4.07±0.04	4.05±0.04	4.05±0.04	4.04±0.04	4.10±0.06
FBW, g	27.46±0.06^{a}	19.47±0.11^{c}	22.59±1.03^{bc}	26.93±1.00^{a}	25.34±1.91^{ab}	26.06±1.72^{ab}
WG, g	23.37±0.37^{a}	15.40±0.15^{c}	18.54±1.02^{bc}	22.88±0.96^{a}	21.30±1.88^{ab}	21.96±1.78^{ab}
DWG, g	0.33±0.01^{a}	0.22±0.00^{c}	0.26±0.01^{bc}	0.33±0.01^{a}	0.30±0.03^{ab}	0.31±0.03^{ab}
SGR, %/d	3.02±0.11^{a}	2.48±0.02^{c}	2.73±0.07^{b}	3.00±0.04^{a}	2.91±0.11^{a}	2.93±0.13^{a}
Survival%	96.66±1.98^{a}	91.67±1.98^{c}	93.33±3.96^{bc}	95.00±2.22^{ab}	95.00±2.22^{ab}	96.66±1.98^{a}

Means with different superscripts in the same row are significantly different (P<0.05).

on the control SBM based diet. Moreover, results indicated that differences among fish maintained on diets containing Z^2, Z^1C, Z^2C and fish fed on FM diet were insignificant (P>0.05). These results agree with those found by several authors who reported that exogenous enzymes improved nutrients digestibility of plant-based fish diets and leading to better growth performance and feed efficiency (Tovar *et al.,* 2002; Mohapatra*et al.,*2012; Ray *et al*.,2012; Dawood*et al.,* 2014; Mahmoud *et al.,* 2014).Moreover, these results are in agreement with those found by El-Dahhar (2006) who indicated that exogenous enzymes supplementation in fish diet improved the weight gain, final biomass and the survival rate of grey mullet larvae.Also, Castillo and Gatlin(2015) stated thatexogenous enzymes supplementation improved nutrients digestibility and reduced nutrient excretion of plant-based fish diets.Dalsgaard*et al.* (2014) indicated that plant-based feed ingredients typically contain remnants of dietary fibers that have various anti nutritive effects of fish. Exogenous enzymes improve the apparent digestibility coefficients of plant-based diets presumably by assisting in the breakdown of non-starch polysaccharides and alleviating some of the anti nutritive effects. Moreover,Ghomi*et al*. (2012) found that optimum growth performance in great sturgeon fingerlings can be obtained by adding 250 mg ofexogenous multienzyme/kg diet.

On the other side, fish fed on the control SBM based diet was the worst in the growth performance and feed utilization values (Table 2). Similar results have been reported in previous studies (Merrifield *etal.,* 2009; Chen *et al*., 2011) who reported that reduced growth response and feed utilization could be explained by many factors as suboptimal amino acid balance, inadequate levels of phosphorus, inadequate levels of energy,lower feed intake caused by palatability or presence of endogenous anti-nutrients. Francis *et al.*(2001) reported that drawback in the use of soybean protein in fish diets is the presence of phytate which cannot be inactivated by heat treatment.Mahmoud *et al.* (2014) reported that the negative effect of total replacement of soybean meal on growth could be mainly explained by a general decline in feed intake combined with reduced nutrient availability. However, lower growth offish fed on SBM based diet without any addition in the present study may have been caused by one or more of previous mentioned factors.

Dataof Table (2) showed that fish fed on cooked soybeandiet were higher in growth performance parameters than fish fed on non cooked soybeandiets.The highest significant values (P<0.05) of growthperformance parameters were recorded for fish fed on diet containingFM, Z^2, Z^1C and Z^2C, where differences among last four groups were not significant (P>0.05). Soybeans contain several anti nutritional factors that are important considerations in fish nutrition. Present results agree with those by Peres *et al.*(2003) who found that autoclaving the defatted raw soybean meal (heated in an autoclave using the dry cycle at 130°C and 22 psi for 40 min) lowered the trypsin inhibitor and protein dispensability index, improved the nutritional value of SBM and increased plasma lysozyme, protein and resistance of fish to E. *ictaluri* challenge.

Studies on the nutritional value of processed plant proteins in various fish species have consistently shown an improvement of digestibility and growth compared to feeding unprocessed ingredients (Drew *et al.,* 2007). However, Barrows *et al.* (2007) indicated that heat treatment of soybeans is necessary to de-nature endogenous trypsin inhibitors and maximize nutritional value, but overheating can damage protein and reduce nutritional value. Also, they demonstrated the importance of extruder processing conditions on fish performance, and indicated that high temperature (127°C) and short time in the extruder barrel results in the greatest weight gain of rainbow trout.The improving in growth parameters in the present study may be due to the positive effect of the exogenous enzymes supplementation or cooked soybean treatment on improving diet quality by make the best nutritional use of raw materials which increase the Nile tilapia capability to utilize all plant based diets.

Values of feed conversion ratio FCR, protein efficiency ratio PER, protein productive value PPV% and energy retention ER % of Nile tilapia (*Oreochromisniloticus*) are shown in Table (3).Results indicated that fish fed on FM, Z^2C, Z^1C and Z^2 diets had significantly (P<0.05) better FCRthan other treatments, however, differences among the last treatments were not significant. The worst (P<0.05) FCR was found in fish maintained onthe control SBM based diet. Results of (Table 3) indicated that highest

Table (3). Feed utilization values (means ± SE) of Nile tilapia fed diets containing different levels of zymogen and cooked soybean.

Item	FM	SBM	Z^1	Z^2	Z^1C	Z^2C
Feed intake	37.74 ± 0.26^a	28.85 ± 0.28^c	32.26 ± 1.85^b	37.73 ± 1.14^a	35.06 ± 3.21^{ab}	35.51 ± 3.15^a
FCR	1.61 ± 0.02^c	1.87 ± 0.01^a	1.74 ± 0.01^b	1.65 ± 0.03^c	1.65 ± 0.01^c	1.62 ± 0.02^c
PER	2.29 ± 0.03^a	1.96 ± 0.01^d	2.11 ± 0.01^c	2.18 ± 0.04^b	2.23 ± 0.01^{ab}	2.27 ± 0.02^a
PPV	36.42 ± 0.46^a	33.50 ± 0.63^c	33.79 ± 0.37^c	35.40 ± 0.59^b	35.55 ± 0.25^{ab}	36.18 ± 0.34^{ab}
ER	20.68 ± 0.21^a	19.01 ± 0.31^b	19.20 ± 0.26^b	20.20 ± 0.33^a	20.48 ± 0.18^a	20.22 ± 0.23^a
ER	20.68 ± 0.21^a	19.01 ± 0.31^b	19.20 ± 0.26^b	20.20 ± 0.33^a	20.48 ± 0.18^a	20.22 ± 0.23^a

Means with different superscripts in the same row are significantly different (P<0.05).

significant (P<0.05) values of PER and PPV were found in fish maintained on FM followed by Z^2C and then Z^1C diets, without any significant differences (P>0.05) among last treatments. Similarly, results indicated that highest significant (P<0.05) value of ER% were found in fish maintained on FM followed by Z^1C, Z^2C and then Z^2 diets, while the lowest significantly values of PER, PPV and ER% were found in fish maintained on the control SBM based diet. These resultssuggestingthat plant diets supplementation with zymogen and cooked soybean meal improve the protein and energy utilization in diet.Same trends were observed by Goda*et al.* (2012) who concluded that the use of exogenous digestive enzymes (pepsin, papain and α-amylase) as a feed additive for Nile tilapia is recommended to stimulate growth performance, feed conversion and nutrient utilization.Also, this result is nearly similar to what found by Ginindza*et al.* (2015) whofound thatall groups of *Oreochromismossambicus* fed diets supplementedwith exogenous enzyme were higher in growth performance, protein digestibility and digestive enzyme activities compared to those fed oncontrol diet.Moreover, they explained that improvement in the growth performance was attributed to the presence of cocktailof enzymes such as cellulase, xylanase and phytase whichare not naturally produced by fish. Oliveira *et al.*, (2007) reported that the inclusion of exogenous enzyme (0.05%) containing cellulose, protease and amylase in Nile tilapia diet enhanced feed conversion rate and nutrient digestibility. Also, Moura*et al.* (2014) indicated that the inclusion of enzymes in Nile tilapia diets may be an alternative to reduce anti nutritional factors found in ingredients of plant origin and increase the availability of nutrients.Moreover, Tomás*et al.*(2005) reported that apparent digestibility coefficient of dry matter, protein, and lipid were high due to the process used for preparing diets in which pellets heating might have inactivated the trypsin inhibitor.

With respect to body composition of Nile tilapia in (Table 4), results showed that no significant differences ($P>0.05$) were observed between treatments in dry matter of fish body contents.Results of fish body protein content showed that highest values ($P<0.05$) were found in fish maintained on Z^2C followed by Z^1C and then FM diet,without any significant differences between the last treatments, while the lowest values ($P<0.05$) were found in the fish maintained on Z^1diet.Results of fish body lipid contents showed that fish maintained on Z^1 and Z^2 diets were significantly ($P<0.05$) higher than other treatments, while the lowest ($P<0.05$) value was found in fish maintained on FM diet. These results are in agreement with those found byMahmoud *et al.* (2014) where crude protein content of Nile tilapiawas increased significantly withexogenous multi enzyme supplementation.Ogunkoya*et al.* (2006) observed a positive effect on the coefficients of apparent digestibility of crude protein and lipids by investigating the inclusion of soybean meal and an enzyme complex containing xylanase, amylase, cellulase, protease and β-glucanase in fish diet. On the other hand, Ghomi*et al.* (2012)revealed thatbody protein contents decreased slightly while fatincreased when fish fed on enzyme-supplemented diets. However,Stone *et al.* (2003) did not found any effect on the apparent digestibility of dry matter, energy or protein contents in Silver Perch (*Bidyanusbidyanus*) when fed on enzyme complex diets. This may be explained as body composition of fish is primarily influenced by diet composition, feeding practices, fish size, and can be controlled through nutrition.

Table (4). Body composition (Means ± SE) % on dry weight basis of Nile tilapia fed diets containing different levels of zymogen and cooked soybean.

Item	FM	SBM	Z^1	Z^2	Z^1C	Z^2C
Dry matter	24.39±0.04	25.88±0.33	24.57±0.27	25.85±0.06	24.96±0.04	24.86±0.01
Crude protein	66.25±0.04[a]	64.65±0.27[b]	63.72±0.37[b]	64.26±0.03[b]	66.32±0.13[a]	66.58±0.35[a]
Lipid	18.53±0.03[c]	19.37±0.09[b]	21.71±0.42[a]	20.67±0.28[a]	19.06±0.02[b]	18.70±0.12[c]

Means with different superscripts in the same row are significantly different (P<0.05).

Economic evaluation of the experimental diets is shown in Table (5).Results showed that fish maintained on zymogen supplementationdiets with or without cooked soybean mealwere more economic

Table 5. Economic efficiency for production of one kg gain of Nile tilapia fed diets containing different levels of zymogen and cooked soybean.

Items	FM	SBM	Z^1	Z^2	Z^1C	Z^2C
Price/ kg feed P.T	5.06	3.83	4.29	4.77	4.31	4.79
FCR kg feed/kg gain)	1.61	1.87	1.74	1.65	1.65	1.62
Feed cost / kg gain P.T	8.15	7.16	7.46	7.87	7.11	7.76
Reduction cost in kg gain%	0.00	12.15	8.41	3.44	12.74	4.79

Means with different superscripts in the same row are significantly different (P<0.05).

and reduced the feed cost. The reduction in feed cost to produce one kg fish gain ranged between3.44 to 12.74% compared to fish fed on FM control diet. One of the aims of present study was to evaluate the effect of zymogen supplementationon cost analysis of production. Totally replacing fish meal protein by soybean meal protein led to reduce the final cost of production by12.74% compared to the fishmeal based diet. Similar results were observed by Dawood*et al*. (2014) who indicated that dietary supplementation of exogenous enzyme would increase the profitability of rabbit fish by 20.4%.

CONCLUSION

In conclusion, the results of the present study show that dietary zymogen supplementation with cooked soybean meal in fish diet had beneficial effects on improving growth performance, feed utilization and survival rate of Nile tilapia fed all plant based diets. Also, it is more economic and sharply reduced the fish feed cost used to produce unit fish. It is clear that studies on exogenous enzyme supplementation in aquaculture nutrition are not extensive. According to these results and favorable effects found in aquaculture species studied to date, it may be significant to increase research on this subject because it could be a useful tool to improve commercial aquaculture.

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تحسين الكفاءة الغذائية للعلائق النباتية للبلطي النيلي بالمعاملة الحرارية لفول الصويا وإضافة الإنزيمات الهاضمة

نـــادر عزت عبد العظيم الطـويـل

قسم بحوث تغذية الأسماك-المعمل المركزى لبحوث الثروة السمكية – مركز البحوث الزراعية – مصر.

أجريت هذه التجربة لدراسة تأثير استخدام الإنزيمات الهاضمة الخارجية (الزيموجين) والمعاملة الحرارية لفول الصويا في الغذاء علي أداء النمو وكفاءة إستخدام الغذاء لأسماك البلطي النيلي ذات الوزن الإبتدائي (4.07 جم) . تم عمل ستة علائق متساوية في نسبة البروتين (27%) والطاقة (4.29 كيلو كالوري لكل جم غذاء)،تم تغذية الأسماك حتي الإشباع لمدة 11 إسبوع. وكانت المعاملات كالآتى: العليقة الأولىتحتوى على مسحوق السمك وبروتين نباتي كمصدرأساسي للبروتين ، العليقة الثانية (نباتية) تحتوى على مصادربروتين نباتي فقط كمصدر للبروتين ، العليقة الثالثة (نباتية) مضافا إليها 1% زيموجين،العليقة الرابعة (نباتية) مضافا إليها 2% زيموجين، العليقة الخامسة والسادسة (نباتية) مضافا إليهما 1أو 2% زيموجين مع المعاملة الحرارية لفول الصويا علي التوالي.أوضحت النتائج تحسن أداء الأسماكبإضافة الزيموجين مع المعاملةالحراريةلفول الصويابالمقارنة بالعليقة النباتية، وأن الأسماك التي تغذت علي العلائق الأولي والرابعة والخامسة والسادسة كانت الأفضل معنويا بالنسبة لكل النتائج المتحصل عليها الخاصة بالنمو ومعدل إعاشة الأسماك وكفاءة إستخدام الغذاء عن باقي المعاملاتوبدون أي فرق معنوي بينهم.تشير النتائج التى تم الحصول عليها فى هذه التجربة إلى أن إضافة الانزيمات الهاضمة الخارجية (الزيموجين) والمعاملة الحرارية لفول الصويا للعلائق النباتية ُيحسن من نمو الأسماك وكفاءة استخدام الغذاء لاسماك البلطي النيلي كما انه أوفر إقتصاديا و يخفض منالتكلفة الكلية للغذاء.