Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(4): 845-849

Received: 19-05-2017
Accepted: 20-06-2017

Sharda
Research Scholar,
Department of Aquaculture,
College of Fisheries, MPUAT,
Udaipur, Rajasthan, India

OP Sharma
Dean and Head,
Department of Aquaculture,
College of Fisheries, MPUAT,
Udaipur Rajasthan, India

VP Saini
Professor, Department of
Aquaculture and In-Charge,
Non Plan Research, MPUAT,
Udaipur Rajasthan, India

Correspondence
Sharda
Research Scholar,
Department of Aquaculture,
College of Fisheries, MPUAT,
Udaipur, Rajasthan, India

Replacement of fishmeal with soybean meal in Nile tilapia (*Oreochromis niloticus*) Diet

Sharda, OP Sharma and VP Saini

Abstract
The present study deals with the "Replacement of Fishmeal with Soybean Meal in Nile Tilapia (*Oreochromis niloticus*) Diet". The fish meal was replaced @ 0 to 100% in experimental diets. As such five diets having 0-100% fish meal replaced with soybean meal i.e., 0% (control), 25 (T_1), 50 (T_2), 75 (T_3) and 100% (T_4) were prepared. The experiment was conducted in triplicate in 200 liters plastic tanks for 42 days. These experimental fish were fed @8% of body weight per day. The growth performances of test fish were observed at weekly interval. Similarly, experimental water quality parameters were also monitored at weekly intervals. The results of this study indicated a significant difference in net weight gain, per cent weight gain, specific growth rate, food conversion ratio and gross conversion efficiency of fry fed with different diets. The highest net weight gain, per cent weight gain, SGR, and GCE were 3.18g (T_0), 185.64% (T_0), 0. 928% (T_0) and was 0.343 (T_0) respectively. The fish fed with fish meal and soybean meals have also indicated better food utilization with lesser food conservation ratio (FCR) i.e.3.22 in control as compared to other experimental feeds including. Proximate composition of fish fed with fish meal and soybean meal in mixed diet further confirmed that its biochemical configuration was fairly satisfactory. The results of this study indicated that the increasing level of soybean meal in fish diet has a negative impact on growth and growth parameters. As the growth significantly decreased with increasing soybean levels in fish diet. On the basis of this experiment, it is concluded that 25% of fish meal can be replaced with soybean Meal because the growth Meal because the growth difference between a fish meal based diet (100%) and fish meal –soybean meal (75 +25) based diet had no significant growth. However, it is recommended replacing 25% of fish meal with soybean meal.

Keywords: Growth, fish meal, soybean meal, Nile tilapia

Introduction
Protein has been described as the most expensive and important components of fish feed. At present fish meal constitutes the major protein source used in commercial feeds. The fish meal use will likely increase in pet foods and specialty livestock feed and direct utilization in the human diet due to the tremendous increase in the world population. Therefore, in near future fish meal prices will increase and hence the costs of fish production will probably be higher than at present unless suitable inexpensive alternative source of protein, which are of constant high quality, are found (Higgs *et. al.*, 1995) [7]. Soybean meal which constitutes about 75% of all plant protein feedstuffs will likely be one of the key ingredients for aquaculture feeds in the future. The partial replacement of dietary fish meal has successfully accomplished in a number of fish. Different anti-nutritional factors (ANFs) have been identified in soybean: Protease inhibitors, lectins, antigenic protein, phenolic compounds, oligosaccharides, phytates, etc. Some ANFs can be inactivated by proper heat treatment technologies involved in the processing of soybean. However, the reduction of the effects of other ANFs present in soybean requires more specific treatments. Fish meal is one of the most expensive ingredients in prepared fish diets. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal. Soybean meal (SBM) is considered to be one of the most nutritious of all plant protein foodstuffs (Lovell, 1988) [11]. However, growth has often been reduced in fish fed diets with SBM replacing all the fish meal (Floreto *et al.*, 2000) [4]. One possible reason may be the activity of protease (trypsin) inhibitors in crude or inadequately heated SBM (Wilson and Poe, 1985) [15]. However, this may not be of practical importance since commercially available SBM usually has little trypsin inhibitor activity if adequately processed.

Materials and methods

Experimental fish: The Nile tilapia (*Oreochromis niloticus*) was selected for the present study. The healthy fingerlings were procured from Aquaculture Research and Seed Unit, DOR, MPUAT, Udaipur.

Experimental diets: The basal (control) diet was prepared by mixing maize flour (10%), rice bran (25%), groundnut oil cake (25%) and fish meal (40%). For the preparation of experimental diets, the three ingredients such as MF, RB & GOC were taken in the same quantity as in basal diet and only the fish meal was replaced with soybean meal (25, 50, 75 and 100%). The details of experimental diet are shown in Table 1.

Table 2.1: Experimental diets

S. No.	Ingredients*	T_0 (Control)	T_1	T_2	T_3	T_4
1	Maize flour (MF)	10	10	10	10	10
2	Rice bran (RB)	25	25	25	25	25
3	Groundnut oil cake (GOC)	25	25	25	25	25
4	Fishmeal (FM)	40	30	20	10	0
5	Soybean meal (SM)	0	10	20	30	40

*All ingredients are in per cent

Experimental Design: The experiment was conducted in fifteen plastic tanks of 225 liters capacity for a period of six weeks. Each tank was washed and disinfected before the introduction of fish. Each plastic tank was filled with tap water. Prior to the start of the experiment, the fish were fed on the control diet (Growell 4 mm pelleted feed having 28% protein) for 7 days in order to make the fish acclimatized to experimental conditions. Before final trial the feeding rate was standardized. The healthy fry of uniform size were randomly distributed in four experimental groups each with three replicates following a completely randomized design (CRD). The volume of water in each tank was about 200 liters. Each tank was stocked with 10 fry of Nile tilapia. The fishes in control treatment were fed with the control diet (MF+RB+GOC+FM) and in treatments with experimental diets as shown in Table-1 (MF, RB, GOC, FM and SM). The ration was divided equally into two feedings based upon total body weight. The weight of experimental fish was determined weekly using weighing machine. The growth parameters were analyzed at weekly interval. Survival was calculated at the end of the experiment. Water quality parameters such as temperature, pH, dissolved oxygen, alkalinity, total hardness and electrical conductivity were analyzed on initial day and subsequently on 7, 14, 21, 28, 35 and 42nd day of the experimental period.

Water Quality Analysis: The selected water quality parameters such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total hardness and total alkalinity were tested by standard methods of APHA at weekly intervals.

Growth Parameters

The fish growth parameters viz., net weight gain, per cent gain in weight, specific growth rate, food conversion ratio and gross conversion efficiency were analyzed following standard formula as described below:

Weight gain (g): Weight gain was determined by considering the final weight and initial weight of experimental fish.

Net weight gain (g) = Final weight (g) – Initial weight (g)

Per cent gain in weight

$$= \frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}} \times 100$$

Specific growth rate (SGR)

$$SGR = \frac{\ln Wt \quad \ln Wo}{t} \times 100$$

Where, Wt = Final weight (g)
Wo = Initial weight (g)
T = time duration (days)

Food conversion ratio (FCR)

$$FCR = \frac{\text{Weight of food given (g)}}{\text{Weight gain of fish (g)}}$$

Gross conversion efficiency (GCE)

$$GCE = \frac{\text{Weight gained (g)}}{\text{Food given (g)}}$$

Statistical Analysis: The data recorded for fish growth in different treatments were statistically analyzed using standard procedure for the analysis of variance of CRD as described by Gometz and Gometz (1984) [6] in order to test the significance of experimental results.

Results

Physico-Chemical Parameters

Physico-chemical parameters of water such as temperature, pH, electrical conductivity (EC), dissolved oxygen, alkalinity and total hardness were recorded and the average values of all these parameters are presented in Table 1.

The water temperature increased progressively from the initial day towards the end of the experiment. During the experiment, the average water temperature ranged between 26.31 - 26.79 °C. Further, the minimum (22.14 °C) and maximum (30.3 °C) water temperature was recorded in T_1 and control respectively (Table 1).

During the experimental period, the water remained alkaline. The values of pH ranged between 7.99 and 8.37. The minimum (7.99) pH value was noticed in T_2, T_3 & T_4 and maximum (8.37) was observed in T_1. Further, the mean values of pH were in the range of 8.54 to 8.59 in different treatments (Table 1).

The range and average values of electrical conductivity (EC) of experimental waters have been presented in Table 1. The highest (2.290 mMho/cm) and lowest (1.806 mMho/cm) values of EC were in control and T_1 respectively. The highest (2.003mMho) and lowest (1.930 mMho/cm) mean values were found in control and T_4.

The range and average values of dissolved oxygen (DO) in experimental waters have been presented in Table 1. The highest (5.66mg/l) and lowest (3.6mg/l) values of dissolved oxygen were in T_1 and control respectively. The highest (4.967mg/l) and lowest (4.622 mg/l) mean value were also found in T_1 and control respectively.

It would be seen from the Table 1 that the highest (376.67mg/l) and lowest (260.66mg/l) values of alkalinity were in control and T_3 respectively. The mean values were highest (315.25mg/l) and lowest (308.89mg/l) in T_4 and control respectively. Further, the respective highest (623.12mg/l) and lowest (400mg/l) values of hardness were in T_2 and control. The highest (517.56mg/l) and lowest (499.33mg/l) mean values were found in T_1 and control respectively.

Growth Parameters

The data pertaining to fish growth parameters such as weight gain, per cent gain in weight, specific growth rate (SGR), food conversion ratio (FCR) and gross conversion efficiency (GCE) of experimental fish, *Oreochromis niloticus* are presented in Tables 2.

Net weight gain

The net weight gain had shown significant positive relationship with rearing period. The highest (3.18 g) net weight gain was recorded in control, which was followed by T_1 (2.86g), T_2 (2.42g) and T_3 (2.13g). Whereas, the lowest net weight gain (1.21g) was in T_4 (Table 2). The recorded net weight gain was statistically significant between control and treatments at 5% level of probability ($p<0.05$).

Per cent gain in weight

The data pertaining to per cent gain in weight are given in Table 2. It would be seen for this that the highest per cent weight gain was in control. This was followed by T_1 (170.23%), T_2 (160.09%), T_3 (132.44%) and in T_4 (79.55%) (Table 2). The per cent weight gain in treatment and control was ($p< 0.05$) significantly different.

Specific growth rate (SGR)

The results pertaining to specific growth rate (SGR) are presented in Table 2. The SGR was significantly higher (0.928) in control as compared to other treatments. The lowest SGR (0.519) was found in T_4. It was significantly different between treatments and control at 5% level of probability ($p<0.05$).

Food conversion ratio (FCR)

The data pertaining to food conversion ratio (FCR) are presented in Table 2. It was significantly higher (11.60) in T_4 as compared to other treatments. The lowest FCR (3.22) was found in control. (Table 2). FCR was significantly different between treatment and control at 5% level of probability.

Gross conversion efficiency (GCE)

The data pertaining to the gross conversion efficiency (GCE) are presented in Table 2. GCE was significantly higher (0.343) in control as compared to other treatments. The lowest GCE (0.187) was found in T_4.

Discussion

Fish meal is considered the most desirable protein ingredients for fish owing to its high nutritional value and palatability. However, fish meal is the most expensive ingredient. Beside this, the availability of fish meal is decreasing day by day due to its high demand in other than aquaculture industry like livestock, poultry etc. The decreased supply of fish meal in future will dramatically affect the fish production. Considering this, it is essential to partially reduce or eliminate fish meal in fish diet. One approach to reduce fish meal from fish diets is to replace it with alternative less expensive and easily available plant protein, which will allow for continued expansion of aquaculture. In view of this, a number of plant protein source has been evaluated for the replacement of fish meal (Alceste and Jory, 2000; Yue and Zhou, 2008; Francis *et al* 2001) [2, 18, 5]. Water temperature is one of the most influencing environmental factors affecting growth of fish. The optimum temperature for feeding, growth and reproduction of tilapia is between 22 and 30 °C (Caulton, 1982) [3]. Studies on several fish species have revealed that growth rates increases with increasing temperature and show a parabolic pattern (Xiao-Jun and Ruyung, 1992; Watanabe *et al*., 1993; Larsson and Berglund, 2005) [16, 14, 9]. In the present study, the water temperature varied between 22.14 °C to 30.3 °C with a mean of 26.31 °C to 26.79 °C. It was well within the favorable range as suggested by Caulton (1982) [3]. Like water temperature, other water quality parameters (*i.e* pH, DO, alkalinity and hardness) were also within the favorable range for good aquaculture. Therefore, the growth variations in different treatments could not be assigned to water quality. This might be due to the quality of the feed given to experimental fish because the protein levels in different experimental diets were significantly different. Similar results were also reported by Al-kenaway *et al*. (2008) [1].

In the present study, the inputs of fish meal replacement with soybean meal (0-100%) have been evaluated on tilapia fry. The highest weight gain (3.18g), per cent weight gain (185.64%) and SGR (0.928) was noticed in control (Table 2) as compared to treatments. While comparing the treatments, it was found that the growth performance of experimental fish had negative impact of increasing soybean meal in fish diet. Similar results were also reported by Yee Lin *et al*. (2004) [13] and Xu *et al*. (2012) [17].

Yee Lin *et al*. (2004) [13] four isonitrogenic and isocaloric diets which contained 0-20% fish meal (or 57-29% dehulled soybean meal), randomly assigned to 4 net pens in each quarter and fed to the tilapia. After 6 weeks' feeding period, no significant ($P>0.05$) difference was found in per cent weight gain, feed conversion ratio and protein efficiency ratio among fish fed different experimental diets. (Yee Lin *et al.*, 2004) [13]. Xu *et al.* (2012) [17] have suggested that 75.00% or more substitution resulted in a poor weight gain, feed conversion ratio and survival rate compared to that of fish fed the control diet ($p<0.05$), whereas no significant differences were observed between diets of 25.00 to 62.50% substitution. Survival rate significantly decreased while FCR increased in the 75 to 100% substitution ($p<0.05$). Similarly, in the present study, the highest (3.18 g) net weight gain was recorded in control, which was followed by T_1 (2.86g), T_2 (2.42g) and T_3 (2.13g). Whereas, the lowest net weight gain (1.21g) was in T_4. The recorded net weight gain was statistically different between control and treatments. SGR was significantly higher (0.928) in control as compared to other treatments. Whereas, lowest SGR (0.519) was found in T_4. SGR was significant at 5% level of probability. FCR was also significantly higher (11.60) in T_4 as compared to other treatment. Whereas, lowest FCR (3.22) was found in control.

The Nile tilapias fed with control diet with no replacement of fish meal with soybean meal attended an average net weight of 3.18±0.93g. Thus, best growth of Nile tilapia was reported when fed with the control diet. Nile tilapia provided with the diet with 25 per cent replacement of fish meal with soybean meal (T_1) attended an average weight of 2.86±0.82g which was reported to be the highest in fish meal replaced diet. Thus, fish meal replaced by soybean meal had retardation effect on growth of Nile tilapia. While warring on tilapia feeding, other workers have also reported the similar result. (Yee Lin *et al*., 2004; Trosvik *et al*., 2013). [13, 12]

Jahan *et al*. (2012) [8] investigated the possibility of using soybean meal protein in lieu of fish meal as dietary protein source for *Labeo rohita* fry. Four iso-nitrogenous (30% protein) and iso-caloric (19 kJ/g GE) experimental diets were prepared as: diet 1 (100% fish meal protein), diet 2 (75% fish meal protein + 25% soybean meal protein), diet 3 (50% fish meal protein + 50% soybean meal protein) and diet 4 (25% fish meal protein + 75% soybean meal protein) and were fed to triplicate groups of 10 fish (per aquarium). Fish were fed two times daily at a rate of 5% of their body weight during the entire experimental period. The feeding ration was adjusted every 10th day through sampling of fish. Growth rate, feed conversion ratio (FCR) and protein efficiency ratio (PER) were significantly higher ($p<0.05$) in fish fed with diet 2, but those were similar to the diets 1 and 3. Analysis of proximate composition of the whole fish fed with different diets did not show any significant difference ($p>0.05$). The growth rates, FCR and PER as obtained from the different treatments indicate that fish meal protein could be replaced up to 50% by soybean meal protein in the diet of *L. rohita* fry without supplementation of amino acids.

There are various alternative protein sources that can be used in aquaculture diets, with soybean meal (SBM) being the most widely used plant protein ingredient.

However, use of SBM as the sole protein source has often resulted in reduced fish growth (Trosvik *et al*, 2013) [12]. Five isonitrogenous, isocaloric diets were fed to Nile tilapia, *Oreochromis niloticus* fry (0.1g) for 6 weeks. Diets contained various percentages (0, 10, 20, 30 and 40%) of yeast extract (YE), with Diet 1 formulated to be similar to a high-quality commercial diet containing 0% YE and 20% FM. At the conclusion of the feeding trial, fish fed Diet 1 had statistically significantly ($p<0.05$) higher mean final weight and specific growth rate and a lower feed conversion ratio than fish fed all other diets. Based upon the data, an organic diet which replaces FM with a combination of SBM and YE appears promising but further research is needed to refine formulation so as to have similar growth performance with a FM-based diet.

In general, it was noticed that the growth pattern between fish meal basal (100%) diet (i.e. control) and soybean meal +fish meal based diets (T_1+T_4) was different. As such the highest growth rate was obtained in control (100% fish meal) than other treatments. Further, on comparing different treatments on the basis of growth, it was noticed that the growth was significantly reduced with increasing soybean meal replacement rate. However, the growth between control (100 FM) and T_1 (75 FM +25 SBM) had no significant difference in growth. Further, the cost of feed used for T_1 is considerably less than the control diet. Therefore it is concluded that the FM could be replaced with SBM in fry of *Oreochromis niloticus.* At the same time it is also recommend that the fish meal replacement rate with 25% SBM also be tested in different size groups as the protein requirement reducing with increasing size.

Acknowledgement

Authors record their sincere thanks to Dean, College of Fisheries for their encouragement and for extending facilities for conducting this research.

Table 1: Range and mean values of selected water quality parameters

Parameters	Treatments				
	T_0 (Control)	T_1	T_2	T_3	T_4
Temperature(ºC)	22.17-30.3 (26.31)	22.14-29.90 (26.79)	22.15-29.77 (26.74)	22.20-29.65 (26.71)	22.55-29.55 (26.68)
DO(mg/l)	3.6-5.6 (4.622)	4.46-5.66 (4.967)	4.02-5.53 (4.79)	3.13-5.49 (4.790)	4.09-5.26 (4.750)
pH	8.00-8.37 (8.16)	8.01-8.31 (8.14)	7.99-8.30 (8.13)	7.99-8.30 (8.13)	7.99-8.31 (8.13)
EC (mMho/cm)	1.810-2.290 (2.003)	1.806-2.170 (1.957)	1.809-2.126 (1.939)	1.812-2.108 (1.931)	1.815-2.114 (1.930)
Hardness (mg/l)	400-600 (499.33)	434.29-614.29 (517.56)	427.66-623.12 (517.13)	427.46-617.16 (514.79)	430.50-616.56 (516.44)
Alkalinity (mg/l)	263.33-376.67 (308.89)	269.05-372.38 (313.97)	267.49-371.73 (315.21)	260.66-370.72 (314.09)	263.71-370-73 (315.25)

Table 2: Summery of growth parameter Nile tilapia

Parameter	Cumulative Net weight gain (g)	Per cent weight gain (%)	SGR (%)	FCR (%)	GCE (%)
T_0(Control)	3.18 ± 0.93^a	185.10 ± 55.01^a	0.928 ± 0.27^a	3.22 ± 0.22^d	0.343 ± 0.10^a
T_1	2.86 ± 0.82^b	170.34 ± 49.31^b	0.881 ± 0.25^b	3.67 ± 0.44^c	0.324 ± 0.09^b
T_2	2.42 ± 0.70^c	160.16 ± 46.22^b	0.847 ± 0.24^b	3.34 ± 0.03^d	0.309 ± 0.09^b
T_3	2.13 ± 0.61^d	132.44 ± 38.25^c	0.748 ± 0.22^c	6.10 ± 0.73^b	0.275 ± 0.08^c
T_4	1.21 ± 0.35^e	79.55 ± 22.98^d	0.519 ± 0.15^d	11.60 ± 3.03^a	0.187 ± 0.05^d
3.3.18 gram of fish net weight for = cost of used feed $ 0.28 1 1000 gram of fish net weight gain = cost of used $ 88.05 [Feed are significant compared to control]					

Reference

1. Al-Kenawy D, El -nagger G, Mohamed YAZ. Total replacement of fishmeal with soybean meal in diets for Nile tilapia in pre-fertilized ponds. 8th International symposium on tilapia in Aquaculture. 2008; 2:773-784.
2. Alceste CC, Jory DE. Tilapia- Alternative protein sources in tilapia feed formulation. *Aquaculture Magazine*, 2000; 26(4):199-1388.
3. Caulton MS. Feeding, metabolism and growth of tilapias: some quantitative considerations. In: Pullin RSV and Lowe McConnell RH (Eds). The Biology and Culture of Tilapias. ICLARM, Manila, Philippines, 1982; 157-180.
4. Floreto EAT, Bayer RC, Brown PB. The effects of soybean-based diets, with and without amino acid supplementation, on growth and biochemical composition of juvenile American lobster, *Homarus*

americanus. Aquaculture. 2000; 189(3-4):211-235

5. Francis G, Makkar HPS, Becker K. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture. 2001; 199(3-4):197-227.
6. Gomez KA, Gomez AA. Statistical procedures agriculture research. 2nd Edition. John Wiley and Sons. New York, 1984.
7. Higgs DA, Dosanjh BS, Prendergast AF, Beames RM, Hardy RW, Riley W *et al*. Use of rapeseed, canola protein products in finfish diets. In C. Lim and D.J. Sessa (eds). Nutrition and utilization technology in aquaculture. ASCS Press, Champaign, Illimois, 1995, 130-156.
8. Jahan DA, Hussain L, Islam MA, Khan MM, Nima A. Use of soybean as partial substitute of fish meal in the diets of rohu, *Labeo rohita* (Ham.) fry. The Agriculturists. 2012; 10(2):68-76.
9. Larsson S, Berglund I. The effect of temperature on the growth energetic, growth efficiency of Aractic charr (*Salvelinus alpinus* L.) from four Swedish populations. *Journal of Thermal Biology*. 2005; 30(1):29-36.
10. Lalles JP. Nutritional and anti-nutritional aspects of soybean and field pea proteins used in veal calf production: a review, Livest Prod Sci. 1993; 34(3-4):181-202.
11. Lovell RT. Use of soybean meal products in diets for aquaculture species. Journal of Aquatic Products. 1988; 2:27-52.
12. Trosvik KA, Webster CD, Thompson KR, Metts LA, Gannam A, Twibell R. Effects on growth performance and body composition in Nile tilapia, *Oreochromis niloticus* and fry fed organic diets containing yeast extract and soybean meal as a total replacement of fish meal without amino acid supplementation. Biological Agriculture & Horticulture. 2013; 29(3):173-185.
13. Way-Yee Lin, Che-Chun Chen, Ming-Che Du, Chen-Huei Huang. Replacement of Fish Meal with De-hulled Soybean Meal in Diets on Growth of Subadult Hybrid Tilapia, Oreochromis niloticus x O. aureus, J. Fish. Soc. Taiwan. 2004; 31(4):263-268.
14. Watanabe WO, Ernst DH, Chasar MP, Wichlund RI, Olla BL. The effects of temperature and salinity on growth and feed utilization of juvenile, sex-reversed male Florida red tilapia cultured in a recirculating system. Aquaculture. 1993; 112(4):309-320.
15. Wilson RP, Poe WE. Effects of feeding soybean meal with varying trypsin inhibitor activities on growth of fingerling channel catfish. Aquaculture, 1985; 46(1):19-25.
16. Xiao-Jun X, Ruyung S. The bioenergetics of the southern catfish (*Silurus meridionalis*, Chen) growth rate as a function of ration level and temperature. Journal of Fish Biology. 1992; 40(5):719-730.
17. Xu QY, Wang CA, Zhao ZG, Luo L. Effects of Replacement of Fish Meal by Soy Protein Isolate on the Growth, Digestive Enzyme Activity and Serum Biochemical Parameters for Juvenile Amur Sturgeon (*Acipenser schrenckii*). Asian-Australas J Anim Sci. 2012; 25(11):1588-1594.
18. Yue YR, Zhou QC. 2008. Effect of replacing soybean meal with cottonseed meal on growth, feed utilization, and hematological indexes for juvenile hybrid tilapia, *Oreochromis niloticus* × *O. aureus*. *Aquaculture*, 284(1/4): 185–189.