Animal Nutrition 2 (2016) 204–210

Contents lists available at ScienceDirect

Animal Nutrition

journal homepage: http://www.keaipublishing.com/en/journals/aninu/

Original research article

Effects of dietary arginine levels on growth performance, body composition, serum biochemical indices and resistance ability against ammonia-nitrogen stress in juvenile yellow catfish (*Pelteobagrus fulvidraco*)

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ARTICLE INFO

Article history:
Received 8 April 2016
Received in revised form
22 June 2016
Accepted 11 July 2016
Available online 17 July 2016

Keywords:
Arginine
Yellow catfish (*Pelteobagrus fulvidraco*)
Growth performance
Body composition
Serum biochemical indices
Ammonia-nitrogen stress

ABSTRACT

This experiment was conducted to investigate the effects of dietary arginine levels on growth performance, body composition, serum biochemical indices and resistance ability against ammonia-nitrogen stress in juvenile yellow catfish (*Pelteobagrus fulvidraco*). Five isonitrogenous and isolipidic diets (42% protein and 9% lipid) were formulated to contain graded levels of arginine (2.44%, 2.64%, 2.81%, 3.01% and 3.23% of diet), by supplementing *L*-Arginine HCl. Seven hundred juvenile yellow catfish with an initial average body weight of 1.13 ± 0.02 g were randomly divided into 5 groups with 4 replicates of 35 fish each and each group was fed one of the diets. After 56 d feeding, fish were exposed to 100 mg/L of ammonia-nitrogen for 72 h. The results showed that weight gain (WG) and specific growth rate (SGR) in 2.64% and 2.81% groups were significantly higher than those in 3.23% group ($P < 0.05$). The feed conversation ratio (FCR) in 2.64%, 2.81% and 3.01% groups was significantly decreased when compared with 3.23% group. The protein efficiency ratio (PER) in 2.64% group was significantly higher than that in 2.44% and 3.23% groups ($P < 0.05$). The condition factor (CF) of fish was significantly higher in 2.81% group than that in 2.44% group ($P < 0.05$). Dietary arginine levels had no significant effect on hepatosomatic index (HSI), viscerosomatic index (VSI), and whole-body dry matter, crude protein, crude lipid, ash contents, as well as serum total protein (TP), triglyceride (TG), glucose (GLU), urea nitrogen (UN) contents and aspartate aminotransferase (AST), alanine aminotransferase (ALT) activities ($P > 0.05$). After the fish were challenged to ammonia-nitrogen for 72 h, their cumulative mortality rate in 2.81% group was significantly lower than that in 2.44% group ($P < 0.05$). The results suggested that dietary arginine level at 2.81% could optimize anti-ammonia-nitrogen stress ability of juvenile yellow catfish and a level of 3.23% arginine seemed to depress the growth performance of fish and decreased their tolerance to the ammonia-nitrogen stress under current study. A quadratic regression analysis based on WG indicated that the optimal dietary arginine requirement of juvenile yellow catfish was estimated to be 2.74% of the diet (6.45% of dietary protein) under current culture conditions.

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Peer review under responsibility of Chinese Association of Animal Science and Veterinary Medicine.

Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.aninu.2016.07.001

1. Introduction

Yellow catfish (*Pelteobagrus fulvidraco*), belongs to Bagridae in Siluriformes, is a fish with particular flavor and rich nutrition (Huang et al., 2010). The fish fillet has no intermuscular bone and tender muscle (Li et al., 2009). Because of its excellent meat quality, yellow catfish not only has good sales in China, but also has a potential market in Japan, South Korea and Southeast Asia (Pan et al., 2008). Recently, the production of yellow catfish has been largely increased in order to meet the market demands in China (Gao et al., 2011) and they tend to be cultured in intensive conditions, which is around 3,000 kg/667 m^2. However, in the high density of factory farming water, the ammonification of bait and fish excreta will produce large amounts of ammonia nitrogen, and excessive ammonia nitrogen will result in food intake decreased, growth reduction and immune suppression, stress for a long time even cause death (Shi et al., 2015).

As one of the essential amino acids for fish, arginine takes part in many metabolic reactions in animal bodies, such as the synthesis of protein, carbamide and ornithine, the metabolism of glutamic acid and proline, the synthesis of creatine and polyamine, and the excretion of insulin and glucagon (Luo et al., 2004). Previous studies have shown that dietary arginine supplementation can improve the growth performance (Pohlenz et al., 2014), enhance immunity (Cheng et al., 2011), and reduce the environmental stress (Oehme et al., 2010) of fish. The arginine requirements among different species of fish have been shown to vary from 1.0% to 3.1% of dietary, which is possibly affected by fish species and sizes, dietary protein sources and levels, management methods, feeding strategy and experimental conditions (NRC, 2011; Ren et al., 2013; Zhou et al., 2015). The arginine requirement of yellow catfish was 2.38% to 2.74% of the dry diet (Zhou et al., 2015).

To our knowledge, there is no information available concerning the effect of dietary arginine on the anti-ammonia-nitrogen stress ability in yellow catfish. This study was conducted to investigate the effects of dietary arginine levels on growth performance, body composition, serum biochemical indices and resistance ability against ammonia-nitrogen stress in yellow catfish.

2. Materials and methods

2.1. Experimental diets

Five isonitrogenous and isolipidic diets (Table 1) (42% protein and 9% lipid), using fishmeal and soybean as main protein sources, wheat flour as main carbohydrate source, fish oil and soybean oil as main lipid sources, were formulated to contain 5 graded levels of arginine (2.44%, 2.64%, 2.81%, 3.01% and 3.23% of diet), by supplementing *L*-Arginine HCl (the purity ≥ 99%, Ningbo Daxie Development Zone Haide Amino Acid Industry Co., Ltd., Ningbo, China). The diets were kept isonitrogenous by adding different levels of alanine before pelleting. Final arginine concentrations of the 5 experimental diets were measured after acid hydrolysis using high performance liquid chromatography (HPLC) system (LC1260, Agilent Technologies Inc., Germany) equipped with Agilent ZORBAX Eclipse Plus C_{18} columns (150 mm × 5 μm, Australia). Dietary protein and lipid levels referenced to the previous formula in our lab (Zhao et al., 2015). The arginine levels were chosen refer to the recommended concentration of Zhou et al., (2015) and adjusted according to the fish size and experimental conditions. All the ingredients were ground into powder through 60-mesh, weighed accurately according to the formula, and then mixed before adding fish oil and soybean oil into kneading machine (NH-10, Science and Technology Industrial General Factory of South China University of Technology, Guangzhou, China). The feed ingredients were thoroughly mixed with appropriate amount of water in a strong stirrer (B20, Guangzhou Panyu Lifeng Food Machinery Factory, Guangzhou, China), then processed into 1.5 mm diameter strip using twin screw extruder (SLX-80, Science and Technology Industrial General Factory of South China University of Technology, Guangzhou, China). The resultant strips were made into granule at granulator (G-500, Science and Technology Industrial General Factory of South China University of Technology, Guangzhou, China) and then dried at the temperature of 55°C for 6 h, stored at −20°C after natural cooling. The proximate composition and amino acid composition of each diet are presented in Tables 1 and 2.

2.2. Fish and experimental conditions

The feeding trial was conducted in an indoor re-circulating aquaculture system at Animal Science Research Institute of Guangdong Academy of Agricultural Sciences (Guangzhou, China). Experimental fish were obtained from Sand Fishery Base in Qingyuan city of Guangdong Province (Qingyuan, China). The circling waterflow rate in each aquarium was maintained at 1.5 L/min. Prior to the feeding trial, the fish were fed a commercial diet (42% protein and 9% lipid) twice daily (08:30 and 18:30) for 2 weeks to acclimate to the experimental conditions. Similar sized juvenile yellow catfish with an initial average body weight of 1.13 ± 0.02 g were selected and randomly distributed into twenty 330-L cylindrical fiberglass tanks (the water volume was 300 L) at 35 fish per tank. Each diet was randomly assigned to 4 tanks. Fish were fed 2 times daily at 08:30 and 18:30, and feeding level was 5% to 6% of

Table 1
Formulation and proximate composition of experimental diets (air-dry basis, %).

Item	Dietary arginine levels, %				
	2.44	2.64	2.81	3.01	3.23
Ingredients					
Peru fish meal[1]	25.00	25.00	25.00	25.00	25.00
Soybean meal[1]	30.00	30.00	30.00	30.00	30.00
Rapeseed meal[1]	9.00	9.00	9.00	9.00	9.00
Corn gluten meal[1]	6.00	6.00	6.00	6.00	6.00
Wheat flour[1]	20.50	20.66	20.82	20.98	21.14
Fish oil[1]	2.50	2.50	2.50	2.50	2.50
Soybean oil[1]	2.50	2.50	2.50	2.50	2.50
Vitamin premix[2]	0.10	0.10	0.10	0.10	0.10
Mineral premix[3]	0.50	0.50	0.50	0.50	0.50
$Ca(H_2PO4)_2$[1]	1.50	1.50	1.50	1.50	1.50
Vitamin C ester[1]	0.10	0.10	0.10	0.10	0.10
Choline chloride[1]	0.30	0.30	0.30	0.30	0.30
L-Arginine HCl	0.00	0.24	0.48	0.72	0.96
Alanine[1]	2.00	1.60	1.20	0.80	0.40
Total	100.00	100.00	100.00	100.00	100.00
Proximate composition					
Crude protein	42.8	42.0	42.6	42.4	42.6
Crude lipid	8.9	9.0	9.3	8.7	8.7
Ash	7.9	7.9	7.9	7.9	7.9
Moisture	7.0	6.7	6.8	6.9	6.8

[1] Fishtech Fisheries Science & Technology Company, LTD, Institute of Animal Science, Guangdong Academy of Agricultural Sciences (Guangzhou, China).

[2] The vitamin premix was provided by Fishtech Fisheries Science & Technology Company, LTD, Institute of Animal Science, Guangdong Academy of Agricultural Sciences (Guangzhou, China). One kilogram of vitamin premix contained the following: VA 3,200,000 IU, VB_1 4 g, VB_2 8 g, VB_6 4.8 g, VB_{12} 0.016 g, VD 1,600,000 IU, VE 16 g, VK 4 g, nicotinic acid 28 g, calcium pantothenate 16 g, folic acid 1.28 g, inositol 40 g, biotin 0.064 g. Moisture ≤10%.

[3] The mineral premix was provided by Fishtech Fisheries Science & Technology Company, LTD, institute of Animal Science, Guangdong Academy of Agricultural Sciences (Guangzhou, China). One kilogram of mineral premix contained the following: $MgSO_4 \cdot H_2O$ 12 g, $Ca(IO_3)_2$ 9 g, KCl 36 g, Met-Cu 1.5 g, $ZnSO_4 \cdot H_2O$ 10 g, $FeSO_4 \cdot H_2O$ 1 g, Met-Co 0.25 g, $NaSeO_3$ 0.003 6 g. Moisture ≤10%.