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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**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 conversion 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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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 m². 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 ≥ 98%, Ningbo Daxie Development Zone Haide Amino Acid Industry Co., Ltd., Ningbo, China). The diets were kept isonitrogenous by adding different levels of arginine (2.44%, 2.64%, 2.81%, 3.01% and 3.23% of diet), by supplementing L-arginine HCl (the purity ≥ 98%, Ningbo Daxie Development Zone Haide Amino Acid Industry Co., Ltd., Ningbo, China). The resultant strips were made into grinder 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 Panju 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-S00, 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 workflow 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 body weight.

Table 1

| Item                      | 2.44% | 2.64% | 2.81% | 3.01% | 3.23% |
|---------------------------|-------|-------|-------|-------|-------|
| Ingredients               |       |       |       |       |       |
| Peru fish meal            | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| Soybean meal              | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 |
| Rapsseed meal             | 9.00  | 9.00  | 9.00  | 9.00  | 9.00  |
| Corn gluten meal         | 6.00  | 6.00  | 6.00  | 6.00  | 6.00  |
| Wheat flour               | 20.50 | 20.66 | 20.82 | 20.98 | 21.14 |
| Fish oil                  | 2.50  | 2.50  | 2.50  | 2.50  | 2.50  |
| Soybean oil               | 2.50  | 2.50  | 2.50  | 2.50  | 2.50  |
| Vitamin premix            | 0.10  | 0.10  | 0.10  | 0.10  | 0.10  |
| Mineral premix            | 0.50  | 0.50  | 0.50  | 0.50  | 0.50  |
| Ca(H2PO4)2                | 1.50  | 1.50  | 1.50  | 1.50  | 1.50  |
| Vitamin C ester           | 0.10  | 0.10  | 0.10  | 0.10  | 0.10  |
| Choline chloride          | 0.30  | 0.30  | 0.30  | 0.30  | 0.30  |
| L-Arginine HCl            | 0.00  | 0.24  | 0.48  | 0.72  | 0.96  |
| Alamine                   | 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   |

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Protein efficiency ratio (PER) = dry diet fed (g)/wet weight gain (g);  
Feed conversion ratio (FCR) = dry diet fed (g)/wet weight gain (g);  
Specific growth rate (SGR, %/d) = 100 × [Ln final individual weight (g) – Ln initial individual weight (g)]/number of feeding days;  
Protein efficiency ratio (PER) = 100 × wet weight gain (g)/protein fed (g);  
CF (g/cm²) = 100 × body weight (g)/body length (cm)²;  
HSI (%) = 100 × liver weight (g)/body weight (g);  
VSI (%) = 100 × viscera weight (g)/body weight (g).

### 2.4.2. Proximate composition analysis

All experimental diets and fish samples were analyzed in duplicate for proximate composition following the standard methods (AOAC, 1995). Moisture was determined by oven drying to a constant weight at 105°C. Crude protein (N × 6.25) was determined by the Kjeldahl method using a semi-automatic Kjeldahl System after acid digestion. Crude lipid was determined by using the Soxhlet extraction method. Crude ash was determined after burning at 550°C in a muffle furnace.

### 2.4.3. Serum biochemical indices analysis

Serum total protein (TP), triacylglycerol (TG), glucose (GLU), urea nitrogen (UN) contents and aspartate aminotransferase (AST), alanine aminotransferase (ALT) activities were analyzed using Roche Kit and an automatic blood analyzer (Hitachi 7170A, Japan) in Kingmed Diagnostics (Guangzhou, China).

### 2.5. Ammonia-nitrogen stress test

After a 56 d feeding trial, fourteen fish were randomly selected from each tank for an ammonia-nitrogen stress test using ammonium chloride. During the test, the fish were not fed. The concentration of un-ionized ammonia and the calculation method as described by Li et al. (2009). Ammonium chloride solution was poured into each tank of 150 L to set the level of total ammonia nitrogen at 100 mg/L, and the concentration of un-ionized ammonia was 2.65 mg/L (pH 7.52; water temperature = 30.5°C). During the stress test, water temperature, pH level, and ammonia nitrogen concentration were determined every 6 h, and adjust the concentration of non-ionized ammonia according to the results using ammonium chloride solution. Mortality was recorded every 6 h during the period of 72 h stress test and dead fish were removed. The cumulative mortality rate (CMR) was calculated as follows:

\[
CMR(\%) = 100 \times \frac{\text{number of death fish after stress test}}{\text{number of fish before stress test}}
\]

### 2.6. Statistical analysis

All data were presented as means ± SD, n = 4, and analyzed using SPSS 20.0 (Chicago, USA) for Windows. The data were analyzed by homogeneity test of variances first. Data accorded with homogeneity of variance were analyzed by one-way analysis of variance and performed using Tukey’s test for multiple comparison if there was a significant difference, or using Dunnett’s T3 for multiple comparison. The statistical significance was examined at P < 0.05. The dietary arginine requirement for yellow catfish was estimated using the quadratic regression method using the SigmAPlot statistical software program (version 10.0).

### 3. Results

#### 3.1. Effect of dietary arginine levels on growth performance of yellow catfish

The SR for all treatments was 100%, and no pathological or abnormal condition were appeared during the feeding trial. The

### Table 2

| Item            | Dietary arginine levels, % | 2.44 | 2.64 | 2.81 | 3.01 | 3.23 |
|-----------------|---------------------------|------|------|------|------|------|
| Essential amino acids | Arg                      | 2.44 | 2.64 | 2.81 | 3.01 | 3.23 |
|                  | His                      | 0.96 | 0.96 | 0.97 | 0.97 | 0.98 |
|                  | Ile                      | 1.75 | 1.76 | 1.75 | 1.76 | 1.76 |
|                  | Leu                      | 3.32 | 3.38 | 3.36 | 3.36 | 3.36 |
|                  | Lys                      | 2.46 | 2.50 | 2.48 | 2.47 | 2.49 |
|                  | Met                      | 0.67 | 0.69 | 0.67 | 0.69 | 0.69 |
| Non-essential amino acids | Ala                  | 4.36 | 4.02 | 3.60 | 3.21 | 2.80 |
|                  | Asp                      | 3.55 | 3.60 | 3.58 | 3.58 | 3.59 |
|                  | Glu                      | 7.70 | 7.85 | 7.78 | 7.81 | 7.81 |
|                  | Gly                      | 2.22 | 2.24 | 2.22 | 2.24 | 2.23 |
|                  | Ser                      | 2.08 | 2.10 | 2.10 | 2.11 | 2.10 |
|                  | Tyr                      | 1.16 | 1.20 | 1.15 | 1.18 | 1.18 |
effects of dietary arginine levels on WG, SGR, FCR, PER, CF, HSI and VSI are presented in Table 3. The WG and SGR in 2.64% and 2.81% groups were significantly higher than those in 3.23% group ($P < 0.05$). The FCR in 2.64%, 2.81% and 3.01% groups was significantly decreased when compared with 3.23% group ($P < 0.05$). The PER in 2.64% group was significantly higher than that in 2.44% and 2.32% groups ($P < 0.05$). The 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 effects on HSI and VSI. A quadratic regression analysis on WG against dietary arginine levels 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) (Fig. 1).

3.2. Effect of dietary arginine levels on body composition of yellow catfish

The contents of dry matter, crude protein, crude lipid and ash in the whole body were not significantly affected by dietary arginine levels ($P > 0.05$) (Table 4).

3.3. Effect of dietary arginine levels on serum biochemical indices of yellow catfish

Table 5 showed that dietary arginine levels had no significant effect on serum TP, TG, GLU, UN contents and AST, ALT activities ($P > 0.05$). The serum TP contents were increased with the increasing of dietary arginine levels.

3.4. Effect of dietary arginine levels on anti-ammonia-nitrogen stress ability of yellow catfish

From Table 6, it was found that after a 72 h ammonia nitrogen stress test, compared with 2.44% group, the CMR of 2.81% group was significantly decreased ($P < 0.05$).

4. Discussion

Arginine can participate in the synthesis of protein and polysaccharide to promote animal growth (Wan et al., 2006). Previous studies have indicated that arginine can improve the growth performance of fish (Alam et al., 2002; Buentello and Gatlin III, 2000; Farhat and Khan, 2012; Wang et al., 2015). According to the results in this study, WG, SGR, FCR and PER of yellow catfish were achieve the best in 2.64% group. In the present study, the SGR of yellow catfish was 5.27 to 5.36%/d, higher than the values reported by Li et al. (2016) (1.82 to 1.99%/d), Zhou et al. (2015) (2.85 to 3.23%/d) and Zhao et al. (2015) (3.75 to 3.94%/d), which is possibly affected by the initial weight of fish, dietary nutrient levels and feeding management. A quadratic regression analysis on WG against dietary arginine levels 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). The optimal requirement level was within the range of reported values from 3.8% to 8.1% protein of different species (NRC, 2011; Tu et al., 2015), but higher than the result (5.29% of dietary protein) in yellow catfish (2.00 ± 0.02 g) at the nutrition levels of 45% protein and 7% lipid of an 84-day feeding trial (Zhou et al., 2015). The reason for the difference may be due to the fish sizes, dietary protein levels, culture cycle and other factors.

![Fig. 1. Relationship between dietary arginine levels and weight gain of yellow catfish (Pelteobagrus fulvidraco).](image)

Table 3
Effects of dietary arginine levels on growth performance of yellow catfish (Pelteobagrus fulvidraco).

| Item                  | Dietary arginine levels, % |
|----------------------|----------------------------|
|                      | 2.44 | 2.64 | 2.81 | 3.01 | 3.23 |
| Initial weight, g    | 1.13 ± 0.01 | 1.13 ± 0.01 | 1.15 ± 0.01 | 1.12 ± 0.02 | 1.14 ± 0.02 |
| Final weight, g      | 22.27 ± 0.74b | 22.79 ± 0.68b | 22.86 ± 0.54b | 22.14 ± 0.61b | 21.73 ± 0.34a |
| WG, %                | 1,867.03 ± 56.36ab | 1,914.04 ± 51.73b | 1,892.88 ± 44.43b | 1,882.52 ± 25.63ab | 1,815.09 ± 19.76a |
| SGR, %/d             | 5.32 ± 0.05ab | 5.36 ± 0.05b | 5.34 ± 0.04b | 5.32 ± 0.01ab | 5.27 ± 0.02a |
| FCR                  | 0.79 ± 0.02ab | 0.77 ± 0.02a | 0.78 ± 0.02b | 0.78 ± 0.01a | 0.81 ± 0.01b |
| PER                  | 2.96 ± 0.09ab | 3.09 ± 0.08b | 3.01 ± 0.07ab | 2.99 ± 0.02ab | 2.89 ± 0.03b |
| CF, g/cm³            | 2.40 ± 0.06a | 2.41 ± 0.10a | 2.69 ± 0.16b | 2.51 ± 0.02a | 2.42 ± 0.09a |
| HSI, %               | 1.35 ± 0.09a | 1.36 ± 0.07a | 1.33 ± 0.06a | 1.19 ± 0.08a | 1.22 ± 0.19a |
| VSI, %               | 7.25 ± 0.39a | 7.78 ± 0.47a | 7.57 ± 0.60a | 8.09 ± 0.13a | 7.52 ± 0.18a |

WG = weight gain; SGR = specific growth rate; FCR = feed conversion ratio; PER = protein efficiency ratio; CF = condition factor; HSI = hepatosomatic index; VSI = viscerosomatic index.

$^{ab}$ In the same row, values with no or the same letter superscripts mean no significant difference ($P > 0.05$), and with different letter superscripts mean significant difference ($P < 0.05$).

![Graph](image)

Table 4
Effects of dietary arginine levels on body composition of yellow catfish (Pelteobagrus fulvidraco) (wet weight, %).

| Item                  | Dietary arginine levels, % |
|----------------------|----------------------------|
|                      | 2.44 | 2.64 | 2.81 | 3.01 | 3.23 |
| Dry matter           | 25.2 ± 0.4 | 25.5 ± 0.6 | 25.3 ± 0.7 | 25.2 ± 0.6 | 25.5 ± 0.9 |
| Crude protein        | 15.1 ± 0.2 | 15.2 ± 0.3 | 15.3 ± 0.2 | 15.2 ± 0.3 | 15.2 ± 0.6 |
| Crude lipid          | 5.5 ± 0.2 | 5.9 ± 0.2 | 6.0 ± 0.3 | 5.4 ± 0.4 | 5.6 ± 0.8 |
| Ash                  | 3.2 ± 0.0 | 3.4 ± 0.0 | 3.4 ± 0.1 | 3.4 ± 0.1 | 3.3 ± 0.2 |

In the same row, values with no letter superscripts mean no significant difference ($P > 0.05$).
The results of the previous studies on arginine requirements of aquatic animals showed that the requirements of some marine fish varied between 6.20% and 7.74% of dietary protein (Ren et al., 2014; Yue et al., 2013; Lin et al., 2015; Zhou et al., 2010, 2012b). And the requirements of some freshwater fish varied between 4.08% and 7.23% of dietary protein (Ahmed, 2013; Zhou et al., 2012a; Wang et al., 2015; Khan and Abidi, 2011; Ren et al., 2013; Liao et al., 2014). A comparison between the 2 types of results indicated that the arginine requirements of marine fish were higher than those of freshwater fish. However, its influencing factors and principle were still unknown, and further research is needed.

In this study, with the further increasing of dietary arginine levels, the negative influence on WG, SGR, FCR and PER was observed, and this was similar to the results reported for stinging catfish (Farhat and Khan, 2012), India major carp (Carassius auratus gibelio) (Ahmed and Khan, 2004), cobia (Rhinoptera bonasus) and Nile tilapia (Yue et al., 2013). The study in mammals has pointed that the reduced growth in animal fed diets with excessive arginine may be due to the antagonism between lysine and arginine, but the mechanism in fish is still far from clear (Ahmed, 2013). Lysine-arginine antagonism was shown to exist in Atlantic salmon (Salmo salar) (Berge et al., 1997) and blunt snout bream (Liao et al., 2014). However, (Alam et al., 2002) and (Zhou et al., 2015) showed that no competitive inhibition was found between arginine and lysine on Japanese flounder (Paralichthys olivaceus) or yellow catfish.

In this study, dietary arginine levels had no significant effects on the HSI and VSI of yellow catfish, and the CF in 2.81% group was significantly increased when compared with 2.44% group. The results were similar to the report in 2 different sizes of gibel carp (Carassius auratus gibelio) var. CAS III) (Tu et al., 2015). However, Lin et al. (2015) pointed that HSI, VSI and CF of golden pompano were not significantly affected by dietary arginine levels. Farhat and Khan (2012) considered that the increasing of dietary arginine levels can significantly reduce the HSI and increase the CF, but no significant effect on VSI of stinging catfish. Different results showed that the HSI, VSI and CF of fish were not only related to the levels of dietary arginine, but also affected by the species and size, management and experimental conditions.

Whole body composition of yellow catfish was not significantly affected by dietary arginine levels, which agreed with the reports in blunt snout bream (Ren et al., 2013) and grouper (Epinephelus coioides) (Luo et al., 2007). However, other studies indicated that the protein content in the whole body increased with dietary arginine level increasing and decreased significantly when dietary arginine was higher than the optimal requirement (Tu et al., 2015; Zhou et al., 2012b). The reason for the different results may be due to that arginine can be digested and absorbed by fish and deposited in the body, while excessive arginine will not be used or even had an inhibiting effect. At present, the mechanism of the effect of arginine on the body protein of fish has not been elucidated, it may be explained through the comparison of an arginine deficiency group.

The serum biochemical can reflect the health status, nutrition status and the adaptability to environment when fish occurring physiological or pathological changes affected by external factors (Shi et al., 2012). Some researchers held that the change of fish serum biochemical indices might be caused by stress, or by some change of amino acids in diet (Lin et al., 2015). In this study, there was no significant effect of dietary arginine levels on serum TG, which agrees with previous finding in red sea bream (Pogrus major) (Rahimnejad and Lee, 2014) and golden pompano (Lin et al., 2015). The AST and ALT are generally used as indicators of cellular damage both in mammals and in fishes (Olsen et al., 2005). The result of the present study showed that dietary arginine levels had no damage to the liver of yellow catfish. The content of serum UN can reflect the balance of protein and amino acid metabolism in fish. Alam et al. (2002) found that the content of UN in serum was affected by the levels of dietary arginine. This study had a different result, which may be caused by the different of fish species, culture cycle, dietary protein and the arginine levels.

Some studies have showed that the excessive ammonia nitrogen in the environment can affect the immune system (Yue et al., 2010), also damage the gill, liver, kidney and other organs of the fish (Zhang et al., 2015). In this study, appropriate of dietary arginine level can reduce the CR after ammonia nitrogen stress, and the results was similar to that of promoting the growth. This agrees to the conclusion of that the growth rate of fish is often related to the disease resistance (Lin et al., 2015). The reason for improving the ability of anti-ammonia nitrogen stress in fish may be related to the effect of arginine and its metabolites in immune regulation and immune defense (Sun et al., 2014). The role of
arginine in the regulation of immune regulation in vivo is mainly carried through the nitric oxide (NO) pathway and the arginine pathway. The NO pathway means that the citrulline and NO derived from oxidation of arginine catalyzed by nitric oxide synthase (NOS). And NO is not only the effector molecule of tumor immunity and microbial immunity, but also the regulatory factors of variety of immune cells. In addition, the synthesis and metabolic pathway of arginine involved in the detoxification pathway of fish to ammonia nitrogen, which means that the relationship between arginine and ammonia nitrogen metabolism related enzymes (glutamate dehydrogenase, glutamine synthetase and arginase) is worth further research. At present, study about arginine on anti-ammonia-nitrogen stress ability has not been reported, and the mechanism needs to be further studied.

5. Conclusions

In summary, 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 on weight gain rate against dietary arginine levels 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).

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