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Dietary Arginine Requirement of GIFT Tilapia (Postprint)

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Abstract

Six isonitrogenous and isoenergetic semi-purified diets with dietary arginine levels of 0.67%, 0.94%, 1.24%, 1.58%, 1.86%, and 2.11% (crude protein content 30.21%, gross energy 17.77 MJ/kg) were fed to GIFT tilapia with initial body weight of (81.52±2.00) g for 60 days to investigate the effects of dietary arginine level on growth performance, feed utilization, body composition, serum biochemical indices, and non-specific immune indices of GIFT tilapia, and to determine the optimal dietary arginine requirement. Each diet was fed to three cages, with 15 fish stocked per cage. The results showed that with increasing dietary arginine level, the weight gain rate, specific growth rate, protein efficiency, and protein retention rate of GIFT tilapia exhibited a trend of first increasing and then decreasing, all reaching maximum values in the 1.58% group, which were significantly different from other groups ($P<0.05$); feed conversion ratio, hepatosomatic index, and viserosomatic index showed a trend of first decreasing and then increasing, with feed conversion ratio reaching its minimum value in the 1.58% group, which was significantly different from other groups ($P<0.05$); whole-body crude lipid and muscle crude ash contents showed similar trends to feed conversion ratio, muscle crude lipid exhibited similar trends to weight gain rate and specific growth rate, while whole-body crude ash and muscle crude protein contents showed a trend of first increasing and then stabilizing. Dietary arginine level had no significant effect on condition factor, whole-body moisture, crude protein, and muscle moisture contents of GIFT tilapia ($P>0.05$). The contents of individual amino acids (except tyrosine, glycine, and alanine), essential amino acids, and total amino acids in muscle all showed a trend of first increasing and then decreasing with increasing dietary arginine level. Dietary arginine level significantly affected the activities of aspartate aminotransferase and alanine aminotransferase, as well as the contents of total cholesterol, triglycerides, total protein, urea nitrogen, and glucose in serum ($P<0.05$), and also significantly affected the activities of total superoxide dismutase, total nitric oxide

synthase, and lysozyme in liver and serum (P<0.05). Using weight gain rate, feed conversion ratio, and protein efficiency as the main evaluation indicators, quadratic regression analysis revealed that the dietary arginine requirement of GIFT tilapia was 1.51%~1.58%, accounting for 4.99%~5.25% of dietary protein.

Full Text

Dietary Arginine Requirement of Genetically Improved Farmed Tilapia (Oreochromis niloticus)

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Abstract

This study investigated the effects of dietary arginine levels on growth performance, feed utilization, body composition, serum biochemical parameters, and non-specific immune indices of genetically improved farmed tilapia (GIFT, *Oreochromis niloticus*) to determine the optimal dietary arginine requirement. Six isonitrogenous and isoenergetic semipurified diets (30.21% crude protein, 17.77 MJ/kg gross energy) containing 0.67%, 0.94%, 1.24%, 1.58%, 1.86%, and 2.11% arginine were fed to GIFT with an initial body weight of (81.52 ± 2.00) g for 60 days. Each diet was assigned to three replicate net cages stocked with 15 fish each. The results demonstrated that weight gain rate (WGR), specific growth rate (SGR), protein efficiency ratio (PER), and protein deposition rate (PDR) increased initially and then decreased with rising dietary arginine levels, peaking in the 1.58% group and showing significant differences from other groups ($P < 0.05$). Feed conversion ratio (FCR), hepatosomatic index (HSI), and viscerosomatic index (VSI) exhibited the opposite trend, decreasing first and then increasing; FCR reached its minimum in the 1.58% group, significantly lower than other groups ($P < 0.05$). Whole-body crude lipid and muscle crude ash content followed a pattern similar to FCR, while muscle crude lipid content mirrored the trends observed for WGR and SGR. Whole-body crude ash and muscle crude protein content increased initially and then plateaued. Dietary arginine level had no significant effects on condition factor or the moisture, crude protein, and ash contents of whole body and muscle ($P > 0.05$). Most muscle amino acids (except tyrosine, glycine, and alanine), essential amino acids, and total amino acids increased first and then decreased with rising dietary arginine levels. Dietary arginine level significantly influenced serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) activities and total cholesterol, triglyceride, total protein, urea nitrogen, and glucose concentrations ($P < 0.05$), as well as

total superoxide dismutase (T-SOD), total nitric oxide synthase (T-NOS), and lysozyme (LYZ) activities in liver and serum ($P < 0.05$). Using WGR, FCR, and PER as primary evaluation indices, quadratic regression analysis indicated that the optimal dietary arginine requirement for GIFT is 1.51%–1.58% of diet, equivalent to 4.99%–5.25% of dietary protein.

Keywords: GIFT (*Oreochromis niloticus*); arginine; requirement; growth; immunity

Introduction

Arginine (Arg) is an aliphatic, basic, polar -amino acid containing a guanidine group and represents one of the essential amino acids for cultured fish species. In fish, arginine directly participates in protein and urea synthesis and serves as a precursor for creatine, polyamines, and nitric oxide (NO). Additionally, it can promote insulin secretion and regulate glucose metabolism. Previous studies have shown that appropriate dietary arginine levels significantly improve weight gain rate, specific growth rate, and protein deposition rate in largemouth bass (*Micropterus salmoides*) and coho salmon (*Oncorhynchus kisutch*). Zhou et al. reported that optimal dietary arginine enhanced disease resistance against *Aeromonas hydrophila* and non-specific immunity in yellow catfish (*Pelteobagrus fulvidraco*). Conversely, arginine deficiency in Jian carp (*Cyprinus carpio* var. Jian) leads to reduced growth performance, survival rate, and disease resistance.

Current estimates of arginine requirements for tilapia vary considerably. The deletion method has been used to calculate nitrogen retention and estimate an arginine requirement of 2.03% (diet percentage) for 20 g tilapia, while Santiago et al. determined a requirement of 1.18% (diet percentage) for 15 g tilapia through dose-response growth studies. However, reports indicate that using body amino acid composition data to estimate amino acid requirements may not be accurate, necessitating growth observation methods for precise determination. Most previous studies have focused solely on growth indices without comprehensively considering nutritional metabolism and fish health.

Genetically improved farmed tilapia (GIFT, *Oreochromis niloticus*) is a major cultured strain in China, representing a genetically enhanced Nile tilapia that grows 5%–20% faster than other strains. Arginine requirements may vary among different strains and life stages, necessitating new growth trials for accurate determination. Therefore, this study employed semipurified diets with varying arginine levels to feed GIFT with an initial average weight of 81.52 g for 60 days. By comprehensively evaluating growth performance, feed utilization, body composition, selected serum biochemical parameters, and non-specific immune indices, we aimed to determine the arginine requirement for this growth stage and provide a scientific basis for developing efficient and environmentally friendly formulated feeds for GIFT.

1.1 Experimental Diets

Six semipurified experimental diets were formulated using fish meal, rapeseed meal, casein, gelatin, and an amino acid mixture as protein sources; soybean oil and corn oil as lipid sources; and dextrin as the carbohydrate source. The formulation proportions are shown in . Arginine levels were designed at 0%, 0.35%, 0.75%, 1.10%, 1.45%, and 1.80% (with L-arginine isonitrogenously replacing L-glycine). The amino acid mixture (excluding arginine and glycine) was formulated according to the muscle amino acid composition pattern of GIFT. Sodium carboxymethyl cellulose, carrageenan, and -starch at a 1:1:1 ratio served as coating materials, and the amino acid mixture was encapsulated following Millamena et al.' s method. The amino acid mixture composition is presented in .

All ingredients were ground to pass through an 80-mesh sieve, weighed according to the proportions in , thoroughly mixed, and processed into pellet form using a small meat grinder. The pellets were briefly dried at 60°C in a feed dryer, air-dried at room temperature, and crushed into 5 mm particles before storage at -20°C. Analysis revealed that the actual dietary arginine levels were 0.67%, 0.94%, 1.24%, 1.58%, 1.86%, and 2.11% of diet, corresponding to 2.15%, 3.11%, 4.10%, 5.23%, 6.16%, and 6.98% of dietary protein, respectively.

1.2 Experimental Fish and Culture Management

Experimental GIFT were obtained from the National Tilapia Breeding Farm in Nanning, Guangxi. Upon arrival, fish were disinfected with 3% NaCl solution and acclimated in temporary pond net cages (4.0 m × 4.0 m × 1.5 m) for 15 days using the basal diet (0.67% arginine) to adapt to the experimental feed and culture environment. Prior to the formal experiment, fish were fasted for 24 h, and 270 healthy GIFT with an initial average weight of (81.52 ± 2.00) g were selected and stocked into 18 pond net cages (1.0 m × 1.0 m × 1.5 m) at 15 fish per cage. The fish were randomly divided into six groups with three replicates (cages) per group, each receiving one of the six experimental diets for 60 days (from mid-August to mid-October 2015). Fish were hand-fed to apparent satiation twice daily (08:00 and 16:00), with feeding rates adjusted according to growth, feeding behavior, and water temperature. Daily feeding and mortality were recorded.

The experimental pond covered approximately 6,666.7 m^2 with a water depth of 1.8–2.5 m. A 3 kW paddlewheel aerator was installed at the pond center and operated from 11:00–14:00 and 00:00–06:00. During overcast weather, dissolved oxygen was monitored, and the aerator was activated when levels dropped below 4 mg/L. Additionally, a 750 W air pump continuously supplied aeration to each net cage. Water temperature during the experiment ranged from 25–32°C (at ~50 cm depth), pH was 6.5–7.0, dissolved oxygen remained above 4 mg/L, and ammonia nitrogen was below 0.05 mg/L.

1.3 Sample Collection

At the end of the experiment, fish were fasted for 24 h before final weighing and counting of survivors per cage. Three fish were randomly selected from each cage for determination of whole-body moisture, crude protein, crude lipid, and ash content. Another three fish per cage were randomly selected for measurement of body weight and length. Blood was collected from the caudal vein, allowed to clot at 4°C for 2 h, and centrifuged at 3,000 rpm for 15 min to obtain serum for biochemical and non-specific immune parameter analysis. Three additional fish per cage were anesthetized with 30 mg/L MS-222 for dissection and weighing of viscera and liver. Dorsal muscle above the lateral line was collected for routine proximate composition and amino acid analysis. All whole-body, serum, liver, and muscle samples were stored at -40°C.

1.4 Parameter Determination and Calculation

The following formulas were used to calculate growth and physiological indices:

- Weight gain rate (WGR, %) = 100 × (Wt -W0) / W0
- Specific growth rate (SGR, %/d) = 100 × (ln Wt -ln W0) / t
- Feed conversion ratio (FCR) = F / (Wt -W0)
- Protein efficiency ratio (PER, %) = (Wt -W0) / (F × P)
- Protein deposition rate (PDR, %) = 100 × (Wt × Pt -W0 × P0) / (F × P)
- Survival rate (SR, %) = 100 × Nt / N0
- Condition factor (CF, %) = 100 × W / L^3
- Hepatosomatic index (HSI, %) = 100 × Wh / W
- Viscerosomatic index (VSI, %) = 100 × Wv / W

Where: Nt = final fish number; N0 = initial fish number; Wt = final body weight (g); W0 = initial body weight (g); t = culture period (d); F = total feed intake (g); P = dietary crude protein content (%); Pt = final whole-body crude protein content (%); P0 = initial whole-body crude protein content (%); Wh = liver weight (g); Wv = viscera weight (g); L = body length (cm); W = body weight (g).

Proximate composition of whole-body, muscle, and feed samples was determined using AOAC (1995) methods. Crude protein was measured by the Kjeldahl method, crude lipid by Soxhlet extraction, ash by muffle furnace incineration, and gross energy by bomb calorimetry (Parr-6200). Whole-body and feed moisture was determined by drying at 105°C to constant weight, while muscle moisture was determined by freeze-drying. Amino acid composition in muscle and feed was analyzed using a Hitachi L-8900 amino acid analyzer (according to GB/T 5009.124-2003).

Serum AST and ALT activities and urea nitrogen (UN), triglyceride (TG), total cholesterol (T-CHO), total protein (TP), and glucose (GLU) concentrations were measured using original Sysmex reagents by UV-visible spectrophotometry

on an automatic biochemical analyzer (Sysmex CHEMIX-800, Japan). Serum and liver T-SOD, T-NOS, and LYZ activities were determined using assay kits from Nanjing Jiancheng Bioengineering Institute.

1.5 Data Processing

All data were analyzed using one-way ANOVA and Duncan's multiple range test with SPSS 18.0 statistical software. Results are expressed as mean ± standard deviation (SD). Significance was set at $P < 0.05$. Quadratic regression analysis was used to model the relationships between dietary arginine level and WGR, FCR, and PER.

2.1 Effects of Dietary Arginine Level on Growth Performance, Feed Utilization, and Morphological Indices

The effects of dietary arginine level on growth performance, feed utilization, and morphological indices of GIFT are presented in . With increasing dietary arginine levels, WGR, SGR, PER, and PDR increased initially and then decreased, reaching maximum values in the 1.58% group, which were significantly different from other groups ($P < 0.05$). Conversely, FCR decreased first and then increased, reaching its minimum in the 1.58% group, significantly lower than other groups ($P < 0.05$). HSI and VSI showed similar decreasing-then-increasing trends. HSI was lowest at 1.24% arginine, showing no significant difference from the 0.67%, 0.94%, and 1.58% groups ($P > 0.05$) but differing significantly from the 1.86% and 2.11% groups ($P < 0.05$). VSI was lowest in the 1.58% group, showing no significant difference from the 1.58%, 1.86%, and 2.11% groups ($P > 0.05$) but differing significantly from the 0.67% and 0.94% groups ($P < 0.05$). No significant differences were observed in survival rate or condition factor among all groups ($P > 0.05$).

Quadratic regression analysis of WGR, FCR, and PER against dietary arginine level yielded the following equations (Figures 1–3):

- WGR (Y) vs. dietary arginine level (X): $Y = -65.711X^2 + 198.13X + 98.384$ ($R^2 = 0.9711$). Maximum WGR of 247.73% was achieved at 1.51% dietary arginine (4.99% of dietary protein).
- FCR (Y) vs. dietary arginine level (X): $Y = 0.1596X^2 - 0.5074X + 1.7469$ ($R^2 = 0.8162$). Minimum FCR of 1.34 was achieved at 1.58% dietary arginine (5.25% of dietary protein).
- PER (Y) vs. dietary arginine level (X): $Y = -0.2696X^2 + 0.8546X + 1.7851$ ($R^2 = 0.8229$). Maximum PER of 2.46% was achieved at 1.58% dietary arginine (5.25% of dietary protein).

2.2 Effects of Dietary Arginine Level on Whole-Body and Muscle Composition

The effects of dietary arginine level on whole-body and muscle composition are shown in . Whole-body crude lipid content decreased initially and then increased

with rising dietary arginine levels, reaching its lowest value in the 1.58% group, which differed significantly from the 0.67% and 2.11% groups ($P < 0.05$) but not from other groups ($P > 0.05$). Whole-body ash content increased initially and then plateaued, with the 2.11% group significantly higher than the 0.67% group ($P < 0.05$) but no other significant differences among groups ($P > 0.05$).

Muscle crude protein content increased initially and then stabilized, with the 1.86% and 2.11% groups significantly higher than the 0.67% and 0.94% groups ($P < 0.05$) but no other significant differences ($P > 0.05$). Muscle crude lipid content increased initially and then decreased, peaking in the 1.58% group, which differed significantly from the 0.67% and 2.11% groups ($P < 0.05$) but not from other groups ($P > 0.05$). Muscle ash content decreased initially and then increased, reaching its lowest value in the 1.58% group, which differed significantly from the 0.67% and 2.11% groups ($P < 0.05$) but not from other groups ($P > 0.05$). No significant differences were observed among groups in whole-body moisture, whole-body crude protein, or muscle moisture content ($P > 0.05$).

2.3 Effects of Dietary Arginine Level on Muscle Amino Acid Composition

The effects of dietary arginine level on muscle amino acid composition are presented in . Dietary arginine level significantly affected all muscle amino acids except tyrosine, glycine, and alanine ($P < 0.05$). With increasing dietary arginine levels, individual amino acids (except tyrosine, glycine, and alanine), essential amino acids (EAA), and total amino acids (TAA) increased initially and then decreased, reaching maximum values in the 1.58% group.

2.4 Effects of Dietary Arginine Level on Serum Biochemical Indices

The effects of dietary arginine level on serum biochemical indices are shown in . Serum total protein content and urea nitrogen concentration increased initially and then decreased or plateaued, respectively, both peaking in the 1.58% group. Serum total cholesterol, triglyceride, and glucose concentrations and AST activity decreased initially and then increased, while ALT activity decreased initially and then plateaued. Total cholesterol, glucose, AST, and ALT reached minimum values in the 1.58% group, whereas triglyceride reached its minimum in the 1.24% group.

2.5 Effects of Dietary Arginine Level on Non-Specific Immune Indices

The effects of dietary arginine level on non-specific immune indices are presented in . Serum T-SOD, T-NOS, and LYZ activities increased initially and then decreased with rising dietary arginine levels. T-SOD and T-NOS activities peaked in the 1.58% group, significantly higher than the 0.67% group ($P < 0.05$). LYZ activity peaked in the 1.86% group, significantly higher than the 0.67% and 0.94% groups ($P < 0.05$).

Liver T-SOD activity generally increased with dietary arginine level, reaching its maximum in the 2.11% group, significantly higher than all other groups ($P < 0.05$). Liver T-NOS and LYZ activities increased initially and then plateaued, peaking in the 1.24% and 1.86% groups, respectively.

3.1 Effects of Dietary Arginine Level on Growth Performance, Feed Utilization, and Morphological Indices

As an essential amino acid for aquatic animals, arginine directly participates in protein synthesis and the urea cycle, promoting growth and protein deposition. Appropriate dietary arginine supplementation improves growth performance, feed efficiency, and protein utilization in fish. In this study, both deficient and excessive dietary arginine levels adversely affected growth performance, feed utilization, and protein utilization in GIFT. Previous research has shown that optimal dietary arginine levels significantly enhance weight gain rate, feed efficiency, and protein deposition rate in Japanese flounder (*Paralichthys olivaceus*), orange-spotted grouper (*Epinephelus coioides*), and European sea bass (*Dicentrarchus labrax*). Conversely, excessive arginine inhibits growth and protein utilization in hybrid catfish (*Clarias gariepinus* × *Clarias macrocephalus*), red sea bream (*Pagrus major*), and Indian major carp (*Cirrhinus mrigala*).

The declining growth performance observed when dietary arginine exceeded optimal levels may result from antagonism with dietary lysine, reducing lysine utilization and impairing growth. This antagonistic relationship has also been reported in poultry and mice, possibly mediated by accelerated amino acid degradation that interferes with normal metabolic processes of digestive intermediates, thereby reducing digestive capacity. In this study, muscle lysine content in the 1.58%, 1.86%, and 2.11% groups showed a negative correlation with dietary arginine level, directly indicating that excessive arginine affected muscle lysine deposition. However, the arginine-lysine antagonism mechanism in fish remains inconclusive and requires further investigation.

Dietary arginine level had no significant effect on condition factor in GIFT, consistent with findings in golden pompano (*Trachinotus ovatus*) and grass carp (*Ctenopharyngodon idellus*). While HSI and VSI increased with dietary arginine level in some species, this study observed a decreasing-then-increasing trend. This may occur because optimal arginine mobilizes energy reserves in the liver and pancreas for extensive protein synthesis, reducing organ mass and volume, thereby lowering HSI and VSI.

The results indicate that when dietary arginine level is 1.51%–1.58% (4.99%–5.25% of dietary protein), GIFT achieve maximum WGR, SGR, PER, and PDR with minimum FCR. This optimal arginine-to-protein ratio is similar to that reported for milkfish (5.25%), cobia (5.17%), and coho salmon (4.90%), but lower than for blunt snout bream (7.23%) and Nile tilapia (6.24% for 6.03 g fish). These variations suggest that arginine requirements differ among fish species, sizes, and dietary protein sources and amino acid patterns.

3.2 Effects of Dietary Arginine Level on Body Composition

Whole-body crude lipid content decreased significantly with increasing dietary arginine levels, consistent with trends observed in black sea bream (*Sparus macrocephalus*). However, muscle crude lipid content showed the opposite pattern, aligning with observations in yellow grouper (*Epinephelus awoara*), possibly due to species-specific differences. Whole-body ash content increased initially and then plateaued, similar to reports in orange-spotted grouper, while muscle ash content decreased initially and then increased, with the lowest value in the 1.58% group, consistent with findings in gibel carp (*Carassius auratus gibelio*) and rohu (*Labeo rohita*). Inorganic salt deposition is directly related to amino acid intake, particularly calcium absorption, which may be enhanced by arginine supplementation and contribute to differences in ash content between whole body and muscle.

Muscle protein synthesis and deposition increased with dietary arginine level. Numerous studies have shown that whole-body protein synthesis efficiency and deposition rate increase linearly with dietary arginine up to the optimal level, then decrease significantly when exceeded, due to accelerated degradation of other amino acids. However, some studies in grass carp found no significant difference in protein synthesis efficiency beyond the optimal arginine level, suggesting species- and size-specific responses.

Aquatic animals achieve protein deposition by digesting and absorbing dietary amino acids for tissue protein synthesis. Studies have reported that essential amino acid content in black sea bream muscle increases with dietary arginine intake. In this study, muscle amino acid content increased with dietary arginine level; when arginine reached optimal levels, dietary amino acids achieved ideal balance, promoting greater protein synthesis and deposition. Excess arginine led to oxidative degradation of surplus amino acids, causing losses and potential tissue damage. The observed pattern of muscle essential amino acids, most non-essential amino acids (except tyrosine, glycine, and alanine), and total amino acids increasing initially and then decreasing with dietary arginine level aligns with these findings.

3.3 Effects of Dietary Arginine Level on Serum Biochemical Indices

Urea nitrogen is a key product of amino acid metabolism in serum, and arginine serves as an important intermediate in the ornithine cycle. Studies have reported that serum urea nitrogen in rainbow trout (*Oncorhynchus mykiss*) is closely related to arginine intake. In this study, serum urea nitrogen increased with dietary arginine level, likely because optimal arginine enhanced the ornithine cycle and protein metabolism, maximizing urea nitrogen production. When arginine exceeded optimal levels, the ideal amino acid balance was disrupted, reducing protein synthesis and deposition while excess arginine enhanced catabolism of other amino acids, resulting in non-significant changes in serum urea nitrogen beyond the optimal level. Similar linear-then-plateau responses have been re-

ported in Japanese flounder.

Serum triglyceride and total cholesterol concentrations typically change in parallel. In this study, both decreased initially and then increased with dietary arginine level, possibly because optimal arginine mobilized energy reserves for oxidation, promoting protein synthesis and deposition. This corresponds with the trend in whole-body crude lipid content, which also decreased initially and then increased. The combined deamination action of AST and ALT represents the primary pathway for hepatic amino acid catabolism. Optimal dietary arginine inhibited transaminase activity, reducing amino acid degradation and enhancing protein synthesis. When arginine was deficient or excessive, enhanced amino acid catabolism increased hepatocyte permeability and blood flow, significantly elevating serum AST and ALT activities, consistent with findings in European sea bass.

Serum total protein content reflects protein synthesis capacity and amino acid metabolism intensity. Zhou et al. reported a strong positive correlation between serum total protein and growth performance in black sea bream. In this study, serum total protein increased initially and then decreased with dietary arginine level, consistent with amino acid metabolism intensity. As a NO synthesis precursor, arginine is metabolized by NOS to produce NO, which exerts insulin-like effects. Studies have shown that increased dietary arginine significantly reduces serum glucose in black sea bream, possibly because NO regulates hepatic glycogen production as an endocrine signaling molecule, stimulating glucose reduction. This explains the observed decreasing-then-increasing trend in serum glucose with dietary arginine level.

3.4 Effects of Dietary Arginine Level on Non-Specific Immune Indices

Research on channel catfish (*Ictalurus punctatus*) has confirmed that arginine is a regulatory factor in acquired immunity, modulating immune system function and macrophage production. As a NO synthesis precursor metabolized by T-NOS, NO serves as a cellular defense mechanism that improves antioxidant capacity against invading pathogens. In this study, serum and liver T-NOS activities increased with dietary arginine level.

Superoxide dismutase (SOD) converts superoxide anion radicals (O ·) into H O and O , acting as a natural superoxide radical scavenger that reduces tissue damage and protects against free radical injury. Reduced SOD activity can lead to excessive reactive oxygen species, causing metabolic disorders, physiological dysfunction, decreased immunity, pathogen invasion, and disease. Buentello et al. found that increased dietary arginine significantly elevated liver SOD activity in channel catfish. This study similarly showed that elevated dietary arginine significantly increased T-SOD activity in GIFT, indicating enhanced non-specific immunity. In fish, lysozyme is an important defense factor that promotes bacterial lysis and activates phagocytes and the complement system. The observed initial increase and subsequent stabilization of serum and liver

LYZ activities with dietary arginine level suggests improved immune capacity within a certain range.

Conclusion

Optimal dietary arginine levels enhance growth performance, increase protein deposition, reduce feed conversion ratio, and improve amino acid metabolism and non-specific immunity in GIFT. Using WGR, FCR, and PER as primary evaluation indices, quadratic regression analysis determined that the optimal dietary arginine requirement for maximum growth, feed utilization, protein deposition, and optimal physiological health in GIFT is 1.51%–1.58% of diet, equivalent to 4.99%–5.25% of dietary protein.

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