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An Estimate of the Dietary Lysine Requirement of Juvenile Red Drum *Sciaenops ocellatus*

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Abstract

Quadruplicate groups of juvenile red drum (initial mean weight 2.7 g; 20 fish per replicate) were fed experimental diets containing 35% crude protein and graded levels of lysine for eight weeks. Lysine concentration in the basal diet was 1.2% and was supplied by a combination of peanut meal and shrimp-head meal. The basal diet was supplemented with lysine-HCl to provide 1.6, 2.0, and 2.4% lysine. Each of these diets contained an essential amino acid (EAA) premix. Two additional diets were formulated to contain 1.2 and 2.4% lysine without the EAA premix. Weight gain and feed efficiency (FE) data indicated between 1.2 and 1.6% dietary lysine was adequate. However, serum lysine concentrations indicated 1.6-2.0% lysine was required. Fish fed 1.2 or 2.4% lysine, without the EAA premix, exhibited reduced weight gain and feed efficiency. Results indicated that red drum were able to utilize crystalline amino acids when incorporated into diets containing intact protein and, when lysine was adequate, the proteins were deficient in at least one other essential amino acid. It is recommended that a dietary lysine level of 5.7% of the dietary protein be used in formulating red drum diets.

Aquaculture of red drum (*Sciaenops ocellatus*) is promising, primarily because restrictions on commercial harvest led to inadequate supplies to meet the increasing market demand. However, there are several constraints to successful culture. One of the most important is the lack of nutritional information. Knowledge of the nutritional requirements would allow formulation of feeds specifically for red drum. Feed development is essential because feed cost generally represents about 50% of the production costs in aquaculture.

Daniels and Robinson (1986) determined the optimum dietary protein to energy ratio for juvenile red drum. The dietary phosphorus and lipid requirements have also been studied (Davis and Robinson 1987; Williams and Robinson 1988). However, there have been no studies to determine the amino acid requirements of red drum. Qualitatively, the same ten amino acids found to be essential for other fish (Wilson and Halver 1986) are most likely essential for red drum. Lysine, an essential amino acid in all animals studied thus far, is often first-limiting in practical feed formulations for warmwater fish; that is, using typical fish feed ingredients, if lysine is adequate, other amino acid concentrations are generally satisfactory. Therefore, knowledge of the dietary lysine requirement would assist in formulation of red drum feeds on an amino acid basis. The present study was designed to investigate the lysine requirement of juvenile red drum reared in brackish water.

Materials and Methods

Previous lysine requirement studies conducted in our laboratory used casein and gelatin as sources of intact protein, and fish oil as an attractant, but were unsuccessful due to inadequate consumption of experi-

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TABLE 1. *Composition of basal diet (% dry matter basis) used to determine the lysine requirement of juvenile red drum.*

Ingredient[a]	%
Peanut meal	50.0
Shrimp-head meal	10.0
Menhaden oil	10.0
Dextrin	5.0
Mineral premix[b]	4.0
Vitamin premix[b]	0.5
Carboxymethylcellulose	2.0
Amino acid premix[c]	5.0
Cellulose	13.5

[a] Peanut meal was supplied by Dotham Oil Mill Company, Dotham, Alabama and contained 50% crude protein; shrimp-head meal was supplied by Blum and Bergeron, Incorporated, Houma, Louisiana and contained 45% crude protein; menhaden oil was supplied by Zapata Haynie Corporation, Hammond, Louisiana; all other dietary ingredients were purchased from United States Biochemical Corporation, Cleveland, Ohio.

[b] Vitamin and mineral premixes were the same as reported by Robinson et al. 1984.

[c] Amino acid premix contained (% dry matter basis) L-histidine (3.0), L-isoleucine (5.0), L-leucine (5.0), L-methionine (28.0), L-phenylalanine (20.0), and L-tryptophan (4.0).

mental diets. Other studies in this laboratory indicated that shrimp-head meal improved feed palatability for red drum (unpublished data). Thus shrimp-head meal was used in combination with peanut meal (which is limiting in lysine) to formulate a lysine-deficient basal diet.

Experimental diets were formulated to contain 35% crude protein (Table 1). This level of dietary protein is marginal for juvenile red drum, but was chosen in order to accentuate amino acid deficiencies. Quantitative amino acid requirement studies with channel catfish were conducted using relatively low-protein diets (Wilson and Robinson 1982). The basal diet provided 1.2% dietary lysine. The peanut meal/shrimp-head meal combination was deficient in six other essential amino acids when dietary concentrations were compared to the essential amino acid requirements of chinook salmon (National Academy of Sciences 1981). Therefore, an essential amino acid (EAA) premix (Table 1) was formulated and added to the basal diet. Quantitative essential amino acid requirements have been reported for chinook salmon, Japanese eel, and common carp (National Academy of Sciences 1983; Wilson and Halver 1986). Of those reported, it is felt that the essential amino acid requirements of red drum would be similar to those of chinook salmon because of similarity in feeding habits. Lysine-HCl was added to the basal diet in gradations of 0.4% to give concentrations of 1.6, 2.0, and 2.4% of the dry diet. In addition, two diets (1.2 and 2.4% lysine) were formulated without the EAA premix.

Juvenile red drum (supplied by Texas Parks and Wildlife Department) were reared in 120 L aquaria, which were part of a closed, recirculating experimental system. Water flow rate was 4 L/min. Salinity ranged from 4–6 ppt and was adjusted with artificial salts (Fritz Chemical Company, Houston, Texas). Fish were held in the experimental system for two weeks prior to initiation of the study and were fed a commercial salmonid diet. Dietary treatments were randomly assigned to quadruplicate groups of 20 fish (initial average fish weight was 2.7 g).

Fish were fed an average of 8% of body weight per day divided into three equal feedings. Previous studies in this laboratory indicated that this feeding rate was excessive but ensured that the fish were satiated and cannibalism was therefore minimized. All fish were group-weighed biweekly and feeding rates were adjusted accordingly. Temperature, dissolved oxygen, ammonia, and nitrite were monitored weekly in randomly chosen aquaria and ranged as follows: 26–30 C, 5.0–6.3 mg/L, 0.1–0.5 mg/L, and 0.01–0.03 mg/L, respectively.

At the end of eight weeks, final fish weights were determined and all fish were bled via the caudal artery. Serum samples were deproteinated by the method of Cross et al. (1975) and stored frozen (−15 C) prior to determination of amino acid concentrations.

Amino acid concentrations were deter-

mined by reverse phase liquid chromatography using a C-18 PICO-TAG analysis column and sodium acetate (trihydrate), triethylamine, and glacial acetic acid : acetonitrile and water mobile phase (PICO-TAG method, Waters, New Milford, Massachusetts). Individual amino acids were identified and quantified by comparison with known standards (Pierce Chemical Company, Boston, Massachusetts).

Weight gain, feed efficiency (FE), and serum lysine data were analyzed as a completely randomized design using SAS (Helwig and Council 1979). If analysis of variance indicated significant differences were present, Duncan's multiple range test was used to rank treatment means (Snedecor and Cochran 1967). The accepted level of significance was 0.05.

Results and Discussion

Requirement Estimate

Weight gain and FE were significantly lower in fish fed 1.2% dietary lysine compared to fish fed higher lysine levels, but there were no clear distinctions among treatment means of fish fed 1.6, 2.0, and 2.4% dietary lysine (Table 2). Serum lysine concentrations were significantly lower in fish fed diets containing 1.2 and 1.6% dietary lysine compared to concentrations in fish fed diets containing lysine levels of 2.0 and 2.4%.

Data from previous studies demonstrated that serum amino acid concentrations of fish fed inadequate levels of certain essential amino acids remain low due to rapid tissue uptake; however, once the dietary requirement has been met, serum amino acid concentrations increase (Wilson and Robinson 1982). Weight gain and serum lysine data from channel catfish fed graded levels of lysine were reported to be reliable estimates of the lysine requirement (Wilson et al. 1977). However, serum lysine data from a subsequent study with catfish were not as clearly reflective of the dietary requirement (Robinson et al. 1980). Differences in the two studies were attributed to differences in the dietary protein levels (24 vs. 30% crude protein). Apparently, serum lysine concentrations are not always an appropriate indicator of dietary lysine adequacy. Weight gain and FE data from the present study indicate that the lysine requirement for red drum is not greater than 1.6% of the dry diet. However, the serum lysine response was significantly higher in fish fed 2.0 and 2.4% lysine. Therefore, the serum lysine concentration appears to be an adequate indicator of lysine status in red drum and, based on the serum amino acid levels, the optimum dietary concentration appears to be between 1.6–2.0% of the dry diet or 4.6–5.7% of the dietary protein. Until the estimate can be further refined, a level of 2.0% (5.7% of the dietary protein) in practical diets appears to be adequate for juvenile red drum reared in brackish water. This estimate is similar to lysine requirements of other fish, which vary from 5.0–5.7% of the protein depending on species (National Academy of Sciences 1983; Wilson and Halver 1986).

Feed efficiencies were low and the result of the high feeding rate. However, the excessive feeding ensured satiation and reduced cannibalism. Survival ranged from 80.0% to 94.0% (diets number 5 and 2 respectively) and did not appear to be related to the experimental diets.

TABLE 2. *Weight gain, feed efficiency (FE), and serum lysine concentrations of juvenile red drum fed diets containing graded levels of dietary lysine.*[a]

Dietary lysine (%)	Weight gain (% increase)	FE	Serum lysine (μM/dl)
1.2 (w/o)[b]	20.9z	0.04y	2.76z
1.2	172.8y	0.25x	5.47y,z
1.6	292.3x	0.36w	6.61y,z
2.0	320.6w,x	0.35w	17.61w
2.4	338.0w	0.37w	12.08x
2.4 (w/o)[b]	12.8z	0.03y	10.21x,y

[a] All values are means of four replicates. Mean values in any column with the same letter are not significantly different. Pooled standard errors of the mean for weight gain, FE, and serum lysine were 5.8, 1.0, and 3.4, respectively.

[b] Without the essential amino acid premix.

Utilization of Crystalline Amino Acids

Weight gain and FE of fish fed 1.2 and 2.4% dietary lysine, without the supplemental EAA premix, were significantly lower compared to weight gain and FE of fish fed diets containing the EAA premix regardless of the dietary lysine level. These data indicate that red drum utilize free amino acids when incorporated in diets containing intact protein and that the peanut meal/shrimp-head meal combination was deficient in lysine and at least one other essential amino acid. These results are similar to those of Robinson et al. (1980) for channel catfish. Therefore, this combination of protein sources should prove useful in determining other essential amino acid requirements for red drum, particularly since some experimental amino-acid test diets are poorly accepted.

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