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Replacement of fish meal by meat and bone meal in diets for large yellow croaker, *Pseudosciaena crocea*

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Abstract

A growth experiment was conducted to investigate the effects of replacement of fish meal (FM) by meat and bone meal (MBM) in diets on the growth and body composition of large yellow croaker (*Pseudosciaena crocea*). Six isonitrogenous (43% crude protein) and isoenergetic (20 kJ g^{-1}) diets replacing 0, 15, 30, 45, 60 and 75% FM protein by MBM protein were formulated. Each diet was randomly allocated to triplicate groups of fish in sea floating cages (1.0 × 1.0 × 1.5 m), and each cage was stocked with 180 fish (initial average weight of 1.88 ± 0.02 g). Fish were fed twice daily (05:00 and 17:30) to apparent satiation for 8 weeks. The water temperature ranged from 26.5 to 32.5 °C, salinity from 32 to 36‰, and dissolved oxygen content was approximately 7 mg l^{-1} during the experimental period. Survival decreased with increasing dietary MBM and the survival in the fish fed the diet with 75% protein from MBM was significantly lower than other groups ($P < 0.05$). There were no significant differences in specific growth rate (SGR) among the fish fed the diets with 0 (the control group), 15, 30 and 45% protein from MBM. However, SGR in the fish fed the diets with 60 and 75% protein from MBM were significantly lower than other groups ($P < 0.05$). No significant differences in feeding rate were observed among dietary treatments. The digestibility experiment showed that the apparent digestibility coefficients (ADC) of dry matter, protein, lipid and energy of MBM were significantly lower compared with those of FM ($P < 0.05$). Essential amino acid index was found to be correlated positively with SGR in the present study, suggesting that essential amino acid balance was important. Body composition analysis showed that the carcass protein and essential amino acids were not significantly affected by dietary MBM. The lipid and n-3 highly unsaturated fatty acid (n-3 HUFA) in fish muscle, however, significantly decreased with increasing dietary MBM. These results showed that 45% of FM protein could be replaced by MBM protein in diets of large yellow croaker without significantly reducing growth. It was suggested that the reduced growth with higher MBM was due to lower digestibility and imbalance of essential amino acids.

Keywords: Large yellow croaker; *Pseudosciaena crocea*; Fish meal; Replacement; Meat and bone meal; Feeding and nutrition

1. Introduction

Fish meal (FM) is a major protein source in feed industry. However, increasing demand, uncertain availability and high price with the expansion of aquaculture made it necessary to search alternative protein sources. Meat and bone meal (MBM) is one of the economically rendered animal protein sources, which was widely used in poultry feed (Parsons et al., 1997; Wang and Parsons, 1998). MBM has relatively higher protein content, and better growth promotion effect in comparison with other

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Table 1
Formulation and proximate composition of experimental diets for large yellow croaker (*Pseudosciaena crocea*) (% dry matter)

Ingredient	Diet No. Substitution level					
	Diet 1 (0%)	Diet 2 (15%)	Diet 3 (30%)	Diet 4 (45%)	Diet 5 (60%)	Diet 6 (75%)
Fish meal[1]	55.0	46.75	38.50	30.25	22.00	13.75
Meat and bone meal[1]	0.00	10.86	21.72	32.58	43.44	54.30
Beer yeast	3.0	3.0	3.0	3.0	3.0	3.0
Wheat meal	29.97	27.43	24.92	22.41	19.88	17.36
Menhaden fish oil	3.18	3.18	3.18	3.18	3.18	3.18
Soybean oil	1.9	1.83	1.73	1.63	1.55	1.46
Attractant[2]	0.3	0.3	0.3	0.3	0.3	0.3
Mold inhibitor[3]	0.1	0.1	0.1	0.1	0.1	0.1
Ethoxyquin	0.05	0.05	0.05	0.05	0.05	0.05
Lecithin	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin premix[4]	2.0	2.0	2.0	2.0	2.0	2.0
Mineral premix[5]	2.0	2.0	2.0	2.0	2.0	2.0
Proximate analysis ($n=3$, means±S.E.)						
Moisture (%)	6.8±0.1	7.3±0.1	6.6±0.2	6.8±0.1	6.5±0.1	6.7±0.0
Crude protein (% dry matter)	43.4±0.2	43.0±0.3	43.0±0.4	43.1±0.1	43.3±0.3	43.3±0.1
Crude lipid (% dry matter)	11.5±0.1	11.4±0.2	11.7±0.2	11.8±0.1	11.4±0.1	11.4±0.3
Ash (% dry matter)	11.5±0.2	13.4±0.2	15.3±0.3	17.2±0.1	19.1±0.1	20.9±0.2
Energy (kJ g^{-1} dry matter)	19.9±0.3	19.8±0.2	19.9±0.1	20.0±0.4	19.8±0.3	19.9±0.3

[1]Fish meal, obtained from Cishan Fisheries (Shandong, China), crude protein, 68.9% dry matter, crude lipid, 10.1% dry matter, ash, 15.2% dry matter; meat and bone meal, obtained from Talloman (Bushmead, Australia), crude protein, 52.30% dry matter, crude lipid, 8.93% dry matter, ash, 28.66% dry matter.
[2]Attractant, glycine and betaine (1:2).
[3]Contained 50% calcium propionic acid and 50% fumaric acid.
[4]Vitamin premix (mg or g/kg diet), thiamin 25 mg; riboflavin, 45 mg; pyridoxine HCL, 20 mg; vitamin B_{12}, 0.1 mg; vitamin K_3, 10 mg; inositol, 800 mg; pantothenic acid, 60 mg; niacin acid, 200 mg; folic acid, 20 mg, biotin, 1.20 mg; retinol acetate, 32 mg; cholecalciferol, 5 mg; alpha-tocopherol, 120 mg; ascorbic acid, 2000 mg; choline chloride, 2500 mg, ethoxyquin 150 mg, wheat middling 14.012 g.
[5]Mineral premix (mg or g/kg diet): NaF, 2 mg; KI, 0.8 mg; $CoCl_2 \cdot 6H_2O$ (1%), 50 mg; $CuSO_4 \cdot 5H_2O$, 10 mg; $FeSO_4 \cdot H_2O$, 80 mg; $ZnSO_4 \cdot H_2O$, 50 mg; $MnSO_4 \cdot H_2O$, 60 mg; $MgSO_4 \cdot 7H_2O$, 1200 mg; $Ca(H_2PO_3)_2$. H_2O, 3000 mg; NaCl, 100 mg; Zoelite, 15.447 g.

alternative plant proteins. Recently, MBM was introduced to replace FM in fish diets. Some studies showed that MBM could partially replace dietary FM without affecting growth and feed efficiency of experimental fish (Davies et al., 1991; El-Sayed, 1998; Bureau et al., 2000; Webster et al., 2000). However, the substitution

Table 2
Essential amino acid composition and cystine (% dietary protein) and ratio (A/E[1]) (%, in parentheses) of the experimental diets for large yellow croaker (*Pseudosciaena crocea*)[2]

	Diet No. (substitution level)						
	Diet 1 (0%)	Diet 2 (15%)	Diet 3 (30%)	Diet 4 (45%)	Diet 5 (60%)	Diet 6 (75%)	Whole body tissue[3]
Methionine	2.8 (6.3)	2.6 (6.0)	2.4 (5.7)	2.1 (5.4)	1.8 (5.0)	1.4 (4.2)	3.1 (6.4)
Cystine	1.5 (3.5)	1.5 (3.5)	1.5 (3.4)	1.4 (3.3)	1.4 (3.1)	1.3 (3.1)	0.46 (1.0)
Lysine	7.3 (16.3)	7.0 (16.2)	6.6 (16.0)	6.2 (15.9)	5.8 (15.7)	5.4 (15.6)	8.3 (17.2)
Threonine	4.2 (9.4)	4.0 (9.3)	3.8 (9.2)	3.6 (9.1)	3.3 (9.0)	3.1 (8.9)	4.7 (9.6)
Isoleucine	4.8 (10.7)	4.6 (10.6)	4.3 (10.5)	4.1 (10.5)	3.8 (10.4)	3.6 (10.3)	4.3 (8.9)
Histidine	2.3 (5.2)	2.2 (5.2)	2.1 (5.1)	2.0 (5.0)	1.8 (5.0)	1.7 (4.9)	2.1 (4.2)
Valine	5.2 (11.5)	5.1 (11.8)	5.0 (12.1)	4.9 (12.5)	4.7 (12.9)	4.7 (13.4)	4.8 (9.9)
Leucine	7.7 (17.2)	7.4 (17.1)	7.0 (17.0)	6.6 (16.8)	6.1 (16.7)	5.7 (16.5)	8.5 (17.5)
Arginine	6.5 (14.4)	6.4 (14.8)	6.2 (15.2)	6.1 (15.6)	5.9 (16.1)	5.8 (16.7)	8.8 (18.2)
Phenylaline	4.0 (9.0)	3.9 (9.1)	3.8 (9.2)	3.6 (9.2)	3.4 (9.4)	3.3 (9.5)	4.0 (8.3)
EAAI[4]	1.03	1.03	1.03	1.02	1.00	0.99	

[1](Essential amino acid/total essential amino acid)×100.
[2]No tryptophan was detected because of acid hrdrolysis.
[3]The amino acid of whole body tissue (20 g body weight of large yellow croaker) was used as requirement reference value.
[4]Essential amino acid index.