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Studies on the optimum protein to energy ratio of African catfish (*Clarias gariepinus* Burchell)

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Abstract

A laboratory trial was conducted to determine the optimum dietary protein to energy (P/E) ratio of African catfish, *Clarias gariepinus*. The experiment was carried out in a flow-through system for 6 weeks. There were 12 treatments each with two replicates having 10 fish each with a mean initial weight of 1.80 ± 0.02g. Twelve semi-purified diets were formulated with four digestible crude protein levels (23, 26.5, 30 and 33.5%) and three digestible energy levels (2.25, 2.75 and 3.25 Kcal/g). The fish were fed three times daily at satiation level. The results of the study showed that, diet containing 33.5% digestible protein and 2.75 kcal/g digestible energy with a protein to energy ratio of 121.8 (mg protein/kcal) appeared to be best utilized for growth.

Key words : *Clarias gariepinus,* Protein-energy ratio

Introduction

Presently African catfish, *Clarias gariepinus* is one of the important species being cultured in many commercial fish farms in Bangladesh. Because of higher growth rate, the species has gained popularity among fish culturists both in rural and urban areas. Fish like all other animals, require energy to sustain life. The energy gain is primarily dependent on the protein/energy ratio in the diet (Cho and Kaushik 1985). An effective utilization of energy requires a relatively high proportion of non-protein energy in the diet.

A considerable protein is lost in the transformation of food energy to net energy available for metabolism and growth. It is desirable that the largest possible portion of the diet should be used for growth and the energy requirement met as far as possible from the carbohydrates and fats, the absorbed protein can be used principally for the synthesis of new body tissue.

Unless sufficient dietary energy is provided, the quality and quantity of dietary protein can not reflect protein synthesis (Cowey 1978). Excess dietary protein is wasteful and stresses the animal while excess energy means more fatty fish. Again, conditions where energy intake is inadequate, dietary proteins are used as energy source and the production cost increases. Thus, optimum protein to energy (P/E) ratio in the diet is very important to maintain fish quality and to reduce the dietary cost. The present study was undertaken to determine the optimum dietary protein to energy ratio for fingerlings of *Clarias gariepinus*.

Materials and methods

Experimental system

The experiment was conducted for 6 weeks during the month of October to November'95 in a flow-through system in the laboratory of the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh. Twenty four plastic buckets of 20 l capacity were used as experimental tanks. All the buckets set in the flow-through system were arranged in two rows and kept on a iron frame to facilitate better observation and accessibility. Water supply was from a deep tubewell and water was agitated before being collected in a header tank on the roof of the building. Since it was a continuous flow-through system, no artificial aeration was used in the tanks.

Experimental fish and acclimatization

Fingerlings of African catfish, *C. gariepinus* were collected from the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Fish were then given a prophylactic treatment with 0.5 ppm $KMnO_4$ solution. Before starting the experiment the fish were acclimatized to the experimental system for one week. During this period the fish were fed formulated pelleted feed containing 35% protein.

Experimental procedure

Twelve treatments were scheduled for the study. Each treatment had two replicates and 10 fish per replicate with a mean initial weight of 1.80 $\pm$ 0.02g. Initial and final weight of fish in each tank were recorded individually on an electric balance. The fish were fed three times a day at 9.00, 13.00 and 17.00 h at satiation level throughout the study period. The amount of feed fed by fish was recorded for subsequent calculation of food conversion ratio, protein efficiency ratios and apparent net protein utilization.

Experimental diets

Fish meal was the main protein source used in diet formulation and the analysed proximate composition value of protein, lipid, ash, crude fibre and NFE were 65.18, 11.24, 21.51, 0.5 and 1.57% respectively. Twelve semi-purified diets were formulated with 4 digestible crude protein levels of 23, 26.5, 30 and 33.5% each having 3 digestible energy levels of 2.25, 2.75 and 3.25 kcal/g respectively. The specification and formulation of the experimental diets are shown in Table 1. The digestible coefficient values of protein and energy of fish meal, fish oil, soybean oil and dextrin was based on Rahman (1996) since same ingredients and formulation was used for experimental diets. The digestible energy (DE) value of fish meal, fish oil, dextrin and soybean oil estimated in terms of Kcal/g of the ingredients were 3.68, 3.22, 4.38 and 4.44 Kcal/g. respectively. The protein digestibility coefficients of fish meal used was 88.05%. The desired protein and energy in the experimental diets were maintained by varying proportion of fish meal, fish oil, soybean oil, dextrin and alfa-cellulose (Table 1). Experimental diets were prepared according to Rahman (1996) and the analysed composition of the prepared diets are shown in Table 2.

Table 1. Specification and formulation of the experimental diets

Diet No.	Digestible protein (%)	Digestible energy (Kcal/g)	P/E ratio (mg protein/ Kcal energy)	Ingredients						
				Fish meal	Fish oil	Soybean oil	Dextrin	*Vitamin & min. premix	Cellulose	CMC
1	23.0	2.25	102.20	39.89	2.00	3.00	17.39	2.00	33.72	2.00
2	23.0	2.75	83.64	39.89	2.00	5.00	0.12	2.00	18.99	2.00
3	23.0	3.25	70.77	39.89	2.00	8.00	41.61	2.00	4.50	2.00
4	26.5	2.25	117.78	46.03	-	3.00	13.35	2.00	33.62	2.00
5	26.5	2.75	96.36	46.03	2.00	5.00	3.29	2.00	19.68	2.00
6	26.5	3.25	81.54	46.03	2.00	8.00	4.78	2.00	5.19	2.00
7	30.0	2.25	133.33	52.16	-	3.00	6.21	2.00	34.63	2.00
8	30.0	2.75	109.09	52.16	2.00	5.00	16.15	2.00	20.69	2.00
9	30.0	3.25	92.34	52.16	2.00	8.00	27.64	2.00	6.20	2.00
10	33.5	2.25	148.89	58.30	-	-	3.42	2.00	34.28	2.00
11	33.5	2.75	121.82	58.30	-	5.00	12.11	2.00	20.59	2.00
12	33.5	3.25	103.08	58.30	-	8.00	8.07	2.00	21.63	2.00

* *According to Rahman (1996), CMC = Carboxymethyl Cellulose (high viscosity)*

Table 2. Analysed proximate composition of the experimental (% dry matter basis)

	DIET NO.											
	1	2	3	4	5	6	7	8	9	10	11	12
Dry matter	94.88	94.90	94.51	94.98	94.20	95.85	94.66	94.65	94.42	94.71	94.51	94.60
Protein	26.23	26.30	25.98	29.94	30.20	30.09	34.00	34.61	34.12	37.82	38.01	38.21
	(23.10)	(23.15)	(22.87)	(26.36)	(26.59)	(26.51)	(29.94)	(30.46)	(30.04)	(30.30)	(33.46)	(33.65)
Lipid	9.47	11.46	14.60	8.00	11.40	14.18	9.37	13.07	15.85	6.83	12.16	15.41
Ash	9.23	7.83	8.54	9.30	10.29	9.79	11.58	11.30	10.85	11.87	12.69	12.82
Crude fibre	31.06	16.68	3.78	28.71	18.21	6.46	31.47	18.96	7.21	35.69	18.34	19.31
NFE	24.01	37.73	47.10	24.05	29.86	9.41	13.58	22.06	31.97	9.89	18.80	14.25

* *Figures in the parentheses indicate the digestible protein levels calculated on the basis of digestibility coefficients of fish meal protein used*
Nitrogen free extract calculated as 100 - %(moisture + protein + lipid + ash + crude fibre)

Water quality

The water quality parameters such as temperature was recorded by Celcius thermometer and pH by a pH meter (portable digital pH meter, OSK 1148). Dissolved oxygen was measured using DO meter (Hana HI 8043).

Carcass composition

At the start of the experiment 20 fish from the stock were randomly taken for analysis of proximate composition and considered as initial carcass composition. At the end of the experiment, 5 fish from each replicate was sacrificed for final carcass analysis.

Analytical methods

Feed ingredients, diets and fish samples were analysed for their proximate composition according to standard procedures given in AOAC (1980). Statistical analysis of the data was performed by Analysis of Variance (ANOVA) followed by Duncan's New Multiple Range Test (Duncan 1995).

Results

The proximate composition of the experimental diets are shown in Table 2. The protein content in different diets varied according to their original formulation. The level of lipid, NFE and crude fibre contents in different diets also varied due to variation in amount of ingredients included in diets for keeping the protein and energy contents at desired levels.

The ranges of water quality parameters monitored weekly during the study period were: temperature 25.1-29.2°C, pH 6.7-7.6 and dissolved oxygen 6.6-7.5 mg/l. The ranges of water quality values in the present study are well within the limit for fish life and could not have hampered the growth of fish (Jhingran 1983).

The growth performances and feed utilization by *C. gariepinus* in terms of final weight (g), percent weight gain, specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and apparent net protein utilization (ANPU%) are presented in Table 3. It is seen that fish fed diet 11 containing 33.5% digestible protein and 2.75 Kcal/g digestible energy produced significantly ($p<0.05$) the highest growth and feed utilization among the dietary treatment groups. However, there was no significant differences ($p>0.05$) between the weight gain and SGRs of fish fed diets 7, 8, 9, 10 and 12. Fish fed diet 1 (23% protein and 2.55 kcal/g DE) produced significantly ($p<0.05$) the lowest weight gain and SGR among the dietary treatment groups. The SGR values ranged between 3.42 to 4.08 among different treatment groups.

Table 3. Effect of dietary protein to energy ratio on growth parameters and food utilization by *C. gariepinus* fed experimental diets

Diet NO	Initial weight	Final Weight	weight gain	% weight gain	SGR	FCR	PER	ANPU
1.	1.78[a*]	7.50[e]	5.72[e]	321[e]	3.42[f]	3.01[f]	1.26[bc]	1.46[b]
2.	1.81[a]	8.00[de]	6.19[d]	342[d]	3.54[c]	2.96[f]	1.28[bc]	1.75[b]
3.	1.80[a]	8.20[d]	6.43[c]	356[d]	3.61[e]	2.90[f]	1.33[b]	22.40[ab]
4.	1.81[a]	8.24[cd]	6.43[c]	355[d]	3.60[dc]	2.92[f]	1.14[d]	20.23[b]
5.	1.81[a]	9.10[b]	7.29[b]	403[c]	3.85[c]	2.70[e]	1.23[bc]	21.97[ab]
6.	1.82[a]	9.15[b]	7.33[b]	403[c]	3.85[c]	2.52[d]	1.32[b]	23.82[ab]
7.	1.82[a]	9.26[b]	7.44[b]	409[bc]	3.87[bc]	2.48[d]	1.19[cd]	21.35[ab]
8.	1.81[a]	9.50[b]	7.69[b]	425[b]	3.95[b]	1.96[ab]	1.47[a]	26.65[a]
9.	1.80[a]	9.42[b]	7.62[b]	423[b]	3.94[b]	2.00[b]	1.47[a]	26.67[a]
10.	1.80[a]	9.35[b]	7.55[b]	419[bc]	3.92[bc]	2.10[bc]	1.26[bc]	23.01[ab]
11.	1.81[a]	10.06[a]	8.25[a]	456[a]	4.08[a]	1.82[a]	1.47[a]	26.70[a]
12.	1.80[a]	9.48[b]	7.68[b]	427[b]	3.96[b]	2.02[b]	1.30[bc]	23.42[ab]
±S.E.[**]	0.01	0.16	0.15	5.28	0.03	0.04	0.03	1.41

Figures in the same column having same superscripts are not significantly different (p>0.05)
Standard error (SE) of treatment means calculated from residual mean square in the Analysis of Variance

The mean FCR values with different diets ranged between 1.82 and 3.01 with diet 11 producing significantly (p<0.05) the lowest FCR. However, there was no significant difference (p>0.05) between the FCR values of diets 8 and 11. Again, there was no significant difference (p>0.05) between the FCR values of diets 8, 9, 10 and 12 and these values were higher than those obtained with other diets. The PER values obtained with different diets varied between 1.26 to 1.47 (Table 3). However, diets 8, 9 and 11 had significantly the best PER values. There were no significant (p>0.05) difference between the PERs of diets 1, 2, 3, 5, 6, 10 and 12 and these values were higher than that of diets 4 and 7. The apparent net protein utilization (ANPU %) for the diets ranged between 20.23 and 26:70 (Table 3.). The significantly (p<0.05) highest ANPU values were obtained with diets 3,5, 6, 7, 8, 9, 10, 11 and 12 and these values were not significantly (p>0.05) different among themselves.

The proximate carcass composition of fish at the start and at the end of the experiment is shown in Table 4. The moisture and lipid content was influenced by the dietary P/E ratio. The highest moisture content was observed in fish fed diet 1 and the lowest was with diet 11. The moisture content ranged between 70.20 and 73.40%. The carcass lipid content ranged between 6.60 and 9.20%. The carcass lipid was directly influenced by the dietary lipid content. The highest (17.80%) carcass protein content was observed in fish fed diet 11 and the protein content in different dietary groups ranged between 16.50 to 17.80%.

Table 4. Proximate carcass composition of fish (% fresh matter basis) at the start and end of the experiment

Diet No.	Moisture	Protein	Lipid	Ash
1.	73.40	16.55	6.60	2.71
2.	73.12	16.50	6.88	2.78
3.	73.04	16.49	7.36	2.80
4.	72.66	17.10	7.18	2.92
5.	72.10	17.28	7.56	2.84
6.	71.20	17.44	7.20	2.87
7.	71.42	17.40	8.11	2.90
8.	71.34	17.56	8.20	2.82
9.	70.92	17.41	8.66	2.79
10.	70.24	17.66	9.12	2.86
11.	70.20	17.80	9.05	2.82
12.	70.22	17.21	9.20	2.88
Initial (all fish)	76.44	15.01	5.14	2.66

Discussion

The results of the study revealed that the best growth performance and feed utilization of *Clarias gariepinus* were obtained with feed 11 (33.5% digestible protein and 2.75 Kcal/g energy) with a protein-energy ratio of 121.8. This may be due to the fact that the digestible protein level (33.5%) in diet 11 was optimum to promote growth and the energy (2.75 Kcal/g) of the diet was also adequate for maintenance and growth. The P/E ratio obtained in the present study is similar to that reported by Singh and Bhanot (1987) who found a P/E ratio of 124.8 for *Catla catla.* Catacutan and Coloso (1995) also reported that diet containing 42.5% crude protein and 10% lipid with a P/E ratio of 128 (mg protein/Kcal) was found to be optimum for juvenile (1.34g) sea bass. Reis *et al.*(1989) also found a P/E ratio of 120 in channel catfish, *Ictalurus punctatus* fed diets containing 26, 31, 35 and 39% protein or 91, 107, 120 and 127 mg protein/Kcal digestible energy (DE) respectively for 123 days.

In contrast to the present findings, Mukhopaddhyay *et al.* (1986) observed a significant increase in weight gain, feed efficiency and protein utilization in *Clarias batrachus* fed diets containing P/E ratio of 87.6. Garling and Wilson (1976) demonstrated the optimum P/E ratio for channel catfish to be 88 with a dietary protein levels of 24 to 36%. On the other hand, Winfree and Stickney (1984) reported that optimum protein requirement for channel catfish appeared to be 55% (P/E= 122) at 0.2g size and 54% (P/E= 117) for 1.7g size.

The importance of protein level in relation to the energy level to the diet is very important (Garling and Wilson 1976). The amount of fish meal in diet 11 increased proportionately with the increase in the dietary protein level, which probably gave a best amino acid profile. Lovell (1979) reported that protein levels of 30- 36% will probably be adequate for most warm water fish diets. Use of fish oil and soybean oil as energy source may be another possible factor that influenced the growth performance of fish.

The absence of positive relation between growth and dietary energy level indicates that *C. gariepinus* may probably unable to utilize feeds having higher protein and at a energy level of 3.25 Kcal/g. Page and Andrews (1973) observed in channel catfish that, bigger fish require more energy and less protein compared to smaller fish. Since in the present study experimental fish had an initial average weight of 1.80g, it is expected that it may be possible to further reduce the dietary P/E ratio for growers.

The growth of fish in different treatments was undoubtedly affected by the protein-energy relationship. Growth increased with the increase in energy at 26% digestible protein level while the similar result was not found with other diets. This finding is similar to that of Lovell (1979) who reported that when fish are fed diets containing too much energy in relation to protein, they will not meet their daily protein need for optimum growth even if they are fed to satiation.

Although diet 10 contained same level (33.5%) of digestible protein with 2.25 Kcal/g energy produced much lower growth of fish which indicates that the energy was not sufficient for growth. This may be due to the fact that fish oil and soybean oil were not added in this diet and relatively low levels of lipid and dextrin were present in the diet (Table 1 and 2) which could not supply the required energy for fish growth and the dietary protein might have been spared for the energy.

In the present study poor growth performance of fish was observed with diets containing lower levels (23, 26.5 and 30%) of digestible proteins at high energy levels. This may be due to the fact that when fish were fed higher energy in relation to protein, they could not meet their daily protein needs for optimum growth even if they were fed to satiation level.

The FCR in this study varied between 1.82 to 3.01. Diet 8 (30% digestible protein) and diet 11 (33.5% digestible protein) with 2.75 Kcal/g energy produced significantly ($p<0.05$) the best FCR values. The FCR values in the present study are higher than the values for channel catfish reported by Garling and Wilson (1976) but lower than the values reported by Das *et al*. (1991) for *Labeo rohita* fingerlings. Reis *et al.* (1989) reported a much lower food conversion ratio of 1.15 in channel catfish fed diet containing 35% protein with a P/E ratio of 120.

The PER values followed similar trend of FCR and ranged between 1.26 to 1.47. The best PER value was obtained with diets 8, 9 and 11. The best PER obtained with 30% digestible protein with P/E ratio of 109.09, 92.34 and 33.5% digestible protein with P/E ratio of 121.82. In general, at each protein level, PER increased as the P/E ratio decreased. The PER values obtained in this study are higher than those reported by Das *et al.* (1991) for *L. rohita.*

The ANPU (%) values in the study ranged between 20.23 and 26.70%. Since the carcass protein content (Table 4) of various fish groups are more or less similar the ANPU values in general tended to reflect the PER values.

Proximate carcass composition of fish was found to be influenced by the P/E ratio. Carcass lipid content increased with the dietary lipid content. Similar observation is reported by Daniels and Robinson (1986) with juvenile red drum (*Sciaenopes ocellatus*) fed diets containing different levels of protein and energy. An inverse relationship between lipid and moisture could be observed as reported earlier (Andrews and Stickney 1972, Garling and Wilson 1976).

The results of the present study showed that diet containing 33.5% digestible protein and 2.75 Kcal/g energy with a protein to energy ratio of 121.8 (mg protein/Kcal) appeared to be best utilized for the growth of *C. gariepinus*.

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