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Food Utilization in the Common Carp *Cyprinus carpio* in Relation to Formulated Feeds

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Abstract

A 30-day feed trial was conducted to examine the effects of two groups of formu-lated pelleted feeds (beef waste + rice bran + groundnut oil cake; fish waste + soybean seeds + *Spirogyra maxima*) on the growth and body composition of the common carp *Cyprinus carpio*. Fish fed on beef-based feeds showed a slight increase in the rates of feeding, absorption and metabolism. The highest feeding rate of 1,460 $J \cdot g^{-1} \cdot day^{-1}$ and the highest conversion rate of 182 $J \cdot g^{-1} \cdot day^{-1}$ were noticed in *C. carpio* fed on these feeds. The absorption efficiency was higher in fish-based feeds (77-89%) than in beef-based feeds (65-72%), but the food conversion efficiency showed the reverse trend. Increase in protein content of the diets produced elevated values in the rates and efficiencies of food conversion in all eight experimental feeds. A positive linear relation-ship was obtained between energy density of the diets and food conversion efficiency. The highest food conversion ratio of 1.7 was noticed in *C. carpio* fed on 2:1:1 mixtures by dry weight of the above ingredients in both groups.

Introduction

Artificial feeding is an integral part of managed fish culture practices, where the focus is on maximizing fish production with minimum feed costs (Jeyachandran and Raj 1976; De Silva 1988). Previous experimental trials have proven that leguminous seeds (dela Peña et al. 1987), green algae (Singh and Bhanot 1970) and leaves of *Nymphoides cristatum* (Patnaik and Das 1979) and *Eichhornia crassipes* (Edwards et al. 1985) are highly nutritive feeds for fishes. The present investigation attempts to examine the utility of fish waste, beef waste, soybean seeds and *Spirogyra maxima* in fish-feed formulations.

Materials and Methods

Two sets of diets were formulated using beef waste + rice bran + groundnut oil cake (Groups Ia-Id) and fish waste + soybean seeds + *S. maxima* (Groups IIa-IId) (Table 1). The pellets were prepared by mixing the required quantities of finely powdered material with tapioca flour as the binder. Each feed mixture was then extruded through a 3-mm die, broken into pellets of suitable size and sun-dried for 12 hours. The dried pellets were stored in airtight polythene bags at room temperature.

Juvenile *Cyprinus carpio* (0.75-1.25 g live weight) were purchased from Manimutharu Fisheries Farm (Tirunelveli) and acclimated to laboratory conditions. To test each diet, three groups each comprising a minimum of three individuals were used. The experiments were performed in round plastic 6-l troughs for one month. The test fish were fed thrice daily between 9 and 16 hours and the diets were offered only as long as the fish were actively feeding to avoid wastage (Cho et al. 1982). Leftover food was siphoned causing least disturbance. Feces were collected by filtering the entire aquarium and dried at 65°C.

The energy budget followed here is the slightly modified IBP formula (Petrusewicz and Macfadyen 1970) represented as C=P+R+F, where C is the food energy consumed, P the growth (conversion), R the energy lost as heat due to metabolism and F the feces. Water content of the fish at the commencement and

Table 1. Proximate analysis of feed ingredients and experimental diets (% dry weight).

Feed group	Ingredient	Ratio	Water	Crude protein	Carbohydrate	Fat	Ash	Energy ($J \cdot mg^{-1}$)
Beef waste (B)				50.9	8.4	12.7	4.9	19.7
Groundnut oil cake (G)				43.9	6.7	10.7	11.5	17.2
Rice bran (R)				15.7	20.5	3.4	7.5	15.3
Ia	B, G and R	1:1:1	4.3	34.5	26.8	20.6	18.1	21.82
Ib	B, G and R	1:2:2	4.5	29.3	30.8	19.6	20.0	21.25
Ic	B, G and R	1:4:4	8.1	25.0	32.5	18.5	24.0	20.11
Id	B, G and R	2:1:1	7.4	37.8	24.2	21.8	16.2	27.42
Fish waste (F)				56.5	1.4	15.3	26.3	21.7
Soybean seeds (L)				46.6	8.7	9.6	5.3	16.3
Spirogyra maxima (S)				17.3	21.6	1.1	21.2	10.4
IIa	F, L and S	1:1:1	8.8	28.1	29.4	20.9	21.6	19.87
IIb	F, L and S	1:2:2	8.6	24.7	31.1	19.8	24.4	19.42
IIc	F, L and S	1:4:4	8.3	22.6	35.5	20.0	23.9	18.87
IId	F, L and S	2:1:1	7.9	31.6	27.4	27.7	13.3	20.05

termination of the experiment was estimated. Efficiencies of absorption and net conversion (k^2) were calculated in percentage relating absorption (C-F) to the respective amount of food absorbed. Protein and fat contents were estimated following methods of Lowry et al. (1951) and Folch et al. (1957), respectively. Ash content was estimated by incinerating a known weight of dry substance in a muffle furnace at 560°C for 8 hours (Paine 1964). Energy content of the feeds and fish was estimated using a macrobomb calorimeter. Values obtained for the weight gain, conversion efficiency and ash content of the final fish were analyzed to test the level of significance of the regression coefficient (Snedecor and Cochran 1967).

The following rates were also determined:

$$\text{Conversion rate} = \frac{\text{Final dry weight - initial dry weight (J)}}{\text{Initial live weight of the fish (g) x duration (30 days)}}$$

$$\text{Metabolic rate} = \frac{\text{Food absorbed - (final dry weight - initial dry weight) (J)}}{\text{Initial live weight of the fish (g) x duration (30 days)}}$$

Results and Discussion

Data on feeding rates and absorption are given in Table 2. Maximum feeding rate of 61 $mg \cdot g^{-1} \cdot day^{-1}$ was noticed in Group Ic followed by Ib (58 $mg \cdot g^{-1} \cdot day^{-1}$), Id and Ia (53 $mg \cdot g^{-1} \cdot day^{-1}$). Conversion rate was the highest (6.6 $mg \cdot g^{-1} \cdot day^{-1}$) for Ia and Id diets. In the remaining combinations (Ib and Ic), conversion rate was more or less same (5.8 $mg \cdot g^{-1} \cdot day^{-1}$). Metabolic rate of the test fish was the highest (37 $mg \cdot g^{-1} \cdot day^{-1}$) in Ic feed and the least (29 $mg \cdot g^{-1} \cdot day^{-1}$) in Id feed.

The highest feeding rate of 61 $mg \cdot g^{-1} \cdot day^{-1}$ was reported for Group IId. Metabolic rate was more or less same for all the Group II feeds (37-39 $mg \cdot g^{-1} \cdot day^{-1}$). Conversion rate was highest for IId (7 $mg \cdot g^{-1} \cdot day^{-1}$). Absorption efficiency (Absorption rate/feeding rate x 100) values ranged between 65 and 72% in Group I and 70 and 78% in Group II. But food conversion efficiency (conversion rate/absorption rate x 100) of the fish was higher in Group I (13-18%) than in Group II (11-16%).

Table 2. Weight budget of *Cyprinus carpio* fed on formulated feeds at different ratios. Each val represents the average performance of a minimum of three fish in triplicate and ± indicates the standa deviation.

Feed	Ingredient	Ratio	Feeding rate	Absorption rate	Metabolic rate	Conversion rate	Food conversion ratio (consumption/ conversion in live weight)
			(mg dry weight/g live fish/day)				
Ia	B, G and R	1:1:1	52.95 ± 2.91	38.30 ± 3.91	31.75	6.55 ± 1.02	1.75
Ib	B, G and R	1:2:2	55.40 ± 4.86	36.19 ± 4.82	30.39	5.80 ± 0.96	2.05
Ic	B, G and R	1:4:4	60.79 ± 3.23	43.45 ± 6.02	37.60	5.80 ± 0.84	2.25
Id	B, G and R	2:1:1	53.25 ± 6.44	36.11 ± 7.11	29.47	6.64 ± 1.12	1.73
IIa	F, L and S	1:1:1	56.65 ± 2.84	44.16 ± 4.02	37.85	6.31 ± 1.23	1.89
IIb	F, L and S	1:2:2	55.35 ± 4.26	42.61 ± 3.22	37.34	5.28 ± 0.62	2.17
IIc	F, L and S	1:4:4	58.91 ± 3.31	44.44 ± 2.86	39.48	4.96 ± 0.44	2.49
IId	F, L and S	2:1:1	61.45 ± 2.51	45.70 ± 5.26	38.60	7.09 ± 0.88	1.76

Data on weight budgets (Table 1) were converted into energy units (Table 3). Maximum feeding rate of 1,460 $J \cdot g^{-1} \cdot day^{-1}$ was reported in feed Id and a similar trend in feed IId. Correspondingly, the rates of absorption (990 and 916 $J \cdot g^{-1} \cdot day^{-1}$) and conversion (182 and 142 $J \cdot g^{-1} \cdot day^{-1}$) also showed the highest values in IId.

In the present investigation, *C. carpio* fed on formulated pellets showed a maximum feeding rate of 61 $mg \cdot g^{-1} \cdot day^{-1}$. Pandian and Raghuraman (1972), Vivekanandan (1976) and Haniffa and Venkatachalam (1980) reported 58, 43 and 23 $mg \cdot g^{-1} \cdot day^{-1}$ as the maximum feeding rates for *Oreochromis mossambicus*,

Table 3. Energy budget of *C. carpio* fed on formulated feeds at different ratios. Each value represents the average performance of three fish in triplicate.

Feed	Ingredient	Ratio	Feeding rate	Absorption rate	Metabolic rate	Conversion rate	Absorption efficiency (%)	Conversion efficiency (%)
			($J \cdot g^{-1} \cdot day^{-1}$, live fish)					
Ia	B, G and R	1:1:1	1,155.6	835.8	692.9	142.9	72.3	17.0
Ib	B, G and R	1:2:2	1,177.5	769.2	645.9	123.2	65.3	16.0
Ic	B, G and R	1:4:4	1,220.5	873.7	756.0	116.6	71.5	13.3
Id	B, G and R	2:1:1	1,460.2	990.2	808.0	182.0	67.8	18.3
IIa	F, L and S	1:1:1	1,125.8	877.6	752.2	125.0	77.9	14.2
IIb	F, L and S	1:2:2	1,074.7	846.8	725.0	102.5	78.7	12.1
IIc	F, L and S	1:4:4	1,181.3	838.5	744.9	93.3	70.9	11.1
IId	F, L and S	2:1:1	1,232.3	916.4	774.0	142.1	74.3	15.5

Ophiocephalus striatus and *Ctenopharyngodon idella*, respectively. Regarding the food consumption in calories, the highest feeding rate in the present investigation was 349 $cal \cdot g^{-1} \cdot day^{-1}$. Marian et al. (1982) reported 62 $cal \cdot g^{-1} \cdot day^{-1}$ for the air-breathing fish *Heteropneustes fossilis* fed on goat liver. Conversion rate of *C. carpio* ranged from 5.0 to 7.1 $mg \cdot g^{-1} \cdot day^{-1}$ (93 and 182 $J \cdot g^{-1} \cdot day^{-1}$) and the highest values were reported for Group II (Table 2). Comparative values of other culturable fishes are 7 $mg \cdot g^{-1} \cdot day^{-1}$ for *O. striatus* (Vivekanandan 1976), 5 $mg \cdot g^{-1} \cdot day^{-1}$ for *Anabas scandens* (Pandian et al. 1976) and 4.9-7.7 $mg \cdot g^{-1} \cdot day^{-1}$ for *Labeo rohita* (Haniffa et al. 1987).

Crude protein of the whole fish carcass ranged between 11.1 and 12.3% and 11.7 and 13.0% for Groups I and II, respectively (Table 4).

Table 4. Proximate composition and energy of whole fish carcass at the start and end of the 30 days feeding trial. Each value represents the average performance of three fish in triplicate and is expressed on a wet-weight basis.

Ingredient	Ratio	Water (%)	Crude protein (%)	Lipid (%)	Ash (%)	Energy ($cal \cdot g^{-1}$)
			Initial fish			
		79.0	12.98	4.33	3.89	4,205
			Final fish fed on			
B, G and R	1:1:1	78.3	12.21	4.25	5.22	4,837
B, G and R	1:2:2	78.5	12.47	4.02	5.86	4,728
B, G and R	1:4:4	78.5	11.11	4.21	6.17	4,575
B, G and R	2:1:1	78.4	12.29	4.66	2.46	5,142
F, L and S	1:1:1	79.0	12.58	4.12	4.31	4,554
F, L and S	1:2:2	79.3	11.71	3.76	5.19	4,401
F, L and S	1:4:4	79.0	12.09	4.13	4.77	4,358
F, L and S	2:1:1	79.6	12.97	4.10	3.32	4,597

De Silva et al. (1984) reported the protein content of the natural food of adult *Oreochromis mossambicus* as 24.5%. In the present investigation, protein content of the formulated feeds ranged between 23 and 38%. According to Pandian and Vernberg (1987), the feeding rates of several herbivores and carnivores decrease with increasing protein content in the food. In this study, increase in

dietary protein content produced elevated values of rate and efficiency of conversion in all eight formulations. As suggested by Jackson and Capper (1982), energy provided by protein catabolism improved growth at higher protein levels. Statistical analysis computed for significance test of simple regression (y=a+bx) coefficient (Snedecor and Cochran 1967) confirmed that conversion efficiency with regard to protein levels in the diet was statistically significant (Conversion efficiency (%) = 1.3398 + 0.4572 x protein in feed (%); $P<0.05$).

According to Cho et al. (1985), lipids play an important role as an energy source in fish diets, especially for carnivorous fish in which the availability of dietary carbohydrates for enery flow is low. In the present investigation, feeds were formulated in such a way that the percentage of lipids in the feed caused an increase in energy value [Energy ($J \cdot g^{-1}$) = 19.31 + 0.085 x lipid (%), $P>0.05$] whereas the percentage of carbohydrates in the ingredients showed a reverse trend [Energy ($J \cdot g^{-1}$) = 36.93 - 0.53 x Carbohydrate (%), $P>0.05$]. Cho et al. (1985) also reported that fish given a high energy diet can ingest more nutrients and sustain a higher growth rate. In the present study, high energy diets enhanced the conversion rate [conversion rate ($mg \cdot g \cdot day^{-1}$) = - 2.14 x 0.39 x Energy ($J \cdot g^{-1}$), $P>0.05$] and efficiency of conversion [conversion efficiency (%) = - 24.29 + 0.009 x Energy ($J \cdot g^{-1}$), $P<0.05$]. The best food conversion ratio (growth in live weight/food consumption in dry) of 1.7 was obtained in the 2:1:1 ratio in both the diets. This compares with the conversion ratio of 1.67 for *L. rohita* and 2.20 for *Cirrhinus mrigala* fed on artificial feeds made of rice bran, fish meal, groundnut oil cake and silkworm pupae (Santhanam 1981). Values reported for the conversion ratio by dela Peña et al. (1987) ranged from 1.88 to 5.31 for the milkfish *Chanos chanos* fed on four different leguminous diets.

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References

Cho, C.Y., S.J. Slunger and H.S. Bayley. 1982. Bioenergetics of salmonid fishes. Energy intake, expenditure and productivity. Comp. Biochem. Physiol. 73:25-41.

Cho, C.Y., C.B. Cowey and T. Watanabe. 1985. Methodological approach to research and development, p. 10-79. *In* C.Y. Cho, C.B. Cowey and T. Watanabe (eds.) Finfish nutrition in Asia. International Development Research Centre, Ottawa, Ontario, Canada.

De Silva, S.S., M.K. Perera and P. Maitipe. 1984. The composition, nutritional status and digestibility of the diets of *Sarotherodon mossambicus* from nine man-made lakes in Sri Lanka. Environ. Biol. Fish. 11:205-219.

De Silva, S.S. 1988. Summary of ongoing finfish nutrition research in Asia, p. 3-6. *In* S.S. De Silva (ed.) Finfish nutrition research in Asia. Proceedings of the Second Fish Nutrition Network Meeting. Heinemann Asia, Singapore.

dela Peña, L.D., Y.N. Chiu and F. Ganchero. 1987. Evaluation of various leguminous seeds as protein sources for milkfish *Chanos chanos* Forsskal juveniles. Asian Fish. Sci. 1:19-25.

Edwards, P., M. Kamal and K.L. Wee. 1985. Incorporation of composted and dried water hyacinth in pelleted feed for the tilapia *Oreochromis niloticus* (Peters). Aquacult. Fish. Manage. 1:233-248.

Folch, J., M. Less and G.H.S. Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226:497-509.

Haniffa, M.A. and V. Venkatachalam. 1980. Effects of quality of food on energy budget and chemical composition of the grass carp *Ctenopharyngodon idella*, p. 163-173. *In* M. Nordin, A. Latiff, M.C. Mahani and S.C. Tan (eds.) Proceedings of the International Symposium on Conservation Inputs from Life Sciences. University of Kebangsaan, Malaysia.

Haniffa, M.A., A.G. Murugesan and A.T. Fleming. 1987. Influence of plant and animal food on food utilization of the freshwater carp *Labeo rohita* (Ham.). Curr. Sci. 56:846-848.

Jackson, A.J. and B.S. Capper. 1982. Investigations in the requirements of the tilapia (*Oreochromis mossambicus*) for dietary methionine, lysine and arginine in semi-synthetic diets. Aquaculture 29:289-297.

Jeyachandran, P. and S.P. Raj. 1976. Experiments with artificial feeds on *Cyprinus carpio* fingerlings. J. Inland. Fish. Soc. India 8:33-35.

Lowry, O.H., N.J. Rosebrough, A.L. Farr and R.J. Randall. 1951. Protein measurement with folin phenol reagent. J. Biol. Chem. 193:265-275.

Marian, M.P., A.G. Ponniah, R. Pitchairaj and M. Narayanan. 1982. Effect of feeding frequency on surfacing activity and growth in the air-breathing fish *Heteropneustes fossilis*. Aquaculture 26:237-244.

Paine, R.T. 1964. Ash and caloric determinations of sponge and opisthobranch tissues. Ecology 45:384-387.

Pandian, T.J. and Raghuraman. 1972. Effects of feeding rate on conversion efficiency and chemical composition of the fish *Tilapia mossambica*. Mar. Biol. 12:129-136.

Pandian, T.J., R. Bhaskaran and E. Vivekanandan. 1976. Effects of pO_2 on surfacing activity and food utilization in the climbing perch *Anabas scandens*. Pol. Arch. Hydrobiol. 23:191-201.

Pandian, T.J. and F.J. Vernberg, Editors. 1987. Animal energetics, Vol. 2. Academic Press, New York.

Patnaik, S. and K.M. Das. 1979. Utilization of some aquatic weeds as feed for rearing carp spawn fry. Paper presented at the Symposium of Inland Aquaculture, 12-14 February 1979, Central Inland Fisheries Research Institute, Barrackpore, India.

Petrusewicz, K. and A. Macfadyen. 1970. Productivity of terrestrial animals. IBP Handbook No. 13. Blackwell Scientific Publications, Oxford.

Santhanam, R. 1981. Energy and nitrogen balance in the nutrition and growth on Indian major carps. Final report to the Indian Council for Agricultural Research, Tamil Nadu Agricultural University, Fisheries College, Tuticorin.

Singh, C.S. and K.K. Bhanot. 1970. Freshwater alga *Oedogonium obstruncatum* Wittroch as a nutritive source to *Cirrhinus mrigala* (Ham.). Indian J. Exp. Biol. 8:153-154.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods. Oxford and IBH Publishing Co., New Delhi.

Vivekanandan, E. 1976. Effects of feeding on the swimming activity and growth of *Ophiocephalus striatus*. J. Fish Biol. 8:321-330.

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