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Energy Digestibility Coefficients of Commonly Used Feedstuffs in Different Size-Classes of Indian Major Carps, *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton)

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Abstract

The apparent energy digestibility coefficient of nine different feedstuffs were determined for two size-classes of Indian major carps (*Labeo rohita* and *Cirrhinus mrigala*, Cyprinidae) using chromic oxide as the indigestible marker. Among the ingredients tested, rice polish showed the lowest while the soybean oil cake showed the highest digestibility in both species. The influence of fish size on energy digestibility was found to be insignifi-cant (P>0.01). Irrespective of fish size, plant and animal origin feed stuffs showed no sig-nificant (P>0.01) difference in their digestibility in both species. Only the animal origin feed stuffs, in both size-classes, exhibited species dependent variability in their digestibility.

Introduction

Diet development for practical feeding requires a knowledge of nutritional requirements, and the ability of the concerned species to digest and absorb the nutrients from the feed ingredients. Energy digestion coefficient of various feed stuffs have been reported for several fish species (Cruz 1975; Stickney and Lovell 1977; NRC 1981; Cho et al. 1982; Popma 1982; Wilson and Poe 1985; Hanley 1987; and Hossain and Jauncey 1989) using direct and indirect methods. Information on digestibility of feed ingredients used in feeding Indian major carps in traditional or semi-intensive farming system is limited (Singh,1992; Jafri and Anwar,1995).In order to meet their nutrient/energy requirements through practical feeding and to replace one ingredient with the other for economic reasons, knowledge of digestibility coefficients for such feed stuffs is essential.

In fish, the nutrients/energy digestibility of a particular ingredient is known to be species specific. Several other factors, including age/size of the fish, also govern the extent of digestibility (Hastings 1969; Windell et al. 1978; De Silva and Anderson 1995). This study analyses the energy digestibility coefficients for some commonly used feedstuffs in two size-classes for Indian major carps, namely, *Labeo rohita* and *Cirrhinus mrigala*.

Materials and Methods

Experimental fish and acclimation

Hatchery produced fingerlings of *L. rohita* and *C. mrigala* were used for the study. For each species, two size-groups were selected, stocked in 70 l flow-through type circular troughs (water volume, 55:l and exchange rate, l:l/min), and acclimated to experimental condition. Details of the fish size and stocking density are given in Table 1.

Feedstuffs

Nine different feedstuffs, generally used by fish farmers in various parts of India for the supplementary feeding of carps, were selected for the study. Mixed species of trash fish purchased from the local market were cooked and pressed, and dried (60 °C) in a hot air oven for the preparation of fish meal. Slaughter house waste (buffalo intestine) was collected, cut open, and cleaned using a strong jet of water. It was then processed in the above manner. Dried silk worm (*Bombyx mori*) pupae were procured from a farmer in West Bengal, while expeller type rocket salad oil cake, mustard oil cake, groundnut oil cake, and rice polish were obtained from the local market. Soybean oil cake (with hull, solvent extracted) was supplied by Parag Oil Mill, Aligarh.

Preparation of experimental diets

The experimental diets were formulated following the methods adopted by Cruz (1975) and Popma (1982). A mixture of a-cellulose and finely sieved sug-

Table 1. Details of fish size and stocking density.

Species	Size classes				Stocking density (No. of fish/trough)	
	Group I		Group II			
	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Group I	Group II
Labeo rohita	13.92 ±0.24	24.70 ±1.37	18.07 ±0.38	48.56 ±3.45	10	05
Cirrhinus mrigala	08.20 ±0.19	04.34 ±0.21	12.65 ±0.20	15.81 ±0.98	35	10

± SEM

arcane bagasse (1:1) was used in various quantities to maintain a uniform (15-16%) amount of dietary fibre to facilitate homogeneous enzyme action. The lipid level in the diet was maintained at 9-10% by adding an exogenous oil mixture (2:1, corn and cod liver oil). Gelatin and carboxymethyl cellulose were used as binders while chromic oxide was employed as the indigestible marker (Table 2).

The method of preparation of the experimental diets was the same as the one adopted by Hassan (1993), except that dry dietary ingredients were thoroughly mixed in a mixer before adding to the cooking bowl containing gelatin in the dissolved state.

Digestibility trial

Water exchange rate in fish holding troughs throughout the trial was maintained at 1:1/min. Care was taken to insure that fecal matter did not escape through the outlet. For acclimation to experimental diets, fish were fed *ad lib* daily at 0900 and 1600 h for 7 days. Unconsumed food was siphoned off 2 h after each feeding. After acclimation, fecal matter was collected daily for digestibility estimation 8 to 10 hours after feeding. Fecal collection was made over a fine mesh strainer (ASTM-100) through slow siphoning, using a narrow (8.0 mm) plastic tube, to avoid breakage of thin fecal strings and minimize nutrient loss which is inherent in this method. The feces were pooled together in a plastic container and stored (-20 °C) till enough sample was collected. Later, these were oven dried (100 °C) for further analyses. Each experiment was carried out in triplicate. The water temperature during the trial ranged between 24 and 28 °C. After each run, the troughs were thoroughly cleared by scrubbing and rinsed with dilute $KMnO_4$ solution. Before feeding the next experimental diet, fish were deprived of food for 3-4 days.

Table 2. Ingredient composition of experimental diets.

Feedstuffs (Main ingredients)	Percentage composition, as fed			
	Main ingredient	Crude fibre[1]	Oil[2]	Others[3]
Rocket salad oil cake	87.50	06.0	1.00	5.5
Mustard oil cake	86.50	07.0	1.00	5.5
Soybean oil cake (solv. extd.)	79.50	07.0	8.00	5.5
Groundnut oil cake	83.50	08.0	3.00	5.5
Wheat bran	84.50	06.0	4.00	5.5
Rice polish	80.50	13.0	1.0	5.5
Fish meal (mixed spp.)	79.17	15.0	0.33	5.5
Slaughter house waste	78.17	16.0	o.33	5.5
Dried silkworm pupae	91.17	03.0	0.33	5.5

[1] 1:1 a -cellulose and sugarcane bagasse.
[2] 2:1 corn and cod liver oil.
[3] Carboxymethyl cellulose 2.0%; gelatin 1.0%; vit. mix. 1.0%; mineral mix. 1.0%; and chromic oxide 0.5%.

Analytical methods

Prior to their inclusion, the feedstuffs were analysed for their proximate composition (Table 3) using standard methods (AOAC 1984). Crude fibre was analysed through successive acid and alkali digestion method, while chitin in silkworm pupae was estimated as the difference after prolonged heating (60 °C) in NaOH solution (10%). Gross energy of feedstuffs, diet, and feces were estimated on a ballistic (adiabatic) bomb calorimeter (Gallenkamp and Loughborough Co. Ltd., Loughborough, England).Chromic oxide was estimated using the acid digestion technique (Furukawa and Tsukahara 1966).

Digestible energy content in each diet was calculated using the following formula (Page and Andrews 1973):

Digestible energy ($kJ \cdot g^{-1}$) = Gross energy of diet -[gross energy of feces]

where,

DE = Digestible energy
GED = Gross energy of diet
GEF = Gross energy of feces

Digestible energy values of various diets were fitted to the following equation to estimate the digestibility coefficient (x) for each feed ingredient (Hanley 1987), expressing the values in percentage :

$x = [100\ (á\text{-}cd)]/b$

where,

x = digestibility coefficient of test ingredient (%)
a = digestible energy ($kJ \cdot g^{-1}$) of the diet
b = energy ($kJ \cdot g^{-1}$) contributed by the test ingredient in the diet
c = energy ($kJ \cdot g^{-1}$) contributed by the oil supplement in the diet
d = digestibility coefficient of the oil supplement (%).

The components of the formulated diet, besides the test ingredient, which contributed to its gross energy were gelatin, oil mix, and fibre (mixture of a - cellulose and sugarcane bagasse). Since gelatin formed only 1% of the diet, its energy value was not taken into account while calculating the digestibility coefficient. Oil mix used was considered approximately 90% digestible, as reported in several other herbivore and omnivore fish species (Takeuchi 1979; NRC 1983; and Hanley 1987).

Statistical analyses

The data on coefficients of energy digestibility within each size-class of the species were subjected to one-way analysis of variance to test the variability among the feedstuffs. Significant differences between means were compared using Duncan's (1955) multiple range test. Again, the means of coefficients between plant and animal origin feedstuffs, size-classes and species of fishes were compared using the Student's t-test.

Results

The data (Table 4) indicates that, within each size-class of the test species, *L. rohita* and *C. mrigala*, digestibility varies ($P<0.01$) with feedstuffs. However, no significant ($P>0.01$) difference in the digestibility of the feedstuffs tested was noticed between different size-classes of the two species. Both the species exhibited poor energy digestibility for rice polish (*Oryza sativa*), while soybean oil cake (*Glycine max*) was found to be the most digestible ingredient among the various feedstuffs. Rocket salad (*Eruca sativa*) oil cake, mustard (*Brassica campestris*) oil cake, wheat bran (*Triticum aestivum*), fish meal, slaughter-house waste, and dried silkworm pupae gave comparable values ($P<0.01$) for both the size-classes of the two fish species. When animal origin feedstuffs were compared, coefficients of digestibility did not differ. Within each size-class in both the species, the mean digestibility values between plant and animal origin feedstuffs were not significantly ($P>0.01$) different. Category wise, digestibility of plant and animal origin feedstuffs, compared between size-classes showed no significant ($P>0.01$) difference in both the species. With the exception of animal origin feedstuffs in both the size-classes, differences were not significant ($P>0.01$) between the two species (Table 5).

Table 3. Proximate composition and gross energy content of feedstuffs (g/100 g, as fed).

Feedstuffs	Moisture	Crude Protein	Crude Fat	Crude Fibre	Ash	Gross Energy ($kJ \cdot g^{-1}$)
Rocket salad oil cake	05.89	40.61	07.98	09.63	08.01	18.79
(*Eruca sativa*)	±0.35	±1.46	±0.42	±0.28	±0.19	±0.17
Mustard oil cake	02.64	37.94	09.82	09.26	07.79	20.29
(*Brassica campestris*)	±0.14	±1.17	±0.12	±0.20	±0.04	±0.13
Soybean oil cake (solv. extd.)	07.05	51.05	00.67	08.52	07.13	19.04
(*Glycine max*)	±0.46	±2.09	±0.16	±0.17	±0.12	±0.04
Groundnut oil cake	06.34	47.41	05.76	08.29	06.75	19.46
(*Arachis hypogea*)	±0.15	±1.15	±0.95	±0.27	±0.43	±0.04
Wheat bran	10.86	15.82	04.89	10.26	06.19	18.87
(*Triticum aestivum*)	±0.71	±0.41	±0.10	±0.20	±0.08	±0.17
Rice polish	09.06	09.90	11.57	03.20	05.18	19.12
(*Oryza sativa*)	±0.14	±0.49	±0.52	±0.31	± 0.17	±0.04
Fish meal (mixed spp.)	06.52	59.78	11.48	01.00	19.87	19.42
	±0.30	±0.39	±0.31	±0.10	±0.21	±0.29
Slaughter house waste	04.78	77.98	10.24	00.95	03.47	22.43
	±0.05	±0.82	±0.17	±0.09	±0.01	±0.38
Dried silkworm pupae	02.52	40.69	21.73	13.23*	04.20	23.73
(*Bombyx mori*)	±0.18	±1.24	±0.29	±0.20	±0.12	±0.97

±SEM, n = 5; *Chitin

Table 4. Energy digestibility coefficient of selected feedstuffs in different size-classes of Indian major carps.

Feedstuffs	Coefficient of energy digestibility (%)			
	L .rohita		*C. mrigala*	
	Group I	Group II	Group I	Group II
Rocket salad oil cake	63.32[ab] ±0.88	76.04[a] ±0.29	63.07[a] ±0.44	74.77[a] ±1.25
Mustard oil cake	64.33[ab] ±1.09	63 .14[bc] ±2.82	50.27[bc] ±1.99	55.75[bc] ±3.37
Soybean oil cake (solv. extd.)	96.18[d] ±1.28	90.00[d] ±0.40	81.27[d] ±0.24	89.83[d] ±1.11
Groundnut oil cake	78.36[e] ±1.48	82.98 [e] ±0.29	76.82[e] ±0.74	81.97[e] ±0.96
Wheat bran	58.58[b] ±0.60	63.02[c] ±1.51	44.69[c] ±0.01	5 3.86[bc] ±4.15
Rice polish	48.80[f] ±3.52 ±2.97	43.55[f] ±1.72	45.82[c]	49.07[c] ±5.24
Fish meal (mixed spp.)	69.34[a] ±0.62	72.64[ab] ±0.70	53.97[abc] ±3.27	58.03[bc] ±6.48
Slaughter house waste	61.23[ab] ±2.82	69.51[abc] ±6.47	57.41[ab] ±1.78	64.09[b] ±2.89
Dried silkworm pupae	66.46[ab] ±2.47	68.01[abc] ±1.45	58.34[ab] ±2.01	60.27[bc] ±6.08

± SEM, n = 3

Means in each column with same superscript are not significantly different ($P<0.01$).

Table 5. Comparison of digestibility coefficients between different variables.

Variables	Level of significance	
L. rohita : size classes	$P > 0.01$; n=16	insignificant
L. rohita (small) : origin of feed stuffs	$P > 0.01$; n=7	insignificant
L. rohita (large) : origin of feed stuffs	$P > 0.01$; n=7	insignificant
C. mrigala : size classes	$P > 0.01$; n=16	insignificant
C. mrigala (small) : origin of feed stuffs	$P > 0.01$; n=7	insignificant
C. mrigala (large) : origin of feed stuffs	$P > 0.01$; n=7	insignificant
Plant origin feed stuffs:		
species of fish (small)	$P > 0.01$; n=10	insignificant
species of fish (large)	$P > 0.01$; n=10	insignificant
Animal origin feed stuffs :		
species of fish (small)	$P < 0.01$; n=4	significant
species of fish (large)	$P < 0.01$; n=4	significant

Discussion

The variation in the energy digestibility observed among the feedstuffs may be attributed to the inherent complexity of nutrients, particularly carbohydrate and protein, and to the digestive physiology/enzyme profile of the fish concerned (De Silva and Anderson 1995; Nagase 1964; Reimer 1982; Smith 1989). Since a constant fibre content was maintained in the test diets, such variations could not be due to the crude fibre level of the diet. However, the possibility that the fibrous (cellulose, hemicellulose and lignin) nature of the ingredient itself could cause variations in digestibility can not be ruled out. The lowest digestibility noted for rice polish in both fish species indicate that its inclusion in the diet may not serve as an energy source, but the rich inorganic content of this ingredient may improve the nutritional quality of the diet. Law (1984 1986) has reported poor digestibility of rice bran in *Leptobarbus hoevenii* and *Ctenopharyngodon idella*. High digestibility of soybean oil cake, as observed during the present study, was also evident in other fish species (Law 1986). The digestibility of groundnut oil cake though lower than that of soybean oil cake, was found to be higher when compared to the values of other plant origin feedstuffs. Oil cakes of cruciferae origin were not significantly different in their digestibility indicating a similarity in the nutrient characteristics of these oil cakes. Digestibility of wheat bran showed a close proximity to that of cruciferae oil cakes. Dried silk worm pupae and slaughter house waste, with digestibility values almost similar to fish meal, may provide a suitable alternative to the latter in formulating fish feeds. Silk worm pupae are cheaper and available in abundance as a by-product of the silk industry in some parts of India. Similarly, slaughter house waste, with digestibility comparable to fish meal, may provide a dependable source of cost-effective ingredient in areas where fish meal is scarce and an expensive commodity. These ingredients thus have a great potential for use as dietary ingredients in practical rations for Indian major carps.

The values of energy digestibility coefficient obtained for different feed stuffs in the two species of Indian major carps seemed comparable to those reported for fishes of similar feeding habit (Stickney and Lovell 1977; Popma 1982; NRC 1983; Wilson and Poe 1985; Lovell 1989; Hossain and Jauncey 1989). It indicates that single-ingredient test diets used in the study (without inclusion of a reference diet), besides giving an advantage of using single test ingredient in maximum proportion, can suitably be used for evaluating coefficient of energy digestibility in a short term experiment. Hanley (1987) has successfully used such diets in determining the protein and energy digestibility coefficients of selected feedstuffs in tilapia (*Oreochromis mossambicus*) and noted that these diets were as nutritionally adequate as practical diets.

Several factors, including size and age, are known to influence nutrient digestibility in fishes (Hastings 1969; De Silva and Anderson 1995). Ferraris et al. (1986) observed that digestibility could increase with size in omnivorous and herbivorous fishes. In the present study, however, which involved two significantly ($P<0.01$) different size-classes of Indian major carps with distinct herbivorous/omnivorous feeding habit, no significant difference in digestibility could be seen. The close proximity of size groups used could be one of the reasons for the lack of significant differences in digestibility values. In *L. hoevenii*, a significantly lower digestibility was demonstrated in smaller fish (5-8 cm) than the larger (12 -16 cm and 20-26 cm) ones, although comparisons of digestibility between the large sized (12-16 cm and 20-26 cm) fish showed no significant difference (Law 1984). In *Salmo gairdneri*, Windell et al. (1978) reported size related differences in digestibility at low temperature only. Pandey and Singh (1980) reported that a younger *Colisa fasciatus* (1.69-1.94 g) possesses a lower capacity for protein digestion than a medium sized (4.95-5.29 g) fish. However, an older fish with greater weight (7.80-8.26 g) exhibited no improvement in digestive efficiency for the food protein.

A comparison of digestibility for plant origin feedstuffs revealed that both the species of Indian major carps were equally efficient in digesting the plant materials. However, *L. rohita* showed significantly better ability to digest animal origin feed ingredients. *L. rohita* which predominantly feeds on plant material also consumes rotifers and crustaceans (Jhingran and Pullin 1988). *C. mrigala*, being omnivorous, subsists mainly on detritus which includes both plant and animal origin materials. On the basis of the present study, it may, therefore, be presumed that although the two species exhibit differential ability in digesting animal origin feedstuffs, they are equally equipped with digestive secretion for catabolising nutrients from plant sources. Comparison of the abilities of the species or size-groups of these fishes to digest nutrients from the ingredients tested, point to possible similarity in their digestive enzyme spectrum.

The study thus clearly demonstrates that, notwithstanding generic differences, ecological niche (column and bottom feeder), feeding habit and food composition, the two species (*L. rohita* and *C. mrigala*) do not differ much in their ability to utilize nutrients from the feed stuffs under investigation. This points to the fact that practical rations could be formulated for the polyculture of these fishes using the same feed stuffs. Replacement of one feed stuff with the other, on the basis of their digestibility, cost and availability, could be attempted in formulating such diets.

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References

AOAC. 1984. Official methods of analysis. Fourteenth edition, S. Williams (ed.), Association of Official Analytical Chemists, Arlington, Virginia, 1141 pp.

Cho, C.Y., Slinger, S. J. and Bayley, H.S. 1982. Bioenergetics of salmonid fishes : Energy intake, expenditure and productivity. Comparative Biochemistry and Physiology 73: 25-41.

Cruz, E. M. 1975 . Determination of nutrient digestibility in various classes of natural and purified feed materials for channel catfish. Ph.D dissertation, Auburn University, Auburn, AL, 93 pp.

De Silva, S. S. and Anderson, T.A. 1995. Fish nutrition in aquaculture, Chapman and Hall, London/New York, 319 pp.

Duncan, D. B. 1955. Multiple range and multiple 'F' tests. Biometrics 11:1-42.

Ferraris., R. P., Catacutan, M. R., Mabelin, R. L. and Adan, P. J. 1986. Digestibility in milk fish, *Chanos chanos* (Forsskal) : Effects of protein source, fish size and salinity. Aquaculture 59 : 93-105.

Furukawa, A. and Tsukahara, H. 1966. On the acid digestion method for the determination of chromic oxide as an index substance in the study of digestibility of fish feed. Bulletin of the Japanese Society of Scientific Fisheries 32:502-504.

Hanley, F. 1987. The digestibility of foodstuffs and the effects of feeding selectivity on digestibility determinations in tilapia *Oreochromis niloticus* (L). Aquaculture 66: 163-179.

Hassan, M. A. 1993. Energy nutrition and biological aspects of energetics in selected cultivable fish species. Ph.D Thesis, Aligarh Muslim University, Aligarh, 111 pp.

Hastings, W. H. 1969. Nutritional score. In: Fish in research (eds. O. W. Neuhaus and J. E. Halver) pp. 263-292. Academic Press, Inc., New York.

Hossain, M. A. and Jauncey, K. 1989. Studies on the protein, energy and amino acid digestibility of fish meal, mustard oilcake, linseed and sesame meal for common carp (*Cyprinus carpio L.*). Aquaculture 83:59-72.

Jafri, A. K. and M.F. Anwar 1995. Protein digestibility of some low-cost feedstuffs in fingerling Indian major carps. Asian Fisheries Science 8 (1):47-53.

Jhingran, V. G. and Pullin, R. S. V. 1988. A hatchery manual for Common, Chinese and Indian major carps, ICLARM studies and reviews 11, Manila, Philippines 191 pp.

Law, A. T. 1984. Nutritional study of jelawat, *Leptobarbus hoevenii* (Bleeker), fed on pelleted feed. Aquaculture 41 : 227-233.

Law, A. T.,1986. Digestibility of low-cost ingredients in pelleted feed by grass carp (*Ctenopharyngodon idella* C. et. V.). Aquaculture 51:97-103.

Lovell, R. T. 1989. Nutrition and feeding of fish. Van Nostrand Reinhold, New York, 260 pp.

Nagase, G. 1964. Contribution to the physiology of digestion in *Tilapia mossambica* Peters. Digestive enzymes and the effects of diets on their activity. Zeitschrift für Vergleichende Physiologie 49:270-284.

NRC (National Research Council) 1981. Nutrient requirements of coldwater fishes. National Research Council, National Academy of Sciences, Washington, D.C., 63 pp.

NRC 1983. Nutirent requirements of warmwater fishes and shellfishes. National Research Council, National Academy of Sciences, Washington, D.C., 102 pp.

Page, J. W, and Andrews, J. W. 1973. Interactions of dietary levels of protein and energy on channel catfish (*Ictalurus punctatus*). Journal of Nutrition 103 : 1339-1346.

Pandey, H. S. and Singh , R. P. 1980. Protein digestibilty by khosti fish *Colisa fasciatus* (Pisces, Anabantidae) under the influence of certain factors. Acta Hydrochimica et Hydrobiologica 8 : 583-589.

Pandian, T. J. and Vivekanandan, E. 1985. Energetics of feeding and digestion. In : Fish energetics (eds. P. Tytler and P. Calow), pp. 99-124. Croom Helm Ltd., London.

Popma, T. J. 1982. Digestibility of selected feed stuffs and naturally occurring algae by tilapia. Ph. D. Dissertation, Auburn University, Auburn, AL, 78 pp.

Reimer , G. 1982. The influence of diet on the digestive enzymes of the Amazon fish Matrincha, *Brycon* cf. *melanopterus*. Journal of fish Biology 21: 637-642.

Singh, B. N. 1992. Digestibility of protein and energy from feed stuffs and pelleted diets in Mrigal, *Cirrhinus mrigala* (Ham.) and grass carp, *Ctenopharyngodon idella* (Val.). In : Aquaculture research needs for 2000 A.D. (Eds. J.K. Wang and P.V. Dehadrai) pp.135-142, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Smith, L. S. 1989. Digestive functions in teleost fishes. In : Fish nutrition (ed. J.E. Halver) pp. 331-421, Academic Press Inc., New York.

Snedecor, G. W. and Cochran, W. G. 1967. Staistical methods (Sixth Edition), Iowa State University Press, Ames, Iowa, 593 pp.

Stickney, R. R. and Lovell, R. T. 1977. Nutrition and feeding of channel catfish. Southern Cooperative Series Bulletin No. 218. 67 pp.

Takeuchi, M. 1979. Digestibility of dietary lipids in carp. Bulletin of the Tokai Regional Fisheries Research Laboratory 99 : 55-63.

Wilson, R. P. and Poe, W. E. 1985. Apparent digestible protein and energy coefficients of common feed ingredients for channel catfish. Progressive Fish Culturist 47: 154-158.

Windell, J. T., Foltz, J. W. and Sarokon, J. A. 1978. Effect of fish size, temperature, and amount fed on nutrient digestibility of a pelleted diet by rainbow trout, *Salmo gairdneri*. Transactions of American Fisheries Society 107: 613-616.

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