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FIELD REPORT

EFFECT OF DIETS WITH PROTEIN FROM DIFFERENT SOURCES ON THE GROWTH OF GOLDFISH, *CARASSIUS AURATUS*

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Abstracts

Four isoproteinous (40% crude protein) feeds (based on chicken liver, lean shrimp meal, mussel meal or squid meal) were fed to goldfish, *Carassius auratus,* of 4.61±0.427 g for 30 days at 10% of their body weight. The effect of the feeds on growth performance were compared with two commercial feeds, Brine Shrimp Flake and Tubifex Worm (59% crude protein each). There were no significant differences in food conversion ratio or specific growth rate between the treatments. The protein efficiency ratios (PER) of all the formulated feeds were significantly better than that of the Brine Shrimp Flake and the PER of the diets based on mussel and squid meal were also significantly better than Tubifex Worm. The weight increment with Tubifex Worm was significantly highest of all the treatments. Considering the nutritional parameters and cost of producing one kilogram of fish, the diet based on lean shrimp meal was the best. The cost of producing one kilogram fish using the formulated feeds ranged Rs. 93.75-231.30. Using Brine Shrimp Flake and Tubifex Worm, the costs were Rs. 1150 and Rs. 3500 per kg, respectively. The cost of goldfish rearing can be appreciably reduced by using feeds prepared with locally available protein sources. The crude protein level of 40% was sufficient for the goldfish, as the PER of the fish fed the formulated feeds was better than that of the fish fed the commercial feeds.

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Introduction

There is a growing demand for ornamental fish in several countries of the world. The world ornamental fish trade is about US$5 billion at present (pers. info.) with a growth rate of 10% per annum. Asian countries are estimated to have a share of about 60% of the world trade. The major exporting countries in Asia are Singapore, Philippines, Indonesia, Maldives, Thailand and Hong Kong. In some countries like India, even though the potential for expanding the ornamental fish trade is very high due to their vast natural resources and species diversity, the present level of exploitation is only 1% of the global trade. The main problem limiting the development of the aquarium fish trade is the non-availability of low-cost high-quality feed in many of the countries that are venturing into this important field of business. Therefore, the main objective of the present study was to study the economic and nutritional effectiveness of four formulated feeds prepared with different locally available animal protein sources, compared to two locally available commercial feeds, on the growth performance of one of the most popular ornamental fish, the goldfish *Carassius auratus*.

Materials and Methods

Preparation of formulated feeds. Four isoproteinous feeds, designated T1, T2, T3 and T4, were prepared from dried chicken liver meal, lean shrimp meal, green mussel meal and squid meal, respectively, in addition to groundnut oil cake and fishmeal as the main protein sources. The other ingredients used in the preparation of these feeds were constant in all the feeds. The composition of the feeds is shown in Table 1.

The chicken liver, mussel meat and squid were collected from the market in wet condition; the lean shrimp was obtained in sun-dried form. The ingredients, except for the mineral and vitamin mixture and vegetable oil, were oven dried for 24 hours at 60ºC, then

Table 1. Ingredients (%) of the formulated goldfish feeds.

Ingredients	*T1*	*T2*	*T3*	*T4*
Chicken liver	25	-	-	-
Shrimp meal	-	25	-	-
Mussel meal	-	-	25	-
Squid meal	-	-	-	20
Fishmeal	25	25	25	25
Groundnut cake	20	20	20	25
Wheat bran	10	10	10	10
Maize	10	10	10	10
Mineral and vitamin mix	3	3	3	3
Oil	2	2	2	2
Binder	5	5	5	5

powdered and screened through fine mesh strainers. The powdered ingredients were evenly mixed with a grinder mixer and pellets of 3 mm were prepared with a hand pelletizer. The prepared feeds were first sun dried and then oven dried at 60ºC for eight hours in aluminum trays. The feeds were kept in airtight polyethylene bags costing Rs. 1.50 per bag. Previous experiments (unpublished) revealed that such feeds could be kept at room temperature in such bags up to six months without deterioration of the nutritional quality.

Two commercial freeze-dried feeds, vacuum packed in pouches, were procured from the local aquarium shop. Tubifex Worm was designated Control 1 (C1) and Brine Shrimp Flake was designated Control 2 (C2). The proximate compositions of the formulated and control feeds are presented in Table 2.

Stocking and feeding. Two hundred goldfish, *Carassius auratus,* of the veil tail variety (4.61±0.427 g) were procured from the local aquarium shop. They were treated with 3% common salt for 15 min in a quarantine tank and then transferred to two 1000 l fiberglass reinforced plastic tanks containing water that was disinfected by a mild treatment of acriflavin. The fish were conditioned for seven days during which time they were fed a commercial diet different from those used in the experiment. Sufficient aeration was supplied.

After conditioning, ten healthy and approximately uniform-sized (in weight) fish were stocked into each of 18 experimental tanks containing 200 l water. They were fed at 10% of their body weight for 30 days. The 10% feeding level was chosen after testing different feeding levels (2%, 5%, 10% and 15%) prior to the beginning of the experiment. It was observed that, up to the 10% level, all the given feed was consumed by the fish within 15-30 min. The feed quantity was determined on a dry weight basis after deducting the moisture content. The fish were weighed every 15 days and the quantity of feed was adjusted for each experimental tank. Fish were fed twice daily at 11:00 and 16:00. All treatments and controls were replicated three times. Optimal hygienic conditions in the experimental tanks were maintained by changing 20% of the water volume each day. Water quality parameters were analyzed once a week (APHA, 1985). The proximate compositions of the feeds were analyzed by AOAC (1990). The gross energy value was determined using a 1341 Parr Oxygen Bomb Calorimeter.

Table 2. Proximate composition (%) of the formulated and commercial feeds.

	Chicken liver (T1)	*Shrimp meal (T2)*	*Mussel meal (T3)*	*Squid meal (T4)*	*Tubifex Worm (C1)*	*Brine Shrimp Flake (C2)*
Dry matter	92.5	93.1	92.2	91.9	92.3	93.5
Total ash	17.2	19.8	15.56	16.1	18.95	13.8
Acid insoluble ash	1.0	5.2	2.4	3.0	2.0	0.2
Crude protein	40.5	40.0	40.4	40.15	59.0	59.0
Crude fat	7.5	3.5	10.0	5.5	9.0	13.8
Crude fiber	2.0	3.2	1.5	1.0	0.01	1.5
Energy (Kcal/g feed)	4.33	3.96	4.55	4.31	4.71	4.89

Computation of nutritional indices and statistical analysis. The food conversion ratio (FCR), specific growth rate (SGR) and protein efficiency ratio (PER) were computed using standard methods (De Silva and Anderson, 1995). The food conversion ratio was calculated according to FCR = quantity of dry feed given/wet weight gain of fish. The specific growth rate was calculated according to SGR = $(\ln W_f - \ln W_i)/(t_2 - t_1) \times 100$, where W_f = final mean weight, W_i = initial mean weight and $(t_2 - t_1)$ = duration of experiment (30 days). The protein efficiency ratio was computed according to PER = weight gain/protein fed. The data were subjected to ANOVA (Snedecor and Cochran, 1968) for testing the statistical significance.

Results

There was no mortality caused by disease and no incidence of abnormalities in any of the treatments throughout the experimental period. Water quality was maintained within the optimal range for the growth of the fish. Growth performance is shown in Table 3. Only weight was considered in determining growth. The total length was not taken into account since there is much variation in the initial length of the tail of the veil tail goldfish variety used in the study.

The FCR was best in C1, followed by C2, T3, T4, T1 and T2. However, there were no significant differences ($p>0.05$) in FCR among the treatments or between the treatments and the controls. Similarly, there were no signifi-

Table 3. Comparative growth and costs using six goldfish feeds.

	Chicken liver (T1)	*Shrimp meal (T2)*	*Mussel meal (T3)*	*Squid meal (T4)*	*Tubifex Worm (C1)*	*Brine Shrimp Flake (C2)*
Weight increment (g)	6.30^{b}	5.73^{b}	6.11^{b}	6.70^{b}	9.26^{a}	6.54^{b}
FCR	1.85^{a}	1.89^{a}	1.81^{a}	1.83^{a}	1.46^{a}	1.72^{a}
Specific growth rate	2.810^{a}	2.835^{a}	2.783^{a}	2.706^{a}	3.781^{a}	3.170^{a}
Protein efficiency ratio	1.343^{ab}	1.322^{ab}	1.376^{a}	1.364^{a}	1.164^{bc}	0.995^{c}
Cost of ingredients for 1 kg feed (Rs.)	88.75	58.70	226.30	147.85	-	-
Cost of 1 kg feed (Rs.)*	93.75	63.70	231.30	152.85	3500.00	1150.00
Cost of producing 1 kg fish (Rs.)	173.45	120.40	418.65	279.70	5110.00	1978.00

* Cost of one kilogram feed = cost of ingredients + cost of packaging + cost of preparation. Cost of packaging = Rs. 1.50; cost of preparation = Rs. 3.00. For convenience, cost of packaging and preparing one kilogram feed is calculated as Rs. 5.00 in this table. Labor costs are not included in the production costs as any family member can spare an hour or so of their leisure time to prepare the feed.

cant differences ($p>0.05$) in SGR among the treatments or between the treatments and the controls. All the treatments had significantly better ($p\leq0.05$) PER than that of C2 but there were no significant differences ($p>0.05$) in PER between the treatments. The PER of T3 and T4 were significantly better ($p\leq0.05$) than that of C1 but there were no significant differences ($p>0.05$) between those of T1, T2 and C1. The weight increment was significantly best ($p\leq0.05$) in C1 but there were no significant differences ($p>0.05$) between T1-4 and C2.

The costs of one kilogram of each of the formulated feeds and the costs of producing one kilogram fish using these feeds are much lower than those of the commercial feeds. Water quality parameters were within the optimal ranges (Table 4).

Discussion

Singh (1991) reported that the protein requirements of cultivated carps *Cyprinus carpio*, *C. carpio* spawn and fry, *Labeo rohita* spawn and fry, *L. rohita* fry and fingerlings, *Cirrhinus mrigala* fry, *C. mrigala* fingerlings and *Catla catla* fry were 31-38%, 45%, 45%, 40%, 45%, 40% and 47%, respectively. Sen et al. (1978) obtained maximum growth of common carp spawn, fry and fingerlings, and rohu fry with diets containing 45% protein and 26% carbohydrate (dextrin) within the temperature range of 24-32ºC. As goldfish belong to the carp family (Cyprinidae), a protein level of 40% was tried in the present study. Lochmann and Phillips (1994) observed the best weight gain and feed efficiency when goldfish were fed diets containing 28.9% protein or more and reared in a water temperature of 25±2ºC for 6-8 weeks.

Diets containing protein from more than one source performed better than diets containing protein from a single source (Bardach et al., 1972; Sehgal and Thomas, 1985). In agreement with this finding, the feeds formulated for this study, which contained three protein sources, resulted in satisfactory performance in all nutritional indices. Perhaps all the essential amino acids required for optimum growth were provided when more than one protein source was used in the feeds.

The effects of protein content vary with species (Dabrowski, 1979). Steffens (1981) and Jauncy (1982) found that FCR and PER

Table 4. Water quality parameters during goldfish feeding trials.

	Chicken liver (T1)	*Shrimp meal (T2)*	*Mussel meal (T3)*	*Squid meal (T4)*	*Tubifex Worm (C1)*	*Brine Shrimp Flake (C2)*
Temperature (ºC)	26.2-26.7	26.4-26.6	26.3-26.8	26.5-26.9	26.2-26.5	26.1-26.6
pH	6.5-6.8	6.5-6.7	6.5-6.8	6.5-6.8	6.7-6.8	6.5-6.8
DO (ppm)	3.9-4.3	3.7-4.1	4.1-4.4	3.6-4.3	3.8-4.2	3.9-4.3
NH_4^+ (ppm)	0.075-0.20	0.075-0.30	0.10-0.45	0.25-0.50	0.35-0.70	0.50-0.75
NO_2^- (ppm)	0.25-0.75	0.50-0.75	0.25-0.50	0.25-0.75	0.50-1.00	0.25-0.75
NO_3^- (ppm)	10.0-37.5	10.0-25.0	12.5-37.5	10.0-25.0	25.0-37.5	12.5-25.0
Alkalinity (mmol/l)	0.7-1.10	0.6-1.20	0.8-1.30	0.6-1.40	0.8-1.70	0.7-1.30

decreased as the dietary protein content increased. Tabachek (1986) observed a decrease in PER and net protein retention with an increase in the dietary protein level and a constant level of dietary lipid. In agreement with earlier work, in the present study the PER of all the treatments were significantly better than that of C2 and the PER of two of the treatments were significantly better than that of C1, even though the crude protein level increased from 40% (in the treatments) to 59% (in the controls). There were no significant differences in FCR and SGR between the treatments and the controls.

In the present study, the crude protein level of the commercial diets was 59% because that is the protein content of all the locally available commercial feeds for ornamental fish. From the results, it is evident that 40% protein is sufficient for goldfish. In an experiment testing temperatures ranging 20.0-28.0ºC, Kestemont (1995) obtained the best SGR when goldfish larvae were reared at 28.0ºC. In the present study, although no special care was taken to maintain temperature, it ranged 26.1-26.9ºC, which is optimum for growth.

Tacon and Cowey (1985) found a positive correlation between SGR and dietary protein requirements (g per kg body weight per day). The growth rate correlated to the daily protein consumption, irrespective of the dietary lipid content in red tilapia (De Silva et al., 1991) and chinook salmon (Silver et al., 1991). In the present study, the SGR was better with the control diets than with the formulated diets although there were no significant differences ($p>0.05$) among them. Abi-Ayad and Kestemont (1994) fed goldfish larvae three diets: *Artemia* nauplii only, 50% *Artemia* nauplii plus 50% dry feed, and dry feed only. After two weeks, the group fed *Artemia* nauplii achieved the highest growth rate. It was followed by the group fed 50% *Artemia* nauplii and 50% dry feed and, finally, the group fed the dry feed. Mills et al. (1993) used three diets for goldfish *(C. auratus)* larvae: *Artemia* nauplii sp., a commercial trout grower pellet, and a commercial artificial liquid fry food. They obtained the best performance with *Artemia* nauplii and suggested that the use of *Artemia* nauplii, though costly, is justified by the excellent growth performance of the larvae in terms of length and weight increments, percent survival and deformity rate. However, in the present study, the use of brine shrimp *(Artemia salina)* flakes yielded no significantly better growth performance than the formulated feeds. Since the costs of producing the formulated feeds were much lower than those of the commercial feeds, the cost of goldfish rearing can be reduced substantially and hobbyist and aquarium fish traders will earn more profit if the formulated feeds are used.

The cost of producing one kilogram fish biomass was lowest with T2 (shrimp meal based diet) and highest with C1 (Tubifex Worm). Regarding all nutritional parameters, T2 was statistically equal or better than T1, T3, T4 and the controls (except for weight increment in C1). Therefore, taking growth performance into consideration as well as cost of rearing, it can be concluded that the lean shrimp meal based diet was the best diet and it is suggested for use as feed for ornamental fish.

With each of the formulated feeds, more than 100% growth was achieved within one month of rearing. Hence, aquarium fish traders can rear small fish for about one month using one of the formulated feeds, obtain fish weighing twice or more the original weight and sell them at a much higher price because bigger aquarium fish command better prices than smaller ones. Fish weighing 5 g sell at Rs. 20 whereas fish weighing 10 g fetch Rs. 50-60 in the local market. At the same time, there is not much price difference (<Rs. 5) between fish weighing 10.6 g and those weighing 13.8 g. The equipment used to prepare the feeds used in the present study is readily available to hobbyists and small scale aquarium fish traders.

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