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Soybeans Heat-Treated by Different Methods in Diets for Goldfish (*Carassius auratus*) Fry

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Abstract

The objective of this study was to determine the effect of diets supplemented with soybean meal processed by different heat treatments on growth, survival, and body composition of goldfish (*Carassius auratus*) fry. The fry (5.25±0.27 cm) were fed isonitrogenous (40%) diets containing soybean meal for 60 days. The first treatment contained soybeans toasted in a pan for 10 min. The second and third treatments contained soybeans oven-heated for 30 and 60 min, respectively. The fourth treatment contained raw soybeans. There were no significant differences (p>0.05) in survival between treatments. There was a significant increase in specific growth rate, protein efficiency ratio, and food conversion ratio with the diet containing soybeans oven-heated for 60 min. No significant differences were detected in body composition among the four treatments.

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Introduction

Goldfish (*Carassius auratus*) is one of the fancy fishes in the ornamental fish industry due to its beautiful bright colors and elongated fins. The main problem limiting 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 (Mohanta and Subramanian, 2002). The health and welfare of a fish can be influenced by a variety of factors ranging from water quality to nutrition. However, most of the available references on fish nutrition are related to commercially important food fish, and not ornamental species. The available commercial feed for ornamental fishes is expensive and unaffordable for goldfish breeders and farmers. This is reflected in the formulation of diets available for ornamental fish, which are generally less energy dense, and have lower protein and fat, than commercial production diets used in aquaculture (Priestley et al., 2006). Hence, development of a suitable diet for rearing goldfish is a priority.

Fishmeal is the major component of fish feed since it contains essential amino acids such as lysine and methionine. However it is one of the most expensive ingredients in formulated fish diets. The high cost, increasing demand, and uncertain availability of fishmeal, plus risk factors associated with diseases from animal protein sources, caused nutritionists to study alternative sources of protein for diets of freshwater and marine species.

Research has been carried out on replacing fishmeal with plant protein feedstuffs such as soybean meal. The seeds of soybean (*Glycine max* L. Merr.), a grain legume, are used for human consumption and as a concentrate for farm animals. The hulls of soybeans are removed and the beans are rolled into flakes, which are de-oiled by a solvent. This product is commonly referred to as dehulled soybean meal. However, soybeans contain trypsin inhibitor and several antinutritional compounds such as glycinin, ß-conglycinin, oligosaccharides, lectins, and saponins. Many of these anti-nutritional factors can be selectively removed by solvent (aqueous alcohol) extraction or by isoelectric leaching. Heat-treated full fat soybean meal has been included in fish diets at high percentages with positive results. However excessive heating may cause loss of essential amino acids. Hence, in the present study, three different heat treatments were tried for soybeans to compare the effects of soybean meal obtained from heat-treated soybeans and raw soybeans on growth, survival, and feed conversion of goldfish fry.

Material and Methods

Trials were conducted for 60 days in the laboratory of the Taraporevala Marine Biological Research Station, Mumbai, India. Goldfish fry were purchased from a local fish breeder and acclimated for one week in a 200-l plastic pool. During this period fish were fed a commercially available formulated 40%-protein feed (Mohanta and Subramanian, 2002) at 6% of their body weight daily. After acclimation, the fish (mean 5.25±0.27 cm) were randomly stocked in sixteen 50-l rectangular aquarium tanks at 25 fish per tank, with four replicates per treatment. At the start of the experiment, fish were treated with 5 g/l sodium chloride (NaCl) to ensure they were free of ectoparasites and to prevent fungal infections (Rowland and Ingram, 1991). Thirty percent of the water volume was changed every day to maintain optimum hygienic conditions. Temperature, pH, and dissolved oxygen were measured daily and ranged 27-27.5°C, 7.4-7.5, and 5.20-5.35 ppm, respectively. Ammonia, phosphate, and nitrate were examined weekly and were nil throughout the experiment.

Table 1. Composition of basal diet.

Ingredient	*%*
Soybean	50
Fishmeal	25
Wheat flour	20
Cod liver oil	2
Vitamin/mineral mix	3

Practical diets were formulated from a basal diet (Table 1) and soybean meal prepared from soybeans treated in one of four ways: toasted in a pan for 10 min, oven-heated for 30 min, oven-heated for 60 min, or raw. The soybeans were ground into fine powder using an electric blender to obtain soybean meal. The meal was mixed with the other ingredients to form a dough that was passed through a domestic pelletizer to form pellets. The pellets were dried with forced air at room temperature, crumbled, packed in nylon bags, and stored in a refrigerator at -40°C until used. During the experimental period, fish were fed at the rate of 6% of their live wet weight (Priestley et al., 2006), divided into four equal feedings.

At the end of the experiment final length and weight were measured, and fish were frozen for subsequent analysis. Whole body composition was analyzed for one pooled sample of homogenized fish tissue from each replicate. Standard methods (AOAC, 1995) were used to analyze fish tissue samples and formulated diets (Table 2). The feed conversion ratio (FCR), specific growth rate (SGR) and protein efficiency ratio (PER) were computed using standard methods (De Silva and Anderson, 1995).

Table 2. Proximate composition (% dry wt) of diets containing ground soybeans treated in different ways.

	Diet			
	Toasted 10 min	*Oven-heated 30 min*	*Oven-heated 60 min*	*Raw*
Moisture	5.0	4.9	4.9	5.0
Crude protein	40.1	40.1	40.1	40.0
Fat	5.3	5.2	5.2	5.3
Ash	9.0	9.1	9.1	9.0
Crude fiber	4.6	4.5	4.6	4.5

Data were subjected to ANOVA (Snedecor and Cochran, 1968). Differences were considered significant when $p<0.05$.

Results

Growth and survival are given in Table 3. There was no mortality in any of the treatments throughout the experiment. There were significant differences in weight and length gains with the best gains in fish fed the diet containing meal prepared from soybeans oven-heated for 60 min. Likewise, FCR and PER were significantly better in this treatment. Body composition did not significantly differ among the treatments although the highest protein content was obtained with the same treatment, i.e., oven-heated for 60 min (Table 4).

Table 3. Growth and survival of goldfish (*Carassius auratus*) fry fed diets containing ground soybeans treated in different manners.

	Diet			
	Toasted 10 min	*Oven-heated 30 min*	*Oven-heated 60 min*	*Raw*
Initial avg wt (g)	1.95±0.28	1.95±0.28	1.95±0.28	1.95±0.28
Final avg wt (g)	2.76±0.10	2.55±0.10	3.90±0.10	2.37±0.10
Gain in wt (g)	0.81±0.05^{a}	0.60±0.02^{b}	1.95±0.05^{c}	0.42±0.01^{d}
Specific growth rate	0.57±0.02^{a}	0.44±0.01^{b}	1.15±0.02^{c}	0.36±0.01^{d}
Initial avg length (cm)	5.25±0.27	5.25±0.27	5.25±0.27	5.25±0.27
Final avg length (cm)	6.80±0.20^{a}	6.40±0.20^{b}	7.40±0.20^{c}	5.50±0.20^{d}
Gain in length (cm)	1.55±0.10^{a}	1.15±0.10^{b}	2.15±0.20^{c}	0.25±0.05^{d}
FCR (%)	17.88±1.2^{a}	12.75±1.0^{b}	4.80±0.9^{c}	10.06±1.1^{d}
PER (%)	0.14±0.01^{a}	0.19±0.01^{b}	0.52±0.02^{c}	0.24±0.02^{d}
Survival (%)	100	100	100	100

Means in a row with different subscripts significantly differ (p<0.05).

Table 4. Body composition (% DW) of goldfish fry fed diets containing soybean meal prepared from soybeans treated in different ways.

	Initial	*Final*			
		Toasted 10 min	*Oven-heated 30 min*	*Oven-heated 60 min*	*Raw*
Moisture	10.50	9.00	9.50	10.00	9.50
Crude protein	18.00	20.00	20.00	22.00	21.00
Fat	4.50	5.00	5.10	5.50	5.20
Ash	13.00	15.00	13.00	14.10	14.50

Discussion

Raw soybean meal contains a number of anti-nutritional factors which must be heat-treated before it can be used in feeds for monogastric animals and fish (Peres et al., 2003). Several methods of heat treatment have been used to inactivate or eliminate anti-nutritional factors, thus improving the nutritive value of soybean meal. The degree to which soybeans must be heat treated may vary among fish species (Lim and Akiyama, 1992). In the present study, we evaluated growth performance and body composition of goldfish fry fed diets that included meal prepared from soybeans treated by different heating methods and durations. Full replacement of fishmeal with soybean meal produces a lower growth rate in fish. Thus, in this study, soybean meal (50%) was used as a major protein source together with fishmeal (25%).

Weight gain and SGR were best with the treatment containing soybeans heated for 60 min. The SGR (0.44-1.15) were low, probably because the goldfish in this study were fed rations close to maintenance requirements in order to approximate realistic growth rates for aquarium fish rather than maximal growth rates. The SGR was lowest in fish fed the diet containing meal of raw soybeans, possibly because of the activity of protease (trypsin) inhibitors in crude or inadequately heated soybean meal (Dabrowski and Kozak, 1979; Wilson and Poe, 1985).

The best FCR and highest PER were obtained in the fish fed the diet containing meal from soybeans oven-heated for 60 min. The proximate body composition did not significantly differ among treatments, however, the protein and lipid contents in the 60 min oven-heated treatment were highest. A similar pattern of body composition was reported in African catfish (*Clarias gariepinus*) fingerlings (Fafioye et al., 2005).

Three types of heat processes were used before inclusion of the soybean meal in the diet. Results were better in fish fed the heat-treated soybeans than in fish fed the diet containing raw soybeans. Fish fed a diet containing raw soybean meal autoclaved using a dry cycle at 1300°C and 22 PSI for 40 min improved the growth performance, feed efficiency, whole body protein, and plasma protein in channel catfish (Peres et al., 2003). Heating soybeans improves digestibility of polysaccharides and metabolizable energy in addition to inactivating trypsin inhibitors (Lovell, 1989). Among the different heat treatments, the meal prepared from soybeans heated for 60 min produced significantly beter growth and feed conversion. In the treatment containing meal from soybeans toasted in a pan for 10 min, growth was better than with raw soybeans or soybeans oven heated for 30 min. It might have produced even better results if the toasting time had been increased from 10 min to 20 or 30 min. Further research on this particular heat treatment is recommended as this treatment is comparatively easy to conduct and cost saving for the fish farmer.

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