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Replacing Fish Meal with Poultry By-Product Meal in Practical Diets for Mirror Carp (*Cyprinus carpio*) Fingerlings

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Abstract

Four isocaloric and isonitrogenous rations containing various levels (0% or control), 33%, 67% and 100% of fish meal) of poultry by-product meal (PBM) were fed to three replicate groups of mirror carp (*Cyprinus carpio*) fingerlings with a mean initial weight of 15.40±0.03 g. 50 fish per tank were tested for 10 weeks in 500 l fibreglass tanks. Average weight gain of carp fingerlings fed the control were significantly (P<0.05) higher (42.63±0.66) compared to fish fed 33%, 67% and 100% PBM of fish meal (30.14±0.06, 25.91±0.48 and 19.77±0.07, respectively). Significant variation in feed conversation ratios which varied between 1.71±0.02 and 2.81±0.03 for the control and 100% PBM, respectively, were obtained among the groups. Similarly, specific growth rate and protein efficiency ratio decreased significantly (P<0.05) as the level of PBM increased. However, condition factor, dress out percentage and the whole body composition didn't exhibit any significant variation among the test groups.

Key Words: diet, common carp, *Cyprinus carpio*, poultry by-product meal, fish meal.

Introduction

Fish meal is the major protein source in aquaculture feeds. However, the supply of fish meal is not growing worldwide (Rumsey, 1994; Barlow, 1997) and, it depends entirely on landings from the capture fisheries. Fish meal production from Peru and Chile, two countries producing about two-thirds of annual global production, fluctuates periodically by over 20% in El Nino years when ocean temperatures warm up and cause the fish stocks to move offshore, out of reach of the fishery (Hardy, 1996). Moreover, price of fish meal is often high. These necessitate replacing fish meal with cheaper protein sources (Shepherd, 1998).

One of the alternative ingredients to fish meal is poultry by-product meal (PBM). PBM is made of ground, rendered, or clean parts of the carcass of slaughtered poultry. PBM has been tested at varying success so far in coho salmon (Higss *et al.*, 1979), chinook salmon (Fowler, 1991), rainbow trout (Alexis *et al.*, 1985; Gouveia, 1992; Steffens, 1994; Sevgili, 2002), tilapia (Sadiku and Jauncey, 1995; El-Sayed, 1998), sea bream (Nengas *et al.*, 1999), European eel (Appelbaum *et al.*, 1996), channel catfish (Sadiku and Jauncey, 1995), common carp, catla, rohu (Steffens, 1988; Hasan *et al.*, 1993, Hasan and Das, 1993), sunshine bass (Webster *et al.*, 2000) and Pacific white shrimp (Davis and Arnold, 2000).

Fowler (1991) and Sevgili (2002) reported PBM could replace about 50% of fish meal in the diets for chinook salmon and rainbow trout. Hasan and Amin (1997) found that processing techniques greatly affected the nutritional quality of PBM for *Cirrhinus mrigala* fry. They reported that autoclaved and boiled PBM showed better growth performances than sun-dried and/or oven dried PBM. Dong *et al.* (1993) drew attention to the nutritional quality differences of PBM produced by different manufacturers.

There is a lack of information on nutritional quality of PBM produced in Turkey for fish diets. This study was planned to determine the level of PBM that could be used to replace fish meal in practical diets for mirror carp (*Cyprinus carpio*) fingerlings.

Materials and Methods

Ingredients used in the study were purchased from local market. According to information provided by the manufacturer, PBM used consists of chicken slaughter wastes including viscera, heads, legs and feather, and was produced by exposing to 150-200 °C under a 2.5-atm pressure for ten hours. Both fish meal and PBM were analyzed for proximate composition pirior to the formulation of diets (Table 1).

Four isonitrogenous and isocaloric diets were formulated to evaluate nutritional value of PBM for carp fingerlings (Table 2). The control diet contained 30% of fish meal and 15.5% of soy bean meal as main protein sources. PBM was tested at three inclusion levels (33%, 67% and 100% replacement of fish meal) by reducing fish meal levels. All diets contained the minimum requirement of all essential nutrients to satisfy the needs of common carp (NRC, 1993). The diets were prepared by mixing the dry ingredients and oil, followed by the addition of water

Table 1. Proximate composition of fish meal and PBM (as is basis) used in trial diets

	Fish meal	Poultry by-product meal
Dry matter (%)	93.16	94.23
Crude protein (%)	70.44	52.12
Crude fat (%)	7.36	23.47
Crude ash (%)	11.18	18.34

Table 2. Formulation and composition of the experimental diets (%)

Ingredients	Control	33%	67%	100%
Fish meal	30	20	10	0
Soy bean meal	15.5	15.5	15.5	15.5
PBM	0	12	24	36
Wheat middlings	31.5	30.35	29.2	28.1
Wheat	17.0	17.8	18.6	19.4
Choline chloride	0.1	0.1	0.1	0.1
Vitamin premix[1]	0.5	0.5	0.5	0.5
Mineral premix[2]	0.1	0.1	0.1	0.1
Binder[3]	0.3	0.3	0.3	0.3
Sunflower oil	5	3.35	1.7	0
Total	100	100	100	100
Nutrients levels determined by analysis (as is basis)				
Dry matter	90.99	91.31	90.47	91.14
Crude protein	36.49	36.37	35.0	33.83
Crude fat	7.72	8.7	9.23	9.78
Crude ash	6.48	6.92	7.63	8.26
Crude fiber	2.4	2.4	2.99	2.33
Nitrogen free extract	37.9	36.92	35.62	36.94
Gross energy (kcal / 100 g)[4]	444.7	451.1	443.7	445.1

[1] Per kg premix: 4,000,000 IU vitamin A, 480,000 IU vitamin D_3, 40,000 mg vitamin E, 2,400 mg vitamin K_3, 4,000 mg vitamin B_1, 6,000 mg vitamin B_2, 40,000 mg niacin, 10,000 mg Ca-panthothenate, 4,000 mg vitamin B_6, 10 mg vitamin B_{12}, 100 mg D-biotin, 1,200 mg folic acid, 40,000 mg vitamin C and 60,000 mg inositol.

[2] Per kg premix: 23,750 mg Mn, 75,000 mg Zn, 5,000 mg Zn, 2,000 mg Co, 2,750 mg I, 100 mg Se, 200,000 mg Mg.

[3] Lignosulfate

[4] Gross energy based on 5.65, 4.1 and 9.5 kcal / g protein, carbohydrate and fat, respectively (Belal *et al*., 1995).

until a stiff dough was obtained. The moist diet was extruded through a mincer with a 2 mm die. The resulting pellets were then dried on the shelves at the room temperature. The diets were stored in the plastic bags under ambient conditions over the experimental period.

The feeding trial was conducted in outdoor fibreglass tanks with holding capacity of 12,500 L. Each tank was supplied with a water flow of 10 l/min. Over the experimental period, water temperature (°C), dissolved oxygen (mg/l) and pH changed between, 26.1-27.5, 8.0-8.7 and 7.3-7.8, respectively.

Fish fry (initial mean weight 15.40±0.03) were randomly allocated at a stocking rate of 50 fish per tank with three replicate tanks for each experimental diet. All fish were fed two times daily at a fixed feeding rate of 4 % body weight per day for ten weeks. Total biomass of the fish from each tank was weighed at biweekly intervals and feeding rates adjusted accordingly. At the beginning of the trial, 25 fish, and at end of the trial, 5 fish per tank were sampled to determine the whole body composition. 5 fish per tank were also picked at the end of the study to determine condition factors and dress out percentage of the groups fed different PBM levels.

Fish performance, including average weight gain (AWG), feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), condition factor (CF) and dress out percentage (DOP) were determined as described by Metailler (1987) and Goddard (1996).

The protein content of the diets and the whole body was determined by Kjeldalh, fat by solvent extraction, ash by placing the samples in a muffle furnace (550°C) for 12 h, fiber by placing the samples remaining in a muffle furnace (550°C) for 6 h after acid and alkali hydrolysis and moisture by drying (105°C) until constant weight has been attained. Nitrogen free extract was calculated by substracting the protein, fat, fiber and ash from the dry matter (Akyıldız, 1984).

Results were analysed by a one-way analysis of variance and the treatment means compared by Duncan's multiple range tests. Significance was tested at the $P \leq 0.05$ level.

Results

The growth response and performance data of carp juveniles fed diets containing various inclusions of PBM are presented in Table 3. Weekly growth responses of carp juveniles over the experimental period are shown in Figure 1. The performance of carp juveniles differed significantly ($P<0.05$) in terms of final weight, AWG, FCR, SGR and PER. Growth responses were lower in groups fed diets with PBM compared to those fed the control diet. The growth performance worsened in fish fed diet containing even lowest PBM level (33%) and kept worsening as the level of PBM increased. However, there were no significant differences in CF and DOP among the groups (Table 3).

Initial and final body compositions of fish were presented in Table 4. There were no significant differences in body composition among the treatments.

Discussion

PBM seems to be a good source of dietary protein for fish culture. Higss *et al.* (1979) found that defatted PBM and PBM mixed with hydrolysed feather meal could replace up to 33% and 75 % of fish meal, respectively, in coho salmon diets. About 50 % of fish meal was successfully replaced with PBM in chinook salmon and rainbow trout (Alexis *et al.*, 1985; Fowler, 1991; Steffens, 1994; Sevgili, 2002). Moreover, Gouveia (1992) reported PBM mixed with hydrolysed feather meal could be used without growth retardation at a level of 80 % of total protein in trout diets.

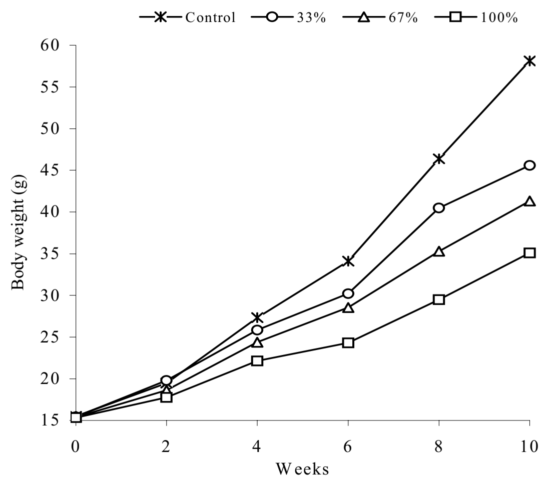

Figure 1. Live weight variations in carp juveniles over the experimental period.

Table 3. Growth, FCR, SGR, PER, CF and DOP of carp fry after 10 weeks

	Control	33%	67%	100%
Initial weight (g)	15.50±0.06	15.43±0.15	15.40±0.06	15.33±0.13
Final weight (g)	58.13±0.64^{a}	45.57±0.20^{b}	41.31±0.45^{c}	35.10±0.12^{d}
AWG (g)	42.63±0.66^{a}	30.14±0.06^{b}	25.91±0.48^{c}	19.77±0.07^{d}
FCR	1.71±0.02^{d}	2.24±0.01^{c}	2.42±0.06^{b}	2.81±0.03^{a}
SGR (%/day)	1.89±0.02^{a}	1.55±0.01^{b}	1.41±0.02^{c}	1.19±0.01^{d}
PER	1.46±0.02^{a}	1.23±0.07^{b}	1.07±0.03^{b}	0.96±0.01^{c}
CF	2.75±0.06	2.67±0.07	2.63±0.06	2.56±0.04
DOP (%)	85.83±1.62	85.65±1.26	84.54±0.46	85.55±0.49

Values are means± SE for three replications. Figures in the same row with different superscripts are significantly different ($p<0.05$).
AWG = Final weight (g)-Initial weight (g)
FCR = Total feed (g)/Total weight gain (g)
SGR = 100 ($\ln W_f - \ln W_i$)/time (days) where W_f is final weight, W_i is initial weight.
PER = Wet weight gain (g) / Protein fed (g)
CF = Final weight (g) / Fork length (cm) X 100
DOP = Viscera (g) / Whole weight (g) X 100

Table 4. The whole body composition analyses (on wet weight basis) of carp fed test diets

Component (%)	Initial	Control	33%	67%	100%
Dry matter	26.64	28.96±1.40	29.50±0.30	29.38±0.20	29.49±0.16
Protein	16.35	15.66±0.86	15.55±0.12	15.40±0.16	15.88±0.51
Fat	7.50	11.51±0.72	11.97±0.35	12.29±0.33	11.49±0.58
Ash	2.67	1.56±0.10	2.00±0.10	1.72±0.22	1.87±0.16

Values are means± SE for three replications.

Nengas *et al.* (1999) compared PBMs produced via old (OTPBM) or high technology (HTPBM) in sea bream diets and found that while OTPBM reduced growth performances at high inclusion levels, HTPBM did not effect negatively growth at a level of 100 % of fish meal. In Pacific white shrimp and sunshine bass diets, 80 % and 100 % of fish meal replacement with PBM, respectively, did not effect negatively weight gain and feed conversion ratio. The results obtained from European eel (Appelbaum *et al.*, 1996), tilapia (El-Sayed, 1998), catla (Hasan *et al.*, 1993), rohu (Hasan and Das, 1993) and carp (Steffens, 1988) indicate that total replacement of fish meal with PBM could be possible.

In the present study, the diets containing PBM even at lowest level significantly limited weight gain, FCR, SGR and PER. The values worsened as PBM level increased. These results are contradictory to ones mentioned in previous paragraph. Poor performance of this material may be due to; i) limiting amino acid (histidine, methionnine+cystine, lysine and phenylalanine) content (Tacon and Jackson, 1985; Nengas *et al.*, 1999; Sevgili, 2002), ii) feather, connective tissue and skin contents which are considered to be difficult for fish to digest (Davies *et al.*, 1989; Fowler, 1990; Hasan *et al.*, 1997; Hardy, 2000; Sevgili, 2002), iii) subjection of the product to high temperature (150-200ºC) for a long time (10 hours) during the processing (Nengas *et al.*, 1999; Sevgili, 2002), iv) or combination of all. High temperature during the raw material processing leads to lysine, cystine+cystein losses and thus, digestibility of protein and amino acids is reduced (Opstvedt *et al.*, 1984; McCallum and Higgs, 1989). The reason of reduced growth performances of fingelings fed diets with PBM was not their fat contents. Optimal dietary fat levels have been suggested to be below 12% in the practical diets of cyprinids (Kaushik, 1995). In the present study, the highest fat level was 9.78% which is in the range of the optimal levels. Moreover, Gallagher and Degani (1988) successfully used 10% poultry oil as a replacement of fish oil for the diets of European eels.

Body compositions of carp fry fed diets containing various levels PBM were not significantly differed in the present study. These findings are in agreement with the values reported by Hasan *et al.* (1993), Nengas *et al.* (1999) and Sevgili (2002). The final body dry matter and lipid levels are higher (Fowler, 1991; Gouveia, 1992; Hasan *et al.*, 1993 and 1997; Weatherup and McCracken, 1999) and ash is lower (Hasan and Amin, 1997; Nengas *et al.*, 1999) than initial levels. However, final body protein level obtained in this trial was slightly lower compared to initial value. This is contradictory findings reported by Fowler (1991) Gouveia (1992) and Hasan and Amin (1993).

Consequently, our results indicate that growth of carp fingerlings was negatively effected with PBM levels. Dong *et al.* (1993) found differences in proximate composition and protein digestibility among the samples of PBM from different manufacturers. In our previous study (Sevgili, 2002), however, PBM from the same manufacturer was used to replace fish meal in practical rainbow trout diets. In this study, it was found that PBM could be used up to 20 % of diet as a protein source. Unlike nutritional disadvantages of PBM compared to fish meal, it is much cheaper and more easily available than fish meal. Thus, the level of PBM that can be used in diets of carp fingerlings needs to be further evaluated.

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