Effects of Replacement of Fish Meal with Poultry By-product Meals on Apparent Digestibility, Body Composition and Protein Efficiency Ratio in a Practical Diets for Rainbow Trout, *Onchorynchus mykiss**

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ABSTRACT : This study examined the replacement of the fish meal (FM) with commercial poultry by-product meal (PBM) in practical diets for rainbow trout (Onchorynchus mykiss, Walbaum). Five isocaloric and isonitrogenous diets containing levels 0 (control), 10, 20, 30 and 40% of PBM as a replacement for FM were fed to three replicate groups of rainbow trout with a initial weight 34.50±0.43 g (mean±SE). Protein efficiency ratio (PER) of diets containing PBM up to 20% were similar to the control while significantly lower values were obtained from the groups receiving higher levels of PBM ($p<0.05$). Apparent protein digestibility coefficients (ADCs) were significantly lower than that of the control group when PBM was included at level of 20% or more. Similarly, significantly lower values were observed with diets containing 30 and 40% PBM in terms of dry matter, organic matter, ether extract, ash and energy digestibility ($p<0.05$). Dietary treatments did not significantly affect the body composition of the fish in terms of dry matter, crude protein, ether extract and ash. In conclusion, PBM in a proportion of 20% may replace about 40 % of FM in rainbow trout diet without significant impairment grow. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 9 : 1355-1359)***

Key Words : Rainbow Trout, Poultry By-product Meal, Protein Efficiency Ratio, Apparent Digestibility, Body Composition

INTRODUCTION

Animal by-products have been a major contributor to the growth and expansion of the World's aquaculture food industry and have supplied the major of the proteins, fats and minerals, and significant quantities of vitamins, for animals through the years. Fish meal (FM) accounts for 30-50% by weight of most commercial carnivorous fish feeds (Cheng et al., 2003). Therefore, it is important for researchers to identify and utilize some less expensive ingredients which are of equal or even better nutritional quality as compared to those based mainly on FM. Poultry by-product meal (PBM) has similar nutrient profile compared to FM, it may have good application in trout feeds. The range of dry weight proximate composition for PBM samples was 55-74% for protein, 10-19% for lipid, and 11-23% for ash (Dong et al., 1993). The apparent protein digestibility coefficients obtained from the *in vivo* method were in the range of 64.4-77.7. These results indicated that PBM could successfully be used as protein and energy sources for growing fish. Previous study reported that diets including up to 40% PBM (Pokorny, 1982) and replace up to 25-35% FM (Alexis et al., 1985) could be successfully used for rainbow trout. These results may allow for less expensive diet formulations for rainbow trout and may reduce diets costs for producer, thereby increasing profitability. It was aim of the present study to determine the effects of diets with PBM at various levels on apparent nutrient digestibility of the diets, body composition and protein efficiency ratio of rainbow trout (*Onchorynchus mykiss,* Walbaum). This research is also dedicated to help the rendering industry to keep our environment clean and help aquaculture industry make economic and efficient use of alternative animal proteins, and thus increase profit margin.

MATERIALS AND METHODS

The feeding trial was performed at the Kepez Aquaculture Center, Kepez (Antalya-Turkey) aquaculture facility with rainbow trout (*Oncorhynchus mykiss,* Walbaum), averaging 34.5±0.43 g initial weight. The chemical compositions of the feed ingredients used in the study are given in Table 1. Five isocaloric and isonitrogenous diets on the basis of gross energy and crude protein including PBM at the levels of 0% (control), 10% (PBM10), 20% (PBM20), 30% (PBM30) and 40% (PBM40) were formulated (Table 2) to contain National Research Council (1993) requirements of all nutrients (Table 3). PBM used in the study was produced at 150-200 °C with 2.5 atmosphere for about 10 h and included all remainders without any excluding as the provider's

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Table 1. Chemical composition of feed ingredients (as fed basis, %)

Ingredient	Dry matter	Crude protein	Crude fat	Crude ash	Crude fiber
FM[a]	94.33	68.50	10.19	10.94	0.96
PBM[b]	94.84	57.75	18.93	11.54	1.26
Corn gluten	93.94	71.75	5.33	1.74	3.86
Soybean meal	92.55	47.62	3.69	7.48	5.85
Wheat middling	91.95	15.87	6.15	3.49	11.12

[a] FM: Fish mail, [b] PBM: Poultry by-product meal.

Table 2. Ingredient composition of experimental diets (%)

	Diets				
	Control	PBM10	PBM20	PBM30	PBM40
FM[a]	46.83	38.22	29.61	21.01	12.40
PBM[b]	0.00	10.00	20.00	30.00	40.00
Corn gluten meal	10.00	10.00	10.00	10.00	10.00
Soybean meal	5.00	5.00	5.00	5.00	5.00
Wheat middling	21.21	21.97	22.73	23.50	24.26
Fish oil	15.31	13.16	11.01	8.84	6.69
Vitamin mix.[c]	0.50	0.50	0.50	0.50	0.50
Mineral mix.[d]	0.20	0.20	0.20	0.20	0.20
Choline chloride	0.15	0.15	0.15	0.15	0.15
Pellet binding [e]	0.30	0.30	0.30	0.30	0.30
Cr_2O_3 [f]	0.50	0.50	0.50	0.50	0.50

[a] FM: Fish mail, [b] PBM: Poultry by-product meal, [c] Per kg mix: 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-D-pantothenate, 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 ve 60,000 mg inositol. [d] Per kg mix: 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. [e] Calcium lignosulfonate. [f] SIGMA Product No: 34,296-3.

Table 3. Chemical composition of experimental diets (as dry matter bases)

Prox. composition	Diets				
	Control	PBM10	PBM20	PBM30	PBM40
Dry matter, %	93.66	94.06	94.14	93.99	93.89
Crude protein, %	45.11	45.02	43.78	43.24	43.09
Crude fat, %	21.64	21.36	21.98	20.53	20.07
Crude ash, % [a]	7.46	7.60	7.64	7.60	7.98
Carbohydrate, % [b]	25.32	25.60	26.16	28.15	28.43
Gros energy (kcal/kg)	5,658	5,637	5,649	5,566	5,524
Cr_2O_3, %	0.459	0.425	0.446	0.479	0.447

[a] Except Cr_2O_3, [b] Determined by difference.

recommendation (Abalıoğlu Feed Plant, Denizli, Turkey). The powdered ingredients except fish oil were mixed in an experimental horizontal mixer for 5 min and pelleted with a pellet machine into 3 mm diameter die by offering them directly to the pelleting section of the machine without steam conditioning. Fish oil was covered over the pellets at the levels of predefined. The feeding trial was conducted in 500 l flow-through circular fiberglass tanks, supplied with well water at a flow rate of 15 l min^{-1}. The water quality parameters such as temperature, dissolved oxygen (daily) and pH (one in three days), were 14.2±0.9°C, 8.8±0.3 mg l^{-1} and 7.5±0.2, respectively, during the experimental period. These results were in agreement with the results reported by Sedgwick (1995). The fish were subjected to natural photoperiod over the trial. Each diet was fed to groups of fish to apparent satiation, three times a day except morning meal on the weighing days was offered at 08:30, 12:00 and 15:30 h for 12 weeks. The tanks were siphoned daily after the last meal. At the start of the feeding trial, five fish from each tank were randomly sampled and were anaesthetized with fenoxy ethanol and used for an assessment of initial body chemical composition. The remaining fish (50 rainbow trout) were randomly stocked into each tank with three replications per treatment. Fish were distributed to ensure there were no significant differences between groups mean weight (±SE) (34.5±0.43 g).

Fecal samples were collected to determine apparent digestibility (Gouveia, 1992) by the hand stripping method (Austreng, 1978) after routine weighings during the last three weeks. At the end of the trial ten fish starved for 24 hours from each tank were removed. Five of them were used to determine body measurements while the five ones were minced through a meat mincer and stored at -40°C until whole body analysis. The results of PER were calculated using the following formula (Steffens, 1994):

Table 4. Apparent digestibility coefficients (ADCs) and protein efficient ratio (PER)

Nutrients	Diets				
	Control	PBM10	PBM20	PBM30	PBM40
Dry matter	81.9±0.26 [ab]	82.6±0.34 [a]	79.2±0.32 [b]	75.3±1.50 [c]	72.7±1.02 [c]
Org. matter	85.0±0.20 [a]	85.3±0.24 [a]	83.5±1.27 [a]	79.0±1.27 [b]	76.2±0.82 [b]
Protein	89.3±0.03 [a]	88.6±0.43 [a]	85.3±0.59 [b]	80.8±1.19 [c]	78.0±0.58 [d]
Lipid	96.0±0.11 [a]	95.6±0.85 [a]	92.8±0.35 [a]	88.8±0.95 [b]	81.4±1.81 [c]
Ash	49.2±0.88 [a]	54.7±1.54 [a]	51.5±2.43 [a]	36.6±4.18 [ab]	37.7±3.30 [b]
Energy	88.7±0.19 [a]	88.9±0.36 [a]	87.4±1.09 [a]	83.4±1.11 [b]	79.9±0.89 [c]
PER[1]	2.53±0.01 [a]	2.52±0.05 [a]	2.45±0.04 [a]	2.33±0.02 [b]	2.09±0.02 [c]

Means within a row having different letters are significantly different ($p<0.05$). [1] PER : Protein efficiency ratio.

PER=Wet weight gain (g)/Protein intake (g)

Moisture, ash, crude protein, ether extract and crude fibre analyses of each ingredient, diet, fish and feces samples were performed according to the methods (7.007, 7.009, 7.025, 7.062, 7.071, respectively) of the Association of Official Analytical Chemists (AOAC, 1984). Carbohydrate (NFE) was determined by difference [NFE=100-(% protein+% fat+% ash+% lipid)]. Gross energy values were calculated by using the multiplier factors of 5.65, 9.45 and 4.2 kcal g^{-1} for protein, lipid and carbohydrate, respectively (Henken et al., 1986). The indirect method described by Cho and Kaushik (1990) was used to calculate the apparent ‘digestibility’ coefficient (ADC), with chromium oxide (Cr_2O_3 -SIGMA Product No: 34,296-3) as the inert marker. The apparent digestibility coefficient of nutrients was calculated by using the following formula:

$$ADC_{nutrient}=[1-(NF/ND\times CrD/CrF)]\times 100$$

Where: NF=% nutrient in faeces, ND=% nutrient in diet, CrD=% chromium oxide in diet, and CrF=chromium oxide in Faeces. During the experimental period, fish were fed with the 0.5% chromium oxide-containing diets.

At the end of the feeding trial all fish were weighed to calculate body weight gain [BWG=final body weight, g-initial body weight, g] and specific growth ratio [SGR=(*ln* final body weight, g-*ln* initial body weight, g)×100/time, day].

A one-way analysis of variance (ANOVA) and Duncan’s multiple range tests were used to compare treatment means for significant differences. Significance was tested at the p=0.05 level.

RESULTS AND DISCUSSIONS

The apparent digestibility coefficients (ADCs) and protein efficient ratio (PER) of the diets and proximate analysis (% of wet weight) of whole fish at the initial and end of the trial were given in Table 4 and 5, respectively. Protein efficiency ratio (PER) is important parameter for amino acid balance and protein quality. PER values of groups fed PBM10 and PBM20 were similar to the control while significantly lower were groups receiving higher levels of PBM ($p<0.05$). Zoccarato et al. (1996) reported that high level of PBM affected negatively PER in trout. The lower PER could be attributed to insufficient amino acids and feather, connective tissue and skin contents that are considered to be difficult for fish to digest (Hardy, 2000). Apparent digestibility coefficients (ADCs) of the diets were significantly depressed in fish fed the diets with higher than 20% of PBM. The ADCs of dry matter, organic matter, lipid, ash and energy were not significantly affected by diets containing 10% and 20% PBM compared to control diets. However, fish fed diets containing 20%, 30% and 40% PBM decreased ADCs of protein significantly. Gouveia (1992) observed that dry matter, protein and lipid digestibility increased along with the inclusion of PBM in diet for rainbow trout. However, Zoccarato et al. (1996) reported that there were no differences among the dry matter, organic matter, protein and lipid digestibility in fish fed diets containing graded levels a “broth” obtained by thermal treatment with super hot steam of poultry processing wastes. The availability of nutrients and energy in feedstuffs to fish may vary considerably, depending on a variety of factors including fish species, ingredient quality and processing conditions (Gaylord and Gatlin, 1996). In the present study the observation of the reduced protein digestibility in fish fed higher than 10% of PBM probably attributed due to the exposed product to high temperature for a long time during the processing along with feather and the other indigestible contents. Lipid digestibility reduced when PBM was included at the levels of 30 and 40%. Pfeffer et al. (1995) found that lipid digestibility of poultry offal meal and feather meal reduced significantly for rainbow trout when their inclusion level in a basal diet was increased from 25 to 50%. Gaylord and Gatlin (1996) and Degani et al. (1997) found that PBM had a lower lipid digestibility than FM while Bureau et al. (1999) found two PBMs had high lipid digestibility close to that of the FM. This may be due to the high-saturated fatty acid content of PBM and high processing temperature of the product used in this study. Body weight gain (BWG) and specific growth

Table 5. Proximate analysis of whole fish, (% of wet weight)

	Diets					
	Initial	Control	PBM10	PBM20	PBM30	PBM40
Dry matter	27.10	29.98±1.01	26.85±1.50	27.66±2.26	24.86±2.58	25.88±0.61
Protein	10.90	12.29±0.64	12.40±0.82	12.21±1.03	12.24±1.11	12.18±0.68
Lipid	14.90	15.64±0.36	12.46±0.71	14.17±1.08	12.54±1.57	14.79±0.25
Ash	2.37	2.0±0.04	1.80±0.12	1.98±0.17	1.80±0.20	2.27±0.07

ratio (SGR) followed the same general trends like the PER values and ADCs of dry matter, organic matter, lipid, ash, energy. BWG and SGR of fish fed Control, PBM10, PBM20, PBM30 and PBM40 diets were found, respectively, as follows: 140.28±6.53, 1.94±0.06; 140.14±2.82, 1.94± 0.03; 136.34±4.42, 1.89±0.03; 118.46±1.51, 1.78±0.01; 95.90±4.00, 1.58±0.04. BWG and SGR of groups fed PBM10 and PBM20 were similar to the control while significantly lower were groups receiving higher levels of PBM (PBM30 and PBM) ($p<0.05$). Results from the present study showed that traits relating to the performance depressed in fish fed PBM30 and PBM40 diets compared to those fed the other diets. These results are accordance with Zoccarato et al. (1996) and Webster et al. (2000). Similarly, Alexis et al. (1985) using a diet containing 25% PBM obtained good performance in trout. The lower growth rates exhibited by the fish fed diets containing 30 and 40% of PBM could be attributed to insufficient amino acids and feather, connective tissue and skin contents which are considered to be difficult for fish to digest (Hardy 2000). This suggestion is also confirmed by the lower digestibility coefficients of the diets in question in the present study.

In the present study, any significant effect of feeding diets with PBM on body composition was not found (Table 5). Similarly, Webster et al. (2000) observed no differences in fillet composition of sunshine bass fed a diet including PBM at a level replacing 100% of FM. However, Gouveia (1992) and Steffens (1994) reported that body lipid content increased with the inclusion of PBM in the diets and protein content reduced. The results indicate that fat content in the body composition may be manipulated by changing the dietary fat content and the experimental conditions. The little differences in the fat content of the experimental diets (Table 3) caused no significant the body fat deposition. Even though a high level lipid content of PBM was found in the present study, lipids from poultry processing and rendered products are good energy sources for both cold water fish. Consequently, our experiment indicate that PBM in a proportion of 20% may replace about 40% of FM in rainbow trout diet without significant impairment grow.

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