Complete replacement of fish meal with poultry by-product in diet formulated for rainbow trout (*Oncorhynchus mykiss*)

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Abstract. A four months feeding trial was conducted to examine the complete replacing fish meal with poultry by-product (PB) in the diets of the rainbow trout. For this purpose, an experiment was designed with two treatments, including control treatment fed by a commercial diet i.e. grower food trout (GFT) and treatment fed with poultry by-products diet (PBD) each with four replicates. Fish were stocked into 8 outdoor raceways at a density of 20 m^{-2}. At the end of the experiment, two treatments showed no differences in growth performances, including weight gain (WG), specific growth rate (SGR), biomass production (BP), mean daily feed intake (FI), feed conversion ratio (FCR) and survival rate. The results showed that rainbow trout can readily use poultry by-products based diet without any negative effects on growth indices.
Key Words: Feed alternative, animal protein, aquaculture, growth performance, diet.

Introduction. Aquaculture is the fastest growing animal production sector in the world to provide the animal protein for increasing population (Lee & Donaldson 2001). In this sector, rainbow trout (*Oncorhynchus mykiss*) is one of the main fish species in the aquaculture industry. This species is carnivorous and its diet should be rich in animal protein, therefore its food is expensive because of using expensive fishmeal (Bureau et al 2006; FAO 2012), however, using poultry by-product protein in fish feed could be an alternative to expensive fishmeal to decrease production cost (Bureau et al 2006).

Poultry by-product is one of the most important sources of animal protein used to feed domestic animals, along with meat and bone meal, blood meal, feather meal and fish meal (Steffens 1994). It is made by combining the by-products coming from poultry slaughterhouses or poultry processing plants. The poultry by-product is used as the ground, rendered, clean parts of the carcass of slaughtered poultry such as necks, heads, feet, undeveloped eggs, gizzards and intestines (Shapawi et al 2007). Hence, a four months feeding trial was conducted to examine the complete replacing fish meal with poultry by-product (PB) in the diet formulated for the rainbow trout.

Material and Method

Experimental design and procedures. This experiment was performed for 4 months in the Sar-Mahal farm (Bandar Gaz, Golestan Province, northern Iran) during autumn and winter 2012. Two treatments with four replicates were designed for this study. Control treatment was fed by a commercial diet i.e. grower food trout (GFT) with a proximate composition including protein 35-38%, fat 7-8%, carbohydrate 4-5%, fiber 4-5%, ash 5-6%, and moisture 10-12%, and second treatment i.e. poultry by-products diet (PBD) was formulated using blood meal, meat meal, and viscera of poultry by-products. PBD ingredients were mixed until obtaining a homogenous mixture and grounded using a meat grinder (with mesh size of 5 mm) producing extruded string shapes, which were dried in an oven at 55°C for 12 h and then broken to produce pellets approximately 10 mm long. The pellets were packed and stored at -20°C in a freezer until be used. The dietary ingredients of PBD are given in Table 1.

Table 1

Proximate composition (percent of weight of dry feed) of poultry by-products based diet (PBD) fed to *Oncorhynchus mykiss*

Ingredients	*% in final diet*
Poultry by-products	30
Viscera by-products	10
Meat meal	20
Blood meal	5
Wheat flour	5
Molasses	5
Soybean meal	16
Corn flour	3
Mashed potatoes	5
Vitamin C	0.5
Lysine	0.5
Total	100

A total of 7400 rainbow trout (with average weight of 122.5±22.5 g), i.e. 925 fish in each rearing canal, were randomly allocated into 8 rearing concrete canals (30×3 m^2 raceways canals) with a flow rate of 1 L/sec of well-water. Water parameters, including temperature, pH and dissolved oxygen were 12.5-15°C, 7.1-8.1, and 10.2-11 mg L^{-1}, respectively. Fish were acclimated to the experiment conditions for one week before beginning of the experiment. Fish were fed with commercial diet during acclimation period (Subhadra et al 2006). During experiment, fish were fed twice a day by hand at a rate of 5% body weight for first two months and then the feeding rate was reduced to 3% for next two months. The fish (n=10) were subjected to biometry every 15 days. Growth performances indices, including weight gain (WG), specific growth rate (SGR), biomass production (BP), mean daily feed intake (FI), feed conversion ratio (FCR) and survival rate (SR) were calculated using following formula (Abdel-Warith et al 2001):

WG (g) = final body weight - initial body weight
SGR (%) = 100 × (Ln final weight - Ln initial weight)/120
BP (kg)= Number × weight
FI = (final body weight - initial body weight)/120
FCR = body mass output / feed mass input
SR (%) = 100 × (initial fish number - dead fish number)/initial fish number

Statistical analysis. For statistical analysis, normality of the data was analyzed by one-sample Kolmogorov-Smirnov test. Independent T test was used for the comparison of growth and feeding performance, and survival rate between treatments by SPSS statistical software. The data were compared using Duncan's test at a significance level of 5%.

Results

Growth performance and survival rate. WG, SGR, BP, FI, and SR of both treatments are shown in Table 2. None of these parameters showed significant difference between the control and PBD treatments. There was no significant difference found between the final average body weights (FBW) between treatments (t = 0.259, P = 0.8, Figure 1). Final average body weights were 485 ± 34.15 g and 475 ± 69.4 g for control and PBD treatments, respectively.

Table 2

WG, SGR, BP, FI, and SR of both control and PBD treatments

Factor	*Treatments*		*T*	*P value*
	Control	*PBD*		
WG (g)	370 ± 25.81	342.5 ± 51.72	0.951	0.37
SGR (%)	1.2 ± 0.1	1.06 ± 0.07	2.152	0.07
BP (kg)	651.05 ± 96.43	632.27 ± 151.66	0.209	0.84
FI (g/fish/day)	5.43 ± 0.72	4.89 ± 0.43	1.288	0.24
SR (%)	98.25 ± 0.11	98.18 ± 0.64	0.214	0.83

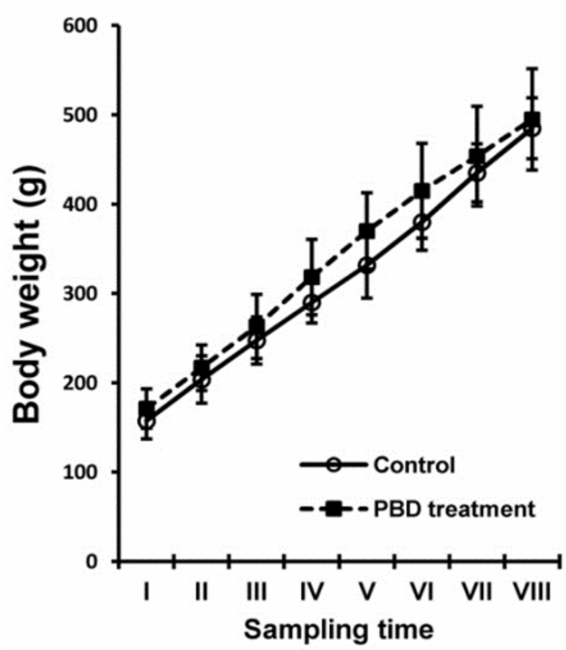

Figure 1. The relationship between average body weight (g) and the time of sampling of *Oncorhynchus mykiss* fed fish meal based diet (control) and poultry by-products based diet (PBD).

Feed conversion ratio (FCR). Total food consumption was not significantly different between control (1200.95 ± 262.36 kg) and PBD treatments (1105.87 ± 189.79 kg) (t = 0.587, P = 0.57). The PBD diet had a lower FCR level (1.74 ± 0.65) compared to that of control diet (1.88 ± 0.58); however, there was no significant difference between them (t = 0.966, P = 0.37).

Discussion. The present study indicated that use of the poultry by-products diet had similar results as the commercial diet. Proper increase in body weight in a given period is the ultimate goal of aquaculture practices (Neori et al 2000). This parameter along with lower FCR is among the main factors influencing profits in fish culture (Cho 1990; Hishamunda & Ridler 2006). Based on the results, since there is no difference in weight gain and FCR levels, therefore, PBD diet can provide nutritional requirements of studied fish as same as the used commercial food. In the present study, two used diets with different contents i.e. fish meal based diet and complete substitution of fish meal with poultry by-products were used. Therefore, it is difficult to compare the present results with other similar investigations.

Furthermore, lacking differences between treatments in terms of growth indices indicated the potential nutritional quality of poultry by-products for feeding practice of rainbow trout that may be due to the high quality of its ingredients (Steffens 1994). There are reliable evidences in which carnivorous fish such as rainbow trout did not palatability problems when poultry by-products replaced fish meal in the diet (e.g. Steffens 1994; Webster et al 2000; Millamena 2002; Yigit et al 2006; Shapawi et al 2007). In agreement with the above mentioned studies, our results showed that fish accepted the PBD diet has similar daily feed intake and FCR to specimens were fed with the fish meal based diet.

Poultry by-products are faced with some nutritional limitation (Emre et al 2003). The major problem is limiting essential amino acids content especially methionnine, phenylalanine, and lysine (Dong et al 1993; Emre et al 2003). Also, fish may suffer from digest feather, connective tissue and skin contents of poultry by-products (Hardy 2000). Emre et al (2003) found that carp (*Cyprinus carpio*) an omnivorous fish, cannot use the high levels of such substances in the diet, although total replacement of fish meal with PBD were reported for tilapia (*Oreochromis niloticus*; El-Sayed 1998; Hernández et al 2010), African catfish (*Clarias gariepinus*; Abdel-Warith et al 2001) and *C. carpio* (Steffens 1988). However, rainbow trout is carnivorous fish with an effective stomach and can successfully use poultry by-products in its diet as shown in this study. Steffens (1994) showed that fish meal can partially or completely replaced by poultry by-products which amino acids additives especially lysine and methionnine were required when substitution was complete. Also, PBD used at a level of 80% of total protein in trout diets without any growth retardation (Gouveia 1992). However, complete substitution without using any additives showed proper growth and survival in our study.

Conclusions. The present results clearly showed that complete replacement of fish meal with poultry by-products is a practical method for the culture of rainbow trout. Economically, poultry by-products meal is cheaper than fish meal. Also, the problem of low fish meal availability and high cost can be alleviated with using poultry by-products. Therefore, in this study complete replacement of fish meal with poultry by-products allowed growth indices of *O. mykiss* similar to control treatment i.e. commercial food. In addition, further studies are recommended to evaluate different levels of substitution of fish meal with poultry by-products.

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