Partial Substitution of Fishmeal with a Mix of Animal and Vegetable Feedstuffs for Rainbow Trout in Argentina

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FIGURE 1. *Fiberglass tanks at the National Aquaculture Development Centre, Argentina.*

FIGURE 2. *Rainbow trout at stocking were 40-50 g.*

Fishmeal continues to be one of the main protein sources used in commercial feeds for trout and salmon, although its availability is not expanding and its cost is increasing (Figueiredo-Silva and Lemme 2014). Toward sustainable aquaculture, Naylor *et al*. (2000) proposes a reduction of fishmeal and fish oil input in feed and promotion of environmentally sound aquaculture practices. Many investigators have replaced partially or totally replaced fishmeal with several animal or plant protein sources for different fish species. Previous experiences carried out at CENADAC with pacú and South American catfish (both omnivorous species) demonstrated that it is possible to totally substitute fishmeal with animal and plant feedstuffs (Wicki and Luchini 2004, Wicki *et al*. 2008).

Feedstuffs of animal origin are generally considered to be of higher quality than those of plant origin, primarily because of their higher protein content and superior essential amino acid profile (Robinson and Li 1998). Also, there have been efforts to increase the proportion of plant ingredients such as soybean meal and corn gluten meal (Moyano *et al*. 1992, Gomes *et al*. 1995).

This article describes a study where fishmeal was partially substituted with a mix of different feedstuffs used to prepare diets for rainbow trout. This mix contains a similar amino acid profile to that of fishmeal.

Study Methods

The study was carried out at CENADAC (National Aquaculture Development Centre, Argentina, Fig. 1) between June and October (winter months) and finished when water temperatures increased and feeding was not possible. Three 1000-L fiberglass tanks were used for each treatment. Twenty-five fish were stocked into each tank (Fig. 2), and water exchange (10 L/min) and supplemental aeration were provided.

Three experimental feeds were formulated (Table 1). A control diet contained 100 percent fishmeal, treatment A contained 50 percent fishmeal and 50 percent of an ingredient mix; treatment B contained 25 percent fishmeal and 75 percent of the ingredient mix. The ingredient mix was made by Asociación de Cooperativas Argentinas and consisted of blood meal (15 percent), high-protein soybean meal (10 percent), poultry byproduct meal (20 percent), corn gluten meal (12 percent), brewers yeast (33 percent) and egg albumin

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TABLE 1. Feed rations tested during feeding trial.

Ingredients	*Control (%)*	*Treatment A (%)*	*Treatment B (%)*
Fish Meal	30	15	7.5
Mix Ingredients		15	22.5
Sunflower meal	33	33	33
Meat meal	15	15	15
Corn	11	11	11
Wheat Meal	5	5	5
Fish oil	5	5	5
Mineral & vitamin	1	1	1

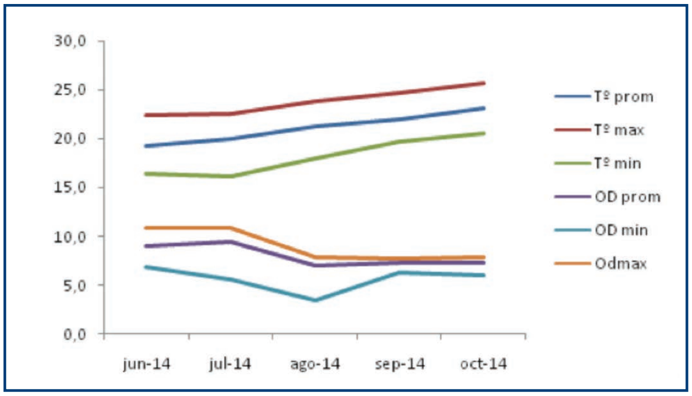

FIGURE 3. *Dissolved oxygen concentration (OD) and temperature (T) measured during the production period.*

FIGURE 4. *Rainbow trout at harvest were around 190 g.*

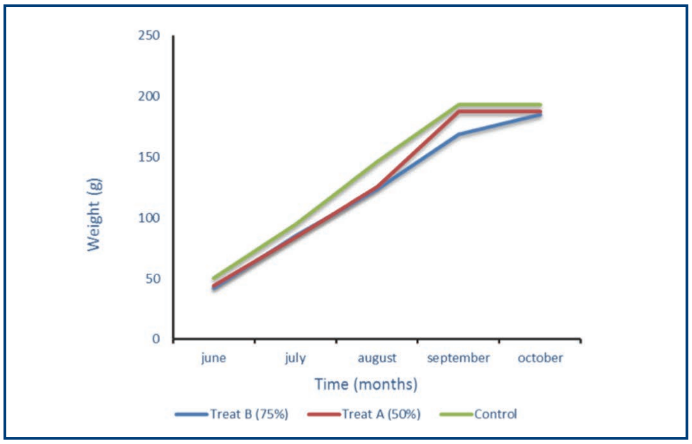

FIGURE 5. *Trout growth curves obtained with different diets.*

FIGURE 6. *Architecture of hepatic parenchyma with a centrilobular vein (VC) (H-E, 20x).*

(10 percent). The mixture had 54.6 percent crude protein, 5.3 percent lipid and 6.5 percent moisture.

Protein content of feeds ranged from 41.4 percent (control) to 42.3 percent for the diet with 75 percent fishmeal replacement. Ash content was 13.2 percent for the control, 11.2 percent for treatment A and 9.9 percent for the treatment B. Lipid content was 10.9 percent for the control diet, 9.1 percent for treatment A and 9.9 percent for treatment B.

Fish were fed *ad libitum* once daily and were not fed when temperature exceeded 22 C. The culture period was 130 days. Water quality variables (temperature, DO, and pH) were measured twice daily in the early morning and before feeding in the afternoon. Ten percent of the fish population was sampled monthly to determine fish growth and health.

At the end of the experiment all fish were weighed and feed conversion ratio (FCR, feed offered/weight gained), daily growth (DG, [final weight — initial weight]/time), protein efficiency ratio (PER, weight gained/protein offered) and specific growth rate (SGR, [ln final weight — ln initial weight]/t) were determined. For histological analysis, samples were fixed in 10 percent formalin and embedded in paraplast. Histological sections were stained with hematoxylin and eosin. Treatments groups were compared by one-way ANOVA (Hintze 1998).

Study Results

Mean water temperature was 20.8 C, with maximum temperatures of around 25 C occurring in October at the end of the trial. Mean dissolved oxygen was 7.9 mg/L and was minimum in August with a concentration of 4.5 mg/L (Fig. 3). Average water pH was 7.6, with slight daily variation between 7.2 and 7.9.

Growth rate, final body weight, feed conversion, protein efficiency ratio, and nutrient content of fillets of rainbow trout fed the three feeds were not significantly different (Fig. 5, Table 2). Fish grew from 45 g to about 190 g in 130 days, for a growth rate of 1.1 g/d. Trout fed the two fishmeal replacement diets reached satiation before those fed the diet containing only fishmeal, but this did not affect fish growth. Although not a significant difference, feed conversion ratio was slightly lower in treatments with the fishmeal replacement ingredient mixture. Protein efficiency ratio ranged from 1.52 to 1.56, with a slight trend towards better utilization of protein in the two experimental diets.

TABLE 2. Production performance of trout fed three different diets for 130 days.

	Treatment B (75%)	*Treatment A (50%)*	*Control*
Initial weight (g)	42	44	50
Final weight (g)	185	187	193
FCR	1.72	1.77	1.89
PER	1.54	1.56	1.52
DG (g/day)	1.1	1.1	1.1

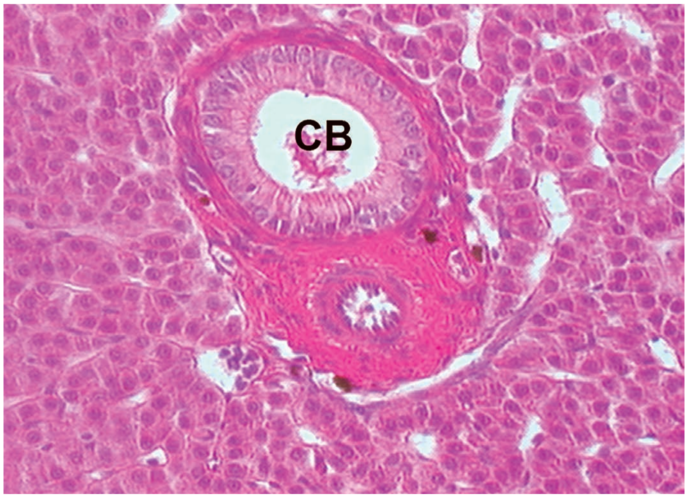

FIGURE 7. *Normal hepatic parenchyma, with a porta space with a bile duct and a branch of the hepatic artery (EP) (H-E, 40x).*

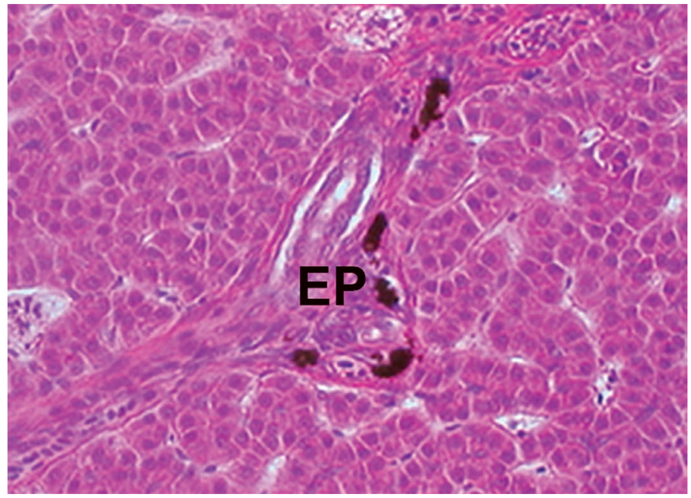

FIGURE 8. *Normal hepatic parenchyma with two bile ducts (CB) (H-E, 40x).*

Fillet protein content was similar among diets, around 21 percent. Fat content ranged from 3.1 to 3.6 percent. In histological sections of livers of trout fed each diet, no differences were found in the structure of hepatic parenchyma (Figs. 6-8).

Discussion and Conclusions

Herbivorous, omnivorous and carnivorous fish require more or less the same amount of dietary protein per unit weight, but herbivorous and omnivorous fish use protein and vegetable oils more efficiently than carnivorous fish and require minimal amounts of fishmeal to provide essential amino acids (Naylor *et al*. 2000). Thus, substitution of protein sources in diets for carnivorous fish such as trout is more complicated.

A wide range of feedstuffs have been evaluated as partial fishmeal replacements for rainbow trout diets. These include sunflower meal and soybean meal (Scott *et al*. (1982), cottonseed flour, soybean meal, and various animal by-products (Lee *et al*. 2002), chicken poultry concentrate byproduct blend and chicken and egg concentrates (Sealey *et al*. 2011), and various plant protein sources and synthetic amino acids (Figueiredo-Silva and Lemme (2014).

A blend of ingredients of different plant and animal origins and high protein quality is appropriate for this stage of rainbow trout farming. Complete replacement of fishmeal should be tested, as well as continuing the experiments until the full culture cycle is completed.

Notes

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