Director's Digest

FATS AND PROTEINS RESEARCH FOUNDATION, INC.

January 1995
Number 263

GARY G. PEARL D.V.M.
Director Technical Services

R.R. #2 Box 298
Bloomington, Illinois 61704
Telephone: 309-829-7744 FAX: 309-829-5147

REPLACING FISH MEAL PROTEIN IN SALMONID FISH DIETS

K. Dabrowski, S.C. Bai and T. Yanik

School of Natural Resources
The Ohio State University
Columbus, OH 43210

SUMMARY

A feeding trial was completed with 11 diets to determine the effect of fish meal replacement by a fish meal analog (mixture of four animal by-products) on growth and protein utilization in rainbow trout. After 14 weeks of feeding there was no significant difference between weight gains of fish fed a control diet (fish meal based) (554.5%) and fish fed diets with 25, 50 75 and 100% replacement (550-591%) if dietary protein level amounted to ± 36%. In the case of diets containing 47% protein, the weight gain was significantly lower in fish fed a diet with 100% fish meal analog (589%)in comparison to control, 100% fish meal (717.4%). Other groups performed as well as the control (733-792%). The other aspect of critical importance is the potential of decreasing P in diets containing fish meal analog and therefore use the diets of low-cost and less polluting. We conclude that 75% of fish meal protein can be replaced with the proposed fish meal analog fortified with essential amino acids (lysine and methionine) without the negative impact of rainbow trout fingerling growth.

OBJECTIVES

1. To evaluate the quality of alternative protein source (a fish meal analog, a combination of animal by-products) at several levels of dietary protein as replacers of high quality fish meals (menhaden and herring fish meal) in rainbow trout fingerling diets.
2. To determine the growth rate of fish, proximate body composition and nutrient utilization in diets with novel animal by-product mixture added.

EXPERIMENTAL DESIGN

Two groups of diets (Table 1) in this feeding trial were formulated to contain the same amount of crude protein and energy content within the same group. The group 1 diets (diet #1 to #5) contain 36% crude protein and 3.8 kcal/g diet, and the group 2 diets (diet #6 to #11) contain 47% crude protein and 4.1 kcal/g diet. The group 1 diets contained up to 20% of fish meal and/or an amount of OSU fish meal analog (the mixture of equal amounts of four animal proteins: meat and bone meal, blood meal, poultry by-products and feather meal) dependent upon the replacement ratio (0, 25, 50, 75, and 100%) of the fish meal protein. The group 2 diets contained up to 40% of fish meal and/or an amount of OSU fish meal analog dependent upon the replacement ration (0, 25, 50, 75, and 100%) of the fish meal protein. Diets #1 through #10 were formulated by using OSU fish meal analog, and diet #11 was prepared by using propak™ as a fish meal analog. Within the same diet group, diets have been adjusted for the total amount of methionine and lysine in the diets by adding the crystaline amino acids (Degussa, Allendale, New Jersey).

Rainbow trout (*Oncorhynchus mykiss*) were produced at the Piketon Research and Extension Center of The Ohio State University (London, Ohio, strain). The feeding trial was conducted in a 40-1 flow-through tank receiving well water at a rate of 500 ml/min. Supplemental aeration was also provided to maintain dissolved oxygen near air saturation. Water temperature was maintained at 10 ± 1 C and a diurnal light: dark cycle was regulated at 12:12 h. Fingerling rainbow trout initially averaging 1.9 g each were sorted and placed in individual tanks as groups of 30 fish with a total weight of 57 ± 1 g.

Each diet was divided into two feedings a day to fish in three randomly selected tanks (except diet #11, 2 tanks only) at a rate according to the previously developed experimental feeding schedule. Fish in each tank were collectively weighed every other week and the amount of diet fed adjusted according to the schedule. After 14 weeks of feeding trial fecal samples were collected and the availability and absorbability of protein and essential amino acids for each diet will be determined.

Fecal and whole fish samples were freeze-dried and powderized for further analyses. Nitric-perchloric acid digestion was used to prepare the colorless digests for ICP (inductively coupled plasma emission spectrophotometry) analyses (Model ARL-3560, Applied Res. Labs, Valencia, CA).

RESULTS & DISCUSSION

The growth response of rainbow trout fed with the 36% protein diets did not differ (Fig. 1) between control (fish meal based diet 1) and four levels of replacement. In case of diets containing ± 50% protein, the body gains were significantly higher than in 40% protein diets, and only 100% fish meal replacement resulted in growth depression (diet #10, see Table 1).

This experiment followed the major trend in aquaculture feed formulation predicted to year 2000 (Rumsey, 1993). A precedent was set by the results of this experiment that suitable alternate protein sources were identified that can be replaced in 75 or 100% fish meal protein. This might cause rainbow trout production cost to decrease dramatically. A research effort is needed to expand these results in rainbow trout of marketable size and possible broodstock fish diets.

It seems that vegetable protein sources without major break-through in biotechnology or processing might not be as important to aquaculture industry. Growth and feed efficiency are relatively low in rainbow trout when a commercial defatted soybean meal was used to replace fish meal, and this was attributed to an inadequate amino acid profile of this protein source (Pongmaneerat and Watanabe, 1993). The most rigid test to a fish meal analog based diet would be to use it in a complete production cycle including broodstock gamate quality evaluation. A feeding experiment needs to be conducted with similar formulation as in the present study where the effect of diets will be investigated in terms of the reproduction of rainbow trout, egg and sperm quality (see Watanabe et al. 1984).

Fish feeds with a high level of fish meal contain excessive amounts of phosphorus which does not contribute to growth but is discharged into the environment in faeces and urinary excretion. Phosphorus in the diets in excess of 0.6% (nutritional requirement) is an aquatic pollutant (see Table 2). It is obvious that a fish meal analog considerably improves the status of P in aquaculture feeds and the low-cost tends to make those diets less polluting. The success of aquaculture will depend on economically and environmentally (ecologically) sound production goals. Therefore, the commodity that could be used to replace fish meal and decrease the adverse effect on the environment should be a focus of the research efforts. The composition of the diets (Table 3) fell close to the approximated values. The level of chromium is high because it is an internal marker to be used in digestibility studies.

In conclusion, we developed a formulation of rainbow trout diet without fish meal and use of the alternative protein source composed of animal by-products which resulted in growth of fish not different from a traditional, fish meal based diets.

REFERENCES

Pongmaneerat, J. and Watanabe, T. 1993. Nutritional evaluation of soybean meal for rainbow trout and carp. *Bull. Jap. Fish. Soc.* 59:157-163.

Rumsey, G.L. 1993. Fish meal and alternate sources of protein in fish feeds. Update 1993. *Fisheries* 18:14-19.

Watanabe, T., Takeushi, T., Saito, M. and Nishimura, K. 1984. Effect of low-protein high calory or essential fatty acid deficiency diet on reproduction of rainbow trout. *Bull. Jap. Soc. Scien. Fish.* 50:1207-1215.

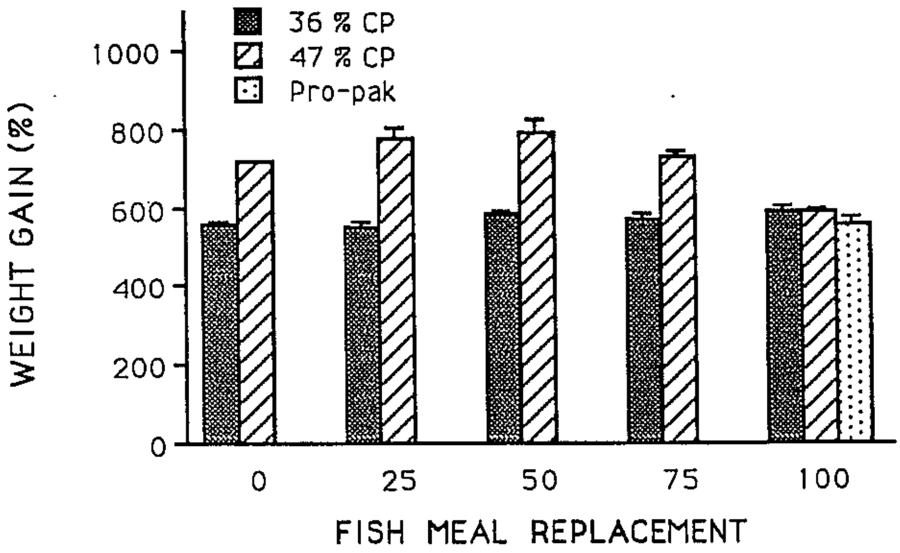

Fig. 1 Weight gain of rainbow trout (initial average weight 1.9 ±0.2g) fed pelleted diets during 14 week trial. Two sets of diets were used (36 and 47% protein). Fish meal protein was replaced with 25, 50, 75 and 100% of fish meal analog protein (mixture of by-products). No significant differences were found among fish fed 36% protein, whereas only complete replacement of fish meal resulted in significant decrease in weight gain ($p<0.01$). Data are means ± S.D. of triplicate tanks per dietary treatment, 30 fish per tank.

Table 1: Fish meal analog study

Diet composition

F meal	20%	15%	10%	5%	0%	40%	30%	20%	10%	0%	0%
F m Ana	0%	5%	10%	15%	20%	0%	10%	20%	30%	40%	40%
					Diet						
Ingredient	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
FM menh	10.00	7.50	5.00	2.50	0.00	20.00	15.00	10.00	5.00	0.00	0.00
FM herr	10.00	7.50	5.00	2.50	0.00	20.00	15.00	10.00	5.00	0.00	0.00
FM analo	0.00	4.75	9.50	14.26	19.00	0.00	9.50	19.01	28.51	38.01	43.51
B yeast	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Corn GM	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Soybean	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Wheat M	20.00	20.00	20.00	20.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00
Whey	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	5.00
Met	0.00	0.00	0.05	0.10	0.15	0.20	0.00	0.10	0.21	0.31	0.00
Lys	0.00	0.00	0.06	0.12	0.18	0.24	0.00	0.12	0.25	0.37	0.44
Cr2O3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
V&M prem	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Alphacel	1.50	1.17	0.83	0.48	0.15	3.00	2.33	1.63	0.96	0.28	0.00
Tender J	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vit. C-MP	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cod Oil	11.85	12.32	12.80	13.28	13.76	10.35	11.30	12.25	13.20	14.16	11.40
Total	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00	100.0	100.0
Prot	35.9	36.0	36.1	36.3	36.4	46.5	46.7	47.0	47.2	47.4	46.7
Energy	3845	3845	3845	3845	3845	4117	4117	4117	4117	4117	4117
Met	0.85	0.85	0.85	0.85	0.85	1.20	1.20	1.20	1.20	1.20	1.20
Lys	2.05	2.05	2.05	2.05	2.05	2.96	2.96	2.96	2.96	2.96	2.96
Fat	15.1	15.4	15.8	16.2	16.5	14.5	15.2	16.0	16.7	17.4	15.5
Cys	0.48	0.48	0.54	0.56	0.59	0.56	0.62	0.68	0.74	0.79	0.88
Ca	0.86	0.83	0.79	0.75	0.72	1.57	1.50	1.43	1.35	1.28	2.85
P	0.84	0.81	0.78	0.75	0.72	1.11	1.05	0.99	0.93	0.87	1.55

Table 2 Proximate and mineral composition of dietary ingredients to be used in the proposed study (% if not otherwise).

	Dry Matter	Protein	P	K	Ca	Mg	Na	Zn ppm	Mn ppm	Fe ppm
Fish meal (herring)	93.8	79.6	2.21	0.47	1.34	0.16	0.33	82	8	167
Fish meal (menhaden)	93.4	69.0	3.34	0.79	0.99	0.20	0.50	234	136	1007
Fish meal analog (by-product mixture, OSU)	95.1	80.2	1.85	0.36	1.18	0.08	0.31	89	11	864

Table 3 Chemical composition of the diets used in rainbow trout study. Diets 1-5; 36% protein with fish meal analog replacement of 0, 25, 50, 75 and 100%, respectively. Diets 6-10; 47% protein with fish meal analog replacement of 0, 25, 50, 75 and 100%, respectively. Diet 11; 47% protein, 100% replacement with Propak (commercial fish meal analog).

Diet #	DM	CP	P	K	Ca	Mg	Na	Zn	Mn	Fe	Cu	Cr
	%							ppm				
1	95.7	39.6	1.36	0.87	1.02	0.16	0.16	60	72	262	10	3032
2	97.1	41.2	1.31	0.84	0.93	0.16	0.16	60	72	256	10	3042
3	95.9	40.8	1.18	0.84	0.79	0.14	0.15	49	64	405	10	2860
4	96.7	41.2	1.14	0.82	0.74	0.14	0.14	48	59	255	10	2878
5	96.3	41.7	1.17	0.86	0.77	0.14	0.14	47	61	424	10	2919
6	96.2	50.2	1.62	0.75	1.27	0.12	0.22	77	64	313	20	3044
7	96.1	48.7	1.71	0.74	1.72	0.13	0.21	81	65	649	13	3479
8	95.8	48.8	1.53	0.75	1.16	0.11	0.22	68	56	422	11	3289
9	96.5	50.1	1.37	0.71	1.12	0.10	0.20	56	47	397	13	3176
10	95.9	47.6	1.22	0.68	1.17	0.08	0.19	45	40	456	13	3051
11	95.6	50.0	2.03	0.74	1.52	0.11	0.33	56	56	635	15	3628

DM – dry matter, CP – crude protein (N x 6.25)