INTRODUCTION INTO AYSEN CHILE OF PACIFIC SALMON

No. 8

Nutritional Evaluation of Chilean Fish Meals as Dietary Protein Source for Rainbow Trout, *Salmo gairdnerii*

By

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and

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ERRATA

Page 1, Paragraph 4, line 1: Read "demonstrated" instead of "demostrated".

Paragraph 7, line 4: Read "through" instead of "trough".

Page 4, Table 3: Fatty acid 22:6 in brown fish meal C-2 should be "21.8".

Line 3 of paragraph 4: Read "docosapentaenoic" instead of "docosapentanoic".

Page 5, Table 4: Read "& Starch" instead of "& Starch".

Page 7, Table 7: The condition factor formula should be "$\frac{BW(g)}{BL(cm)^3} \times 1000$ "

Page 9 : The work of Smith et al in the "Comercial Fisheries Review" should be year "(1964)" instead of "(1966)".

Page 10 : In the Vitamin mix, read "Vit B_{12}" instead of "Vit E_{12}", and "CMC" should be "cellulose powder".

In Mineral mix No 2, read "U.S.P.XII (NRC catalog)" instead of "U.S.P.XIII (NBC catalog)".

In Trace elements, read "Zn SO_4" instead of "Gr SO_4".

In authors address, read "Kasumigaseki" instead of "Kasumijaseki".

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NUTRITIONAL EVALUATION OF CHILEAN FISH MEALS AS DIETARY PROTEIN SOURCE FOR RAINBOW TROUT, *Salmo gairdnerii*

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ABSTRACT

A feeding experiment was conducted with diets containing 57% different fish meals as sole protein source.

The contents of crude protein (N x 6.25) in the test diets were between 37.1% and 40.2%.

The qualities of the fish meals used were evaluated through the feed efficiency, growth rate, PER, NPU and protein digestibility.

Chilean fish meals demostrated their good quality as protein source for salmonid fish diet.

INTRODUCTION

Chilean fish meal production increased during the last years reaching a total of 795.765 tons in 1982, from which 770.563 tons were exported the same year (SERNAP, 1982).

On the other hand, fish culture in Chile grow up on the last years, yielding a total production of 305 tons in 1982, composed mainly by species of genus Oncorhynchus and Salmo (SERNAP, 1982).

The increasing demand of fish meal as protein source for the improving aquaculture activity guided us to the present research work, which was carried out to evaluate the nutritional quality of Chilean brown fish meals, compared against to Japanese fish meals, trough a feeding experiment, using rainbow trout, *Salmo gairdnerii*, as testing animal.

MATERIAL AND METHODS

1.– Experimental design

This experiment was carried out with rainbow trout in six glass acuaria (19 x 40 x 30 cm). using aerated and dechlorinated running city water, held at 17°C constant temperature.

Fish was fed with six different test diets for a period of four weeks. The weight of the fish was measured at the start of feeding period, the second and fourths week.

Feed efficiency, growth rate, PER, NPU and protein digestibility were used as criteria for comparison.

This research was carried out at Tokai Regional Fisheries Research Laboratory in Tokyo, Japan.

2. Biological material

2.1 Fish

From a total of thousand rainbow trout, brought from Nagano Prefectural Fisheries Experimental Station and previously aclimated to the dechlorinated city water, 245 trout between 1.5 to 1.6 g. body weight were selected for the experiment, separated in groups of 35 fish and aclimated to their experimental acuaria. Fish was also trained to accept the artificial diet for a period of two weeks before the experiment started.

2.2 Food

Six different test diets were prepared as dry pellet, using four kinds of Chilean brown fish meal, Japanese white fish meal and Japanese brown fish meal.

Fish meals used and manufacturing data were shown in Table 1. Chilean fish meals were supplied from four fish meal plants located in northern Chile. These meals were produced from horse mackarel, *Trachurus murphyi* and spanish sardine, *Sardinops sagax*. On the other hand, Japanese brown fish meal was manufactured at Hokkaido, northern Japan, using Japanese sardine, *Sardinops melanostictus* as raw material. White fish meal was produced on factory ship from Alaska pollack, *Theragra chalcogramma,* caught in the Bearing Sea.

Table 1. Manufacturing methods of Chilean and Japanese fish meals used

No.	Mateiral	Drying system	Antioxidant (ethoxyquin)	Manufacturing	
				Date	Factory
C-1	Horse mackarel	Direct hot air	Added	Nov. 1981	Empresa Pesquera Coloso
C-2	Spanish sardine	Steam	Added	Sept. 1981	Empresa Pesquera Indo
C-3	Horse mackarel	Direct hot air and steam	Added	Nov. 1981	Empresa Pesquera Iquique
C-4	Horse mackarel	Steam	Added	Nov. 1981	Empresa Pesquera Eperva
J-1	Japanese sardine	Steam	Added	Jun. 1981	Hokusui Hi-meal Hokkaido, Japan
White fish meal	Alaska pollack	Steam	None	Oct. 1981	Factory ship Japan

In Japan white fish meal is used mostly as dietary protein source for fish culture.

All the fish meals were used for the experiment after crushing them into fine powder by a hammer mill.

The proximal analysis of these fish meals was given in Table 2.

Table 2. Approximate analysis of Chilean and Japanese fish meals used

		Brown fish meal					White fish meal
		C-1	C-2	C-3	C-4	J-1	
Moisture	%	5.4	6.2	11.0	8.8	5.5	5.1
Crude protein	%	66.3	66.8	64.4	66.2	64.8	65.7
Cruede fat	%	9.6	9.5	8.3	9.7	10.9	8.0
Crude ash	%	15.6	15.5	14.7	14.5	18.1	20.2

Moisture in Chilean fish meals used were relatively high compared to Japanese meals, but crude ash contents were lower than Japanese ones. Crude protein and crude fat, of both, were almost the same.

Total lipids for fat quality determinantion were extracted from the six fish meals by the method of Smith et al (1964).

The cardinal fatty acid composition and characteristics of total lipids in fish meals was summarized in Table 3.

Table 3. Fatty acid compositions of total lipids, acid value, peroxide value and iodine value of lipids in Chilean and Japanese fish meals used.

Fatty acid	Brown fish meal					White fish meal
	C-1	C-2	C-3	C-4	J-1	
14:0	4.7	8.1	7.7	9.9	6.4	4.7
15:0	0.7	0.5	0.5	0.6	0.3	0.2
16:0	19.2	20.9	19.4	21.3	19.6	18.1
16:1	5.7	7.5	7.5	7.4	6.9	6.2
18:0	5.1	3.7	3.9	3.5	2.6	1.5
18:1	17.4	12.7	16.5	15.1	14.8	22.2
20:1	1.2	0.4	0.4	0.8	4.2	9.9
20:5/22:1	11.8	14.9	14.2	13.6	15.7	20.9
22:5	3.8	2.3	2.2	2.0	1.4	0.9
22:6	22.1	21.7	21.7	17.6	20.5	12.5
Total lipid	11.6	12.8	11.5	12.5	13.4	10.6
Acid value	18.2	17.0	15.1	16.9	21.4	18.8
Peroxid value (meq/kg)	7.2	8.6	8.5	7.2	15.3	31.2
Iodine value	146.7	156.0	146.7	157.2	159.4	130.7

The fatty acid composition of lipids in chilean brown fish meals showed similar pattern to that of Japanese brown meal. Comparing brown meals with white fish meals on fatty acid composition, the percentages of palmitic, stearic, docosapentanoic and docosahexaenoic acids were high in the former fish meals, oleic and eicosamonoenoic acid were higher in the latter meals.

The general formula used for the preparation of the test diets was given in Tabla 4. In each diet 57% of fish meal was used as sole protein source. Vitamine and mineral formula is given in Appendix.

Table 4. Composition of experimental diet

	%
Fish meal	57
& Starch	15
Dextrin	7.5
Minerals	4
Vitamins	1.5
Mixed Oil *	12
CMC	3

* Soybean oil: Alaska pollack liver oil = 3 : 2

The six experimental diets preparad with this formula were analyzed for moisture, crude protein, crude fat and crude ash. The result was given in Table 5.

The contents of crude protein (N x 6.25) in diets were between 37.1 to 40.2%.

Table 5. Approximate analysis of experimental diets

Diet No.		1	2	3	4	5	6
		Protein source					
		Brown fish meal					White fish meal
		C-1	C-2	C-3	C-4	J-1	
Moisture	%	4.5	3.4	3.6	3.6	2.6	2.5
Crude protein	%	39.8	39.0	40.2	39.0	38.4	37.1
Crude fat	%	17.4	17.9	17.0	17.9	18.7	16.8
Crude ash	%	12.2	12.2	12.4	11.7	13.2	14.4
Gross energy*		497	502	501	501	497	489

* kcal/100 g

2.3 Feeding

The test diets were supplied to the fish in the form of dry pellets. The daily feeding rate was initialy 4.5% of body weight for the first two weeks and 4% body weight until the end of the experiment.

Test food was given to the trout at a rigid schedule, 3 times daily, during 6 days of the week.

3. Protein digestibility and Net protein utilization (NPU) determination.

For protein digestibility, six test diets were prepared with a similar formula as the former including this a 0,5% of chromic oxide as innert reference matter for indirect determination of this parameter.

Fish was feed and feces were collected by a siphon inmediately after excretion. Chromic oxide in both of diets and feces were determined by the method of Furukawa and Tsukahara (1966).

The NPU of the dietary protein was determinated by the method of Takeuchi et al (1978).

RESULTS AND DISCUSSION

Results of the four-week feeding trial was shown in Table 6. Growth rate of fish was highest in the group fed on the diet containing Japanese white fish meal. The growth rates of two groups fed on Chilean brown fish meal diet were almost the same as that of the group fed on Japanese brown fish meal. Variance analysis with the final body weights of experimental groups N° 1, 3 and 6 was carried out at a significance level of $p = 0.05$. F value indicates that there is no significative difference among growth attained by trout fed on basis of Chilean brown fish meals C-1 and C-3 compared with that of fish fed with the diet containing Japanese white fish meal.

Table 6. Results of 4-week feeding experiment with rainbow trout

Diet No.	Dietary protein		Average weight		Growth rate	Feed efficiency
			Start	Final		
1	Brown fish meal	C-1	1.59g	5.30g	233	118
2		C-2	1.54	4.72	206	105
3		C-3	1.60	5.40	238	116
4		C-4	1.61	5.11	217	116
5		J-1	1.58	5.23	231	113
6	White fish meal		1.59	5.66	256	119

In the present work good fish growth was achieved with crude protein content as low as 37,1% while Tiews et al (1972) states that optimal growth of rainbow trout cannot be expected if the feed contains less than 40% of crude protein.

Feeding efficiency was no marked different among experimental groups, except for a slightly low value observed in the group fed on the diet containing Chilean fish meal prepared from spanish sardine as raw material.

Approximate composition of entire fish body and condition factor were analyzed at the end of the feeding trial and were given in Table 7. There were no difference among all experimental groups.

Table 7. Approximate analysis and condition factor of rainbow trout at end of feeding experiment for 4 weeks

No.		1	2	3	4	5	6
Moisture	%	72.7	72.5	72.5	72.7	71.8	72.4
Crude protein	%	14.1	14.3	14.3	13.9	14.2	13.7
Crude fat	%	10.2	9.6	9.9	10.0	11.0	10.1
Crude ash	%	2.4	2.5	2.4	2.3	2.3	2.3
Condition factor *		18.3	18.8	19.2	18.8	19.2	18.3

* Condition factor: $\frac{BW\ (g)}{TL\ (cm)^3} \times 1000$

Condition factor of fish fed with the different fish meals was almost around 19.0.

Digestibility, Protein efficiency ratio (PER) and NPU of the dietary protein were summarized in Table 8.

Relative high values for apparent digestibility of protein were found. There were little difference among fish meals used, ranging from 88.4 two 90.9%. The values of brown fish meals were almost the same as that of Japanese white fish meal.

Recently, Watanabe et al (1983) reported the protein digestibilities of Japanese and peruvian brown fish meals. Their values were similar to that obtained in this experiment.

Table 8. Protein digestibility, PER and NPU values of Chilean and Japanese fish meals determined by rainbow trout

Dietary protein		Protein digestibility %	PER	NPU
Brown fish meal	C-1	90.9	2.96	47.0
	C-2	88.4	2.68	47.1
	C-3	90.7	2.88	47.0
	C-4	89.1	2.97	47.1
	J-1	88.4	2.94	49.8
White fish meal		89.0	3.22	48.6

However, the values for digestibility of brown fish meals obtained by Nose and Toyama (1966) were from 60 to 78%, clearly lower than those in this work. Nose and Toyama suggested that oxidated lipid in fish meal tend to decrease the protein digestibility. The high values obtained in this experiment may due to a relatively fresh condition of the fish meals used. The low values of peroxide value of the lipid in the differente fish meals in our experiment, deals with this assumption.

The values for PER obtained with Chilean brown fish meals were slightly lower than those for Japanese white fish meal, but there were no remarkable difference among the values obtained with Chilean and Japanese brown fish meals.

NPU values obtained with Chilean fish meals were only slightly lower than those of Japanese meals.

CONCLUSIONS

The results of this work have demostrated that the nutritional values of Chilean brown fish meals are similar to that of Japanese white fish meal, which is considered a superior material as protein source for fish feed in Japan.

It could be concluded that Chilean brown fish meal have good quality value as feedstuffor fish culture.

ACKNOWLEDGEMENT

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APPENDIX

Vitamin mix (for 10 kg feed)

Choline chloride	50 g
Inositol	20 g
Ascorbic acid	10 g
Niacin	7.5 g
Calcium pantothenate	5.0 g
Riboflavin	2.0 g
Menadione	0.4 g
Pyridoxine	0.5 g
Thiamine hidrochloride	0.5 g
Folic acid	0.15 g
Biotin	0.05 g
Vit A	150.000 - 200.000 U.I. 5 g
Vit D_3	30.000 - 40.000 U.I.
Vit E_{12}	0.001 g
Alfa Tocoferol	4.0 g
CMC	44.9 g
	100 g

Mineral mix No 2 U.S.P. XIII (NBC catalog)

Calcium biphosphate	13.58%
Calcium lactate	32.70%
Ferric citrate	2.97%
Magnesium sulfate	13.70%
Potassium phosfate (Dibasic)	23.98%
Sodium biphosphate	8.72%
Sodium chloride	4.35%
	100%

Trace elements together with 100 g of Mineral Mix No 2)

$Al Cl_3 . 6H_2O$	0.015 g
KI	0.015 g
Cu Cl	0.010 g
$Mn SO_4 . H_2 O$	0.080 g
$Co Cl_2 . 6 H_2O$	0.100 g
$Gr. SO_4 . 7 H_2O$	0.300 g