TECHNICAL BULLETIN NO. 77 NOVEMBER 1968

A Comparison of Hawaiian Tuna Meal and Other Protein Supplements for Raising Broilers

Ernest Ross

HAWAII AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF HAWAII

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THE AUTHOR

ERNEST ROSS is Poultry Scientist at the Hawaii Agricultural Experiment Station, University of Hawaii.

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INTRODUCTION

The literature concerning the use of fish meal in broiler rations, both as a protein supplement and as a source of unidentified growth factors, is extensive. Sullivan *et al.* (1960) reported the activity of unidentified growth factors in a wide variety of fishery by-products, including tuna meal. Ross (1961) compared the growth rate of broiler chicks receiving graded levels of three types of tuna meal. Satisfactory growth was obtained with all three products when included in the ration up to the 10-percent level.

The procedure for the production of Hawaiian tuna meal has recently undergone changes due to the diversion of some of the by-product material into pet food. A major effect of these changes has been to lower the crude protein content of the tuna meal from 60 to approximately 55 percent.

In view of these changes, it seemed desirable to reevaluate the new tuna meal along with meat and bone meal and Peruvian fish meal. These three constitute the major animal proteins commonly used in local poultry rations. The experiments reported here were designed to compare different levels of these products as single supplements as well as in various combinations in broiler rations.

MATERIALS AND METHOD

Three 9-week experiments were carried out using commercial crossbred broiler chicks. In each experiment the day-old chicks were housed in electrically heated, thermostatically controlled battery brooders. At 3 weeks of age the chicks were vaccinated for fowl pox and transferred to unheated grower batteries. The chicks were again transferred at 6 weeks of age to wire-floor developer pens, where they remained until the experiments ended at 9 weeks of age.

Triplicate groups containing five male and five female chicks each were randomly assigned to each treatment in experiments 1 and 2. In the third experiment the number of chicks was increased and the sexes segregated in order to provide more precise information on feed efficiency. In this experiment triplicate groups containing 10 male chicks and triplicate groups containing 10 female chicks were assigned to each treatment.

The tuna meal used in these studies was the commercial product which contained 54 to 55 percent of protein. The flow chart shown in figure 1 depicts the manufacturing process by which Hawaiian tuna meal is produced. The major change in the previous procedure (Ross, 1961) is the shift of some of the dark meat from by-products manufacture to pet food and an increase in the amount of fish solubles going into the tuna meal. The product tested contained an average of about 15 percent of fish solubles on a dry weight basis.

The meat and bone meal tested was from a mainland source and was guaranteed to contain a minimum of 50 percent crude protein. The Peruvian fish meal was guaranteed to contain a minimum of 65 percent protein. These protein values were used as the basis for calculating isonitrogenous rations.

In all cases, the protein supplements under test were added as a percentage of the total ration, rather than as a specific quantity of protein. All rations were calculated to contain 21 percent protein, the necessary adjustment in protein level being made with the milo and soybean meal components. Vitamins and micro-minerals known to be deficient or marginal were adjusted to meet or exceed National Research Council requirements through the use of a micro-ingredient mix. To minimize variations between rations, all the constant ingredients (about 80 to 90 percent of the rations) were premixed and aliquots taken for further mixing with the protein supplements. Thus all diets were essentially isocaloric.

Group body weights were taken at the start of the experiment and individual body weights at 9 weeks. Feed consumption, mortality and incidence of perosis were recorded. All data were subjected to the analysis of variance (Snedecor, 1956). Duncan's (1955) multiple range test was used to further locate treatment effects.

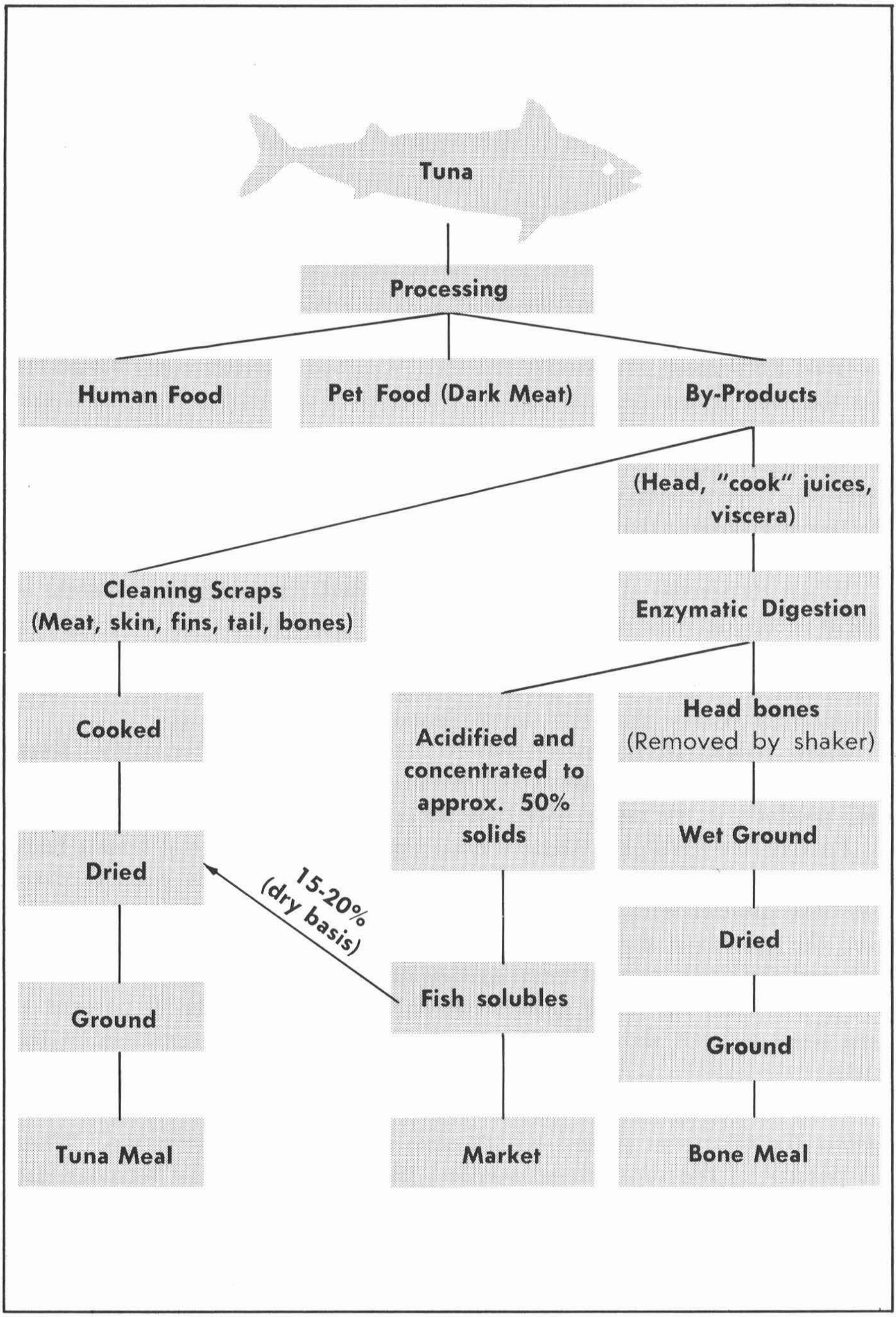

FIGURE 1. Flow chart of fish by-products manufacture.

RESULTS AND DISCUSSION

Experiment 1

The rations used in this experiment are shown in table 1. In addition to the all-vegetable-protein control ration, the experimental rations contained 2.5, 5, or 10 percent of tuna meal, mainland meat meal, or Peruvian fish meal. Calcium and phosphorus levels were adjusted, depending on level of supplement in the rations, with defluorinated phosphate.

Male Body Weight. There were no statistically significant differences in the 9-week body weights of the groups receiving 2.5 percent of the protein supplements. However, the data in table 2 show that the group which received 2.5 percent of Peruvian fish meal weighed approximately 0.3 pound less than the groups fed the corresponding level of meat or tuna meal and the control.

The mean body weight of the group which received 5 percent of meat meal was approximately 0.25 pound less than the mean weight of the other treatment groups at that level. This difference, however, was not statistically significant.

When 10 percent of the supplements was fed, the mean body weight of chicks receiving tuna meal was significantly less than the mean weight of the group receiving 10 percent of Peruvian fish meal. Meat meal gave an intermediate result. The 10 percent tuna group was also the only treatment significantly poorer than the unsupplemented control group.

These results are contrary to those obtained in an earlier study (Ross, 1961) when significant growth depression did not occur until the level of tuna products in the ration was 15 or 20 percent.

Female Body Weight. There was no significant difference in female body weight between supplements or between the levels fed. In general, there was little difference in female body weight between the treatments. However, the growth of the females receiving 2.5 percent of Peruvian fish meal followed the same general trend as that of the males, averaging about 0.25 pound less than the other groups. Female chicks receiving 10 percent of tuna meal did not show the growth depression that was apparent in the males.

Feed Efficiency. There were no significant differences in feed efficiency among the treatment groups within each level of supplementation. When 2.5 percent of the supplement was fed, the efficiency of the Peruvian fish meal group was lower than that of those receiving the other supplements. In general, each supplement tended to improve feed efficiency with increasing concentration, the increase being most marked with Peruvian fish meal.

Mortality. There were no significant differences in mortality between supplements or between levels of supplements, and no trends were apparent.

Table 1. Composition of rations used in experiment 1, percent by weight

INGREDIENTS	RATION NUMBER									
	1	2	3	4	5	6	7	8	9	10
Corn, ground	36.0									
Milo, ground	22.5									
Soybean meal (44% protein)	13.3			Same as Ration 1.						
Cottonseed meal (44% protein)	5.0			This portion of the rations was premixed and						
Alfalfa, dehydrated (20% protein)	2.5			constituted 80.05% of each ration.						
Salt	0.5									
Micro-ingredient mix[1]	0.25									
DL-methionine	0.03									
Premix	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05	80.05
Milo, ground	—	2.00	2.75	1.75	4.00	5.50	3.50	6.85	9.95	5.70
Soybean meal	16.80	13.45	12.70	13.70	9.95	8.45	10.45	3.10	—	4.25
Tuna meal (54% protein)	—	2.50	—	—	5.00	—	—	10.00	—	—
Meat meal (50% protein)	—	—	—	2.50	—	—	5.00	—	—	10.00
Fish meal, Peruvian (65% protein)	—	—	2.50	—	—	5.00	—	—	10.00	—
Defluorinated phosphate	3.00	2.00	2.00	2.00	1.50	1.50	1.50	—	—	—
DL-methionine	0.15	—	—	—	—	—	—	—	—	—

[1]Supplied per pound of diet: Vitamin A, 1750 I. U.; Vitamin D_3, 500 I.C.U.; Vitamin E, 0.5 I.U.; Vitamin B_{12}, 2.5 mcg.; riboflavin, 1.5 mg.; d-pantothenic acid, 2.5 mg.; niacin, 10 mg.; choline chloride, 100 mg.; menadione sodium bisulfite, 0.25 mg.; B.H.T., 56.7 mg.; manganese, 27.2 mg.; iron, 9.08 mg.; zinc, 12.5 mg.; copper, 0.9 mg.; iodine, 0.55 mg.; and cobalt, 0.09 mg.

Table 2. Mean 9-week body weight, feed efficiency, mortality, and perosis of crossbred broiler chicks fed graded levels of tuna meal, meat meal, and Peruvian fish meal, experiment 1

ANIMAL PROTEIN SUPPLEMENT (PERCENT)	BODY WEIGHT, LB.					FEED/ GAIN	S.E.	PE[3]	MORTALITY		PEROSIS	
	Male	S.E.[2]	Female	S.E.	$\bar{X}$				%	S.E.	%	S.E.
None	4.18[ab1]	.09	3.43[a]	.09	3.81	2.17[a]	.01	176	0[a]	0	3.3[a]	3.3
2.5 Tuna meal	4.21[ab]	.12	3.43[a]	.12	3.82	2.14[ab]	.02	179	7.0[a]	3.5	3.8[a]	3.7
2.5 Meat meal	4.23[ab]	.06	3.41[a]	.09	3.82	2.14[ab]	.03	179	0[a]	0	3.3[a]	3.3
2.5 Peruvian fish meal	3.90[bc]	.06	3.16[a]	.05	3.53	2.25[a]	.06	157	3.3[a]	3.3	3.4[a]	3.3
5 Tuna meal	4.38[a]	.19	3.34[a]	.06	3.86	2.11[bc]	.01	183	3.3[a]	3.3	16.7[a]	10.7
5 Meat meal	4.02[abc]	.14	3.46[a]	.03	3.74	2.14[ab]	.02	175	3.3[a]	3.3	3.4[a]	3.3
5 Peruvian fish meal	4.26[ab]	.14	3.49[a]	.04	3.87	2.11[bc]	.02	183	6.7[a]	3.4	3.6[a]	3.3
10 Tuna meal	3.77[c]	.06	3.45[a]	.08	3.61	2.12[bc]	.03	170	3.3[a]	3.3	10.7[a]	6.4
10 Meat meal	4.03[abc]	.12	3.43[a]	.13	3.73	2.09[c]	.02	178	3.3[a]	3.3	10.0[a]	5.8
10 Peruvian fish meal	4.35[a]	.04	3.42[a]	.05	3.88	2.03[c]	.03	191	3.3[a]	3.3	3.4[a]	3.3

[1]Values in any column bearing the same superscripts are not significantly different.
[2]Standard error of the mean.
[3]Production efficiency $= \frac{\text{Average body weight} \times 100}{\text{Feed/gain}}$

The distribution of mortality shown in table 2 indicates a random effect not related to treatments.

Incidence of Perosis. The observed differences in perosis were not statistically significant, although there appeared to be a greater incidence of perotic birds in the 5- and 10-percent tuna groups.

Production Efficiency. Production efficiency (PE) is measure of overall performance, since it equates body weight and feed efficiency. The greater the body weight and the more efficient the feed conversion the higher the PE index. The PE index of the groups that received 2.5 and 5 percent of tuna meal was equal to or higher than that of the groups that received meat or Peruvian fish meal. At the 10-percent level of supplementation, however, the PE index of the group receiving the tuna meal was lower than that of the groups receiving the other supplements, and also lower than that of the groups receiving the lower levels of tuna meal.

Experiment 2

The plan for experiment 2 was developed in view of the fact that it is common practice among feed manufacturers to use combinations of two or more sources of animal protein. Various combinations of tuna meal, Peruvian fish, and meat meal were used in the experimental broiler rations. These rations are shown in table 3.

Rations 11 to 16 contained 2.5 percent of Peruvian fish meal in combination with 2.5 or 5 percent of tuna or meat meal. These rations were also compared with rations 17 and 18, which contained 2.5 and 5 percent, respectively, of tuna meal as the sole animal protein supplement.

Male Body Weight. There was a general trend toward increased body weights with increased levels of animal protein supplements although none of the observed differences were statistically significant (table 4). The mean body weights of the groups that received 2.5 percent of tuna or meat meal and 2.5 percent of Peruvian fish meal in their ration were greater than for those that received only 2.5 percent of Peruvian fish meal. When 5 percent of tuna or meat meal was included in the ration a further increase in body weight was noted.

The body weights of the groups that received 2.5 or 5 percent of tuna meal without additional supplementation with Peruvian fish meal were greater than those of the other treatments This indicates that, as far as effect on male body weight is concerned, tuna meal is as effective as combinations of meat meal and Peruvian fish meal.

The performance of the group receiving only 2.5 percent of Peruvian fish meal in the ration was comparable to that of the same treatment in experiment 1. It is difficult to explain why the groups that received 2.5 percent of Peruvian fish meal failed to equal the performance of the groups that

TABLE 3. Composition of rations used in experiment 2, percent by weight

INGREDIENTS	RATION NUMBER							
	11	12	13	14	15	16	17	18
Corn, ground	36	Same as Ration 11. This portion of the rations was premixed and constituted 88% of each ration.						
Milo, ground	24.5							
Soybean meal (44% protein)	18.25							
Cottonseed (44% protein)	5.0							
Alfalfa, dehydrated (20% protein)	2.5							
Defluorinated phosphate	1.0							
Salt	0.4							
Micro-ingredient mix[1]	0.25							
DL-methionine	0.1							
Premix	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00
Milo, ground	0.50	1.70	1.45	3.65	3.05	3.35	—	1.05
Soybean meal (44% protein)	7.75	4.30	4.55	0.85	1.45	1.15	8.25	4.95
Tuna meal (54% protein)	—	2.50	—	5.00	—	2.50	2.50	5.00
Fish meal, Peruvian (65% protein)	2.50	2.50	2.50	2.50	2.50	2.50	—	—
Meat meal (50% protein)	—	—	2.50	—	5.00	2.50	—	—
Defluorinated phosphate	1.25	1.00	1.00	—	—	—	1.25	1.00

[1]Supplied per pound of diet: Vitamin A, 1750 I.U.; Vitamin D_3, 500 I.C.U.; Vitamin E, 0.5 I.U.; Vitamin B_{12}, 2.5 mcg.; riboflavin, 1.5 mg.; d-pantothenic acid, 2.5 mg.; niacin, 10 mg.; choline chloride, 100 mg.; menadione sodium bisulfite, 0.25 mg.; B.H.T., 56.7 mg.; manganese, 27.2 mg.; iron, 9.08 mg.; zinc, 12.5 mg.; copper, 0.9 mg.; iodine, 0.55 mg.; and cobalt, 0.09 mg.

TABLE 4. Mean 9-week body weight, feed efficiency, mortality, and perosis of crossbred broiler chicks fed various levels and combinations of tuna, meat, and Peruvian fish meal, experiment 2

ANIMAL PROTEIN SUPPLEMENT (PERCENT)	BODY WEIGHT, LB.					FEED/ GAIN	S.E.	PE[3]	MORTALITY		PEROSIS	
	Male	S.E.[3]	Female	S.E.	$\overline{X}$				%	S.E.	%	S.E.
2.5 Peruvian fish meal	3.90^{a}[1]	.01	3.11^{a}	.07	3.51	2.48^{c}	.03	142	0^{a}	0	13.3^{a}	3.3
2.5 Peruvian fish meal + 2.5 tuna meal	4.01^{a}	.11	3.38^{a}	.13	3.70	2.41^{bc}	.01	154	6.7^{a}	3.4	11.7^{a}	7.3
2.5 Peruvian fish meal + 2.5 meat meal	4.05^{a}	.06	3.24^{a}	.07	3.65	2.40^{bc}	.03	152	3.7^{a}	3.7	7.5^{a}	3.8
2.5 Peruvian fish meal + 5 tuna meal	4.14^{a}	.02	3.34^{a}	.09	3.74	2.37^{abc}	.03	158	0^{a}	0	10.0^{a}	5.8
2.5 Peruvian fish meal + 5 meat meal	4.13^{a}	.05	3.24^{a}	.01	3.69	2.34^{ab}	.07	158	3.3^{a}	3.3	0^{a}	0
2.5 Peruvian fish meal + 2.5 tuna meal + 2.5 meat meal	4.10^{a}	.08	3.23^{a}	.05	3.67	2.28^{a}	.01	161	6.7^{a}	3.3	17.4^{a}	6.3
2.5 Tuna meal	4.16^{a}	.06	3.19^{a}	.05	3.68	2.46^{c}	.03	150	0^{a}		6.7^{a}	3.3
5 Tuna meal	4.16^{a}	.08	3.25^{a}	.01	3.71	2.41^{bc}	.02	154	3.3^{a}	3.3	6.7^{a}	6.7

[1] Values in any column bearing the same superscript are not significantly different.
[2] Standard error of the mean.
[3] Production efficiency $= \frac{\text{Average body weight x 100}}{\text{Feed/gain}}$

received 2.5 percent of tuna or meat meal, or at least equaled that of the control group in experiment 1, which did not receive any animal protein supplements.

Female Body Weight. The mean body weights of the females did not appear to follow any particular trend and none of the differences were significant. However, the group receiving 2.5 percent of Peruvian fish meal followed the same pattern as in experiment 1 and again had the lowest body weights of any of the treatment groups.

Feed Efficiency. The efficiency of feed utilization of the control group, which received 2.5 percent of Peruvian fish meal, was again the lowest of any of the treatment groups. Feed efficiency improved with the addition of 2.5 percent of meat or tuna meal to the ration and showed a further improvement when the level of the supplements was increased to 5 percent. The most efficient utilization of feed was obtained when 2.5 percent of each of the three protein supplements was included in the ration. The groups that received 2.5 and 5 percent of tuna meal as single supplements were slightly less efficient than the groups that received the same supplements in combination with 2.5 percent of Peruvian fish meal.

Mortality and Perosis. The mortality rate was slightly lower and the incidence of perosis somewhat higher in experiment 2 than in experiment 1. No consistent trends in either mortality or perosis were apparent. Although the incidence of perosis in the groups receiving 2.5 and 5 percent of tuna meal plus Peruvian fish meal was fairly high, it was low in the groups receiving only 2.5 or 5 percent of tuna meal.

Production Efficiency. The production efficiency (PE) index (table 4) effectively summarizes this experiment. There was little or no difference between the performance of the groups receiving either 2.5 or 5 percent of tuna or meat meal in combination with Peruvian fish meal, although the index was greater at the 5- than at the 2.5-percent level of supplementation. The PE indices for the groups fed 2.5 or 5 percent of tuna meal as the sole protein supplement were not greatly different from each other or from those receiving the combination of Peruvian fish meal with 2.5 percent of tuna or meat meal. The treatment with the highest PE value was the one in which 2.5 percent each of Peruvian fish, tuna meal, and meat meal was fed. The factor contributing most to this high PE value was the superior feed efficiency of this group.

Experiment 3

In experiment 1 various levels of tuna meal were compared with comparable levels of Peruvian fish meal and meat meal. In experiment 2 tuna meal was compared with meat meal at two levels of supplementation in rations containing 2.5 percent of Peruvian fish meal. In experiment 3 all

TABLE 5. Composition of rations used in experiment 3, percent by weight

INGREDIENTS	RATION NUMBER						
	19	20	21	22	23	24	25
Corn, ground	36.00						
Milo, ground	26.85						
Soybean meal (44% protein)	18.30						
Cottonseed meal (44% protein)	5.00		Same as Ration 19. This portion of the rations was premixed and constituted 90.4% of each ration.				
Alfalfa, dehydrated (20% protein)	2.50						
Defluorinated phosphate	1.00						
Salt	0.40						
Micro-ingredient mix[1]	0.25						
DL-methionine	0.10						
Premix	90.4	90.4	90.4	90.4	90.40	90.4	90.4
Milo, ground	1.3	0.7	1.0	—	0.25	1.8	2.1
Soybean meal (44% protein)	0.8	1.4	1.1	2.1	1.85	0.3	—
Tuna meal (54% protein)	5.0	—	2.5	2.5	5.00	—	2.5
Fish meal, Peruvian (65% protein)	2.5	2.5	2.5	—	—	5.0	5.0
Meat meal (50% protein)	—	5.0	2.5	5.0	2.50	2.5	—

[1]Supplied per pound of diet: Vitamin A, 1750 I.U.; Vitamin D_3, 500 I.C.U.; Vitamin E, 0.5 I.U.; Vitamin B_{12}, 2.5 mcg.; riboflavin, 1.5 mg.; d-pantothenic acid, 2.5 mg.; niacin, 10 mg.; choline chloride, 100 mg.; menadione sodium bisulfite, 0.25 mg.; B.H.T., 56.7 mg.; manganese, 27.2 mg.; iron, 9.08 mg.; zinc, 12.5 mg.; copper, 0.9 mg.; iodine, 0.55 mg.; and cobalt, 0.09 mg.

combinations of the three protein supplements were compared at the 2.5- and 5-percent levels. Table 5 shows the composition of the experimental diets and the experimental plan. All rations contained a total of 7.5 percent of crude animal protein in combinations of two or three of the supplements. Males and females were segregated in triplicate pens of 10 each per treatment.

Males. There were no statistically significant differences in male body weight, feed efficiency, mortality, or incidence of perosis (table 6). However, when the data were rearranged as shown in table 8 certain consistent trends became apparent. The average body weights of the treatment groups fed 5 percent of tuna meal were greater than those of the groups fed 5 percent of the other protein supplements. In addition, when the rations of the groups fed 5 percent of either Peruvian fish or meat meal also contained 2.5 percent of tuna meal, the body weights were greater than those of the groups fed 2.5 percent of either of the other supplements. The same general trend was true for feed efficiency.

There was no consistent trend with respect to mortality or incidence of perosis.

Females. The growth and other pertinent data for the female groups are summarized in table 7. The same general trend observed with the males may also be seen with the females in table 8. While there was some variation in feed conversion, the only deviation from the trend was in the treatment group receiving 5 percent of meat meal and 2.5 percent of tuna meal. In these cases, more feed was required per unit of gain.

The incidence of perosis was generally less in the females than in the males although the differences were not significant and there did not appear to be any trend.

For some unaccountable reason the mortality in the female group receiving 5 percent of Peruvian fish meal and 2.5 percent of tuna meal was significantly higher than in the other groups. It is difficult to understand the reason for this inasmuch as the groups receiving other combinations of these supplements had very low mortality rates.

In both sexes, the groups fed tuna meal in combination with Peruvian fish meal were slightly heavier than the groups fed the other combinations. The body weight of the groups that received the meat meal and Peruvian fish meal combinations was generally lowest, with the tuna meal and meat meal group being somewhat intermediate in value (table 8).

TABLE 6. **Mean 9-week body weight, feed efficiency, mortality, and incidence of perosis of crossbred male broiler chicks fed various combinations of tuna, meat, and Peruvian fish meal, experiment 3**

ANIMAL PROTEIN SUPPLEMENT (PERCENT)	BODY WT.		FEED/			MORTALITY		PEROSIS	
	LB.	S.E.[2]	GAIN	S.E.	PE[3]	%	S.E.	%	S.E.
5 Tuna, 2.5 Peruvian fish	4.65[a1]	.03	2.20[a]	.03	211	10.0[a]	5.8	7.9[a]	3.9
5 Tuna, 2.5 meat	4.52[a]	.06	2.16[a]	.04	209	6.7[a]	3.3	17.8[a]	9.7
5 Meat, 2.5 Peruvian fish	4.48[a]	.09	2.23[a]	.02	201	6.7[a]	6.7	3.3[a]	3.3
5 Meat, 2.5 tuna	4.52[b]	.06	2.18[a]	.03	207	3.3[a]	3.3	21.8[a]	17.1
5 Peruvian fish, 2.5 meat	4.53[a]	.05	2.20[a]	.04	206	6.7[a]	3.3	7.4[a]	7.4
5 Peruvian fish, 2.5 tuna	4.56[a]	.05	2.16[a]	.02	211	3.3[a]	3.3	21.1[a]	6.7
2.5 Tuna, 2.5 meat, 2.5 Peruvian fish	4.57[a]	.08	2.19[a]	.01	209	3.3[a]	3.3	10.0[a]	5.8

[1]Values in any column bearing the same superscript are not significantly different.
[2]Standard error of the mean.
[3]Production efficiency $= \frac{\text{Average body weight x 100}}{\text{Feed/gain}}$

TABLE 7. Mean 9-week body weight, feed efficiency, mortality, and incidence of perosis of crossbred female chicks fed various combinations of tuna, meat, and Peruvian fish meal, experiment 3

ANIMAL PROTEIN SUPPLEMENT (PERCENT)	BODY WT.		FEED/ GAIN	S.E.	P.E.[3]	MORTALITY		PEROSIS	
	LB.	S.E.[2]				%	S.E.	%	S.E.
5 Tuna, 2.5 Peruvian fish	3.58[a1]	.01	2.13[a]	.04	168	0[a]	0	3.3[a]	3.3
5 Tuna, 2.5 meat	3.59[a]	.04	2.11[a]	.05	170	3.3[a]	3.3	6.7[a]	6.7
5 Meat, 2.5 Peruvian fish	3.44[a]	.07	2.12[a]	.06	162	3.3[a]	3.3	0[a]	0
5 Meat, 2.5 tuna	3.49[a]	.04	2.22[a]	.01	157	0[a]	0	16.7[a]	8.8
5 Peruvian fish, 2.5 meat	3.48[a]	.03	2.12[a]	.01	164	0[a]	0	0[a]	0
5 Peruvian fish, 2.5 tuna	3.66[a]	.04	1.98[a]	.08	185	16.7[b]	3.4	3.3[a]	3.3
2.5 Tuna, 2.5 meat, 2.5 Peruvian fish	3.54[a]	.08	2.17[a]	.02	163	0[a]	0	0[a]	0

[1]Values in any column bearing the same superscript are not significantly different.
[2]Standard error of the mean.
[3]Production efficiency $= \frac{\text{Average body weight x 100}}{\text{Feed/gain}}$

TABLE 8. Summary[1] of body weight and feed conversion data grouped according to major supplement

	5% TUNA MEAL		5% PERUVIAN FISH MEAL		5% MEAT MEAL	
	2.5 P. Fish	2.5 Meat	2.5 Tuna	2.5 Meat	2.5 Tuna	2.5 P.Fish
Male Body Wt., Lb.						
	4.65	4.52	4.56	4.53	4.52	4.48
Mean	4.59		4.55		4.50	
Male Feed/Gain						
	2.20	2.16	2.16	2.20	2.18	2.23
Mean	2.18		2.18		2.21	
Female Body Wt., Lb.						
	3.58	3.59	3.66	3.48	3.49	3.44
Mean	3.59		3.57		3.47	
Female Feed/Gain						
	2.13	2.11	1.98	2.12	2.22	2.12
Mean	2.12		2.05		2.17	

[1]Data from tables 6 and 7.

SUMMARY

Three 9-week broiler experiments were conducted in which tuna meal, meat and bone meal, and Peruvian fish meal were compared as single supplements, as well as in various combinations. Commercial crossbred broiler chicks housed in wire-floor batteries were used in all experiments. Growth, feed efficiency, mortality, and incidence of perosis were used as criteria in evaluating the different supplements or combinations of supplements.

In most cases, the observed differences were not statistically significant. However, there were some general trends. When used as the sole source of animal protein in the ration 2.5 percent of tuna meal was equal to 2.5 percent of meat and bone meal and superior to 2.5 percent of Peruvian fish meal. At the 5-percent level, tuna meal was equal to Peruvian fish meal and superior to meat and bone meal. Ten percent of tuna meal was inferior to comparable levels of the other supplements.

In combination with 2.5 percent of Peruvian fish meal, 2.5 and 5 percent of tuna meal and meat and bone meal were approximately equal in nutritional value, with somewhat better results at the higher level of supplementation. The growth rate of the chicks receiving 2.5 or 5 percent of tuna meal alone was as good as those receiving 5 percent of either tuna or meat meal in combination with 2.5 percent of Peruvian fish meal although feed efficiency was not as good. The combination of 2.5 percent of all of the supplements resulted in the best efficiency in one but not the other experiment.

No significant differences in body weight, feed efficiency, mortality, or perosis were observed when all combinations of the three supplements were compared using 2.5 percent of one supplement and 5 percent of another. In general, however, there was a tendency toward improved performance when the combinations included 2.5 or 5 percent tuna meal.

From the results of these three experiments, it is concluded that 55 percent protein tuna meal is nutritionally equivalent to Peruvian fish meal and 50 percent protein meat meal when fed up to 5 percent in broiler rations.

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UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII
