# Effect of Different Combinations of Tuna Fishmeal, Meat Meal with Bone, and Soybean Meal upon Growth Rate and Utilization of Feed by Broilers in the Starting and Fattening Periods

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## INTRODUCTION

Commercial poultry feeds prepared in Puerto Rico are composed mainly of imported yellow corn and soybean meal.

Several tuna-processing plants have been established in Puerto Rico in recent years and about 40,000 tons of fishmeal result as a by-product. An Island rendering factory also produces a quantity of meat meal with bone. Tuna fishmeal and/or meat meal with bone may partially substitute soybean meal in poultry diets.

The objectives of this study were: 1, To determine maximum levels of tuna fishmeal and/or meat meal with bone that can be used in combination with soybean meal in starting and fattening diets for broilers without adversely affecting growth rate or feed utilization efficiency and 2, to determine the economical feasibility of developing diets using the maximum amount of locally-produced ingredients.

## LITERATURE REVIEW

Marvel *et al.* (*19*)[3] demonstrated the great variability in the chemical composition of commercial soybean meal samples. Almquist *et al.* (*1*) found that methionine is the first limiting amino acid of the diet based on a 20-percent, properly-processed soybean meal. Askelson and Balloun (*2*) reported that a corn-soybean diet for broilers was deficient in methionine, lysine and glycine. Halpin *et al.* (*12*), Van Landingham *et al.* (*29*), and Fisher *et al.* (*9*) reported that combinations of soybean meal with protein sources of animal origin were superior to diets based on soybean alone. Clark *et al.* (*8*) reported best results with a combination of soybean and low levels of fishmeal.

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[3] Italic numbers in parentheses refer to Literature Cited, pp. 549–50.

Summers *et al.* (*27*) concluded that chickens fed on soybean meal as the sole protein source grew twice as fast as those fed meat meal. They ascribe the poor results of the meat meal diet to its high calcium and phosphorus content. Twining *et al.* (*28*) reported phosphorus in excess of 0.80 percent in a broiler diet retarded growth rate and adversely affected the efficiency of feed utilization. Work recently completed by Runnels (*23*) demonstrates that a level as high as 10 percent of meat meal or 7.5-percent meat meal and 2.5-percent fishmeal caused no adverse effects even when the mineral portion was especially high.

March *et al.* (*17,18*) reported chickens receiving fishmeal grew considerably more than those on meat meals, even though both protein sources had the same approximate content of lysine. Growth rate was notably increased by supplementing the meat meal diets with L-lysine. This demonstrated lysine as the first limiting amino acid in meat meal, and that not all of the lysine present is available for digestion and assimilation.

Chickens on a meat meal diet supplemented with L-lysine and DL-methionine grew more than those on a diet fortified with L-lysine alone. This identified methionine as the second limiting amino acid in meat meal. The findings of Patrick (*22*) confirm this. Kratzer and Davis (*14*) concluded, however, that methionine is the first limiting amino acid in meat meal.

Several authors (*14,24,27*) reported a great variability in the chemical composition of meat meal samples due to differences in sources of prime matter and to lack of uniformity in processing, particularly in the temperatures employed. Gupta *et al.* (*11*), and Choppe and Kratzer (*7*) concluded that the high temperatures employed in processing meat meal lowers the biological value or availability of the protein fraction, and of lysine in particular.

Fishmeals are known to be good sources of essential amino acids, especially sulfur-containing ones, vitamins, calcium and phosphorus (*15,17,26*), although great variability in their chemical composition has been reported (*4,5,16*).

Fishmeal analyses from different species are at hand (*10,13,30*), but no systematic evaluation of tuna fishmeal has been located in the literature reviewed.

## MATERIALS AND METHODS

Nine combinations of soybean meal, tuna fishmeal, and meat meal with bone (diets 1 to 9, table 1) were evaluated during the starting period (study I), in a partially-balanced incomplete-block design using four replications of 25 birds each per diet. Chicks were housed in electrically-heated batteries during the first 2 weeks, after which time each 25-bird replication group was housed in a floor pen 1.22 X 2.44 m. in size.

Studies II and III (table 2) were completed during the fattening period. The birds in both studies were housed in floor pens 1.22 X 2.44 m. in size. In study II, two preliminary evaluations were conducted from the 7th to the 8th week of age (fattening period). Four combinations of soybean and meat meal (diets 10 to 13), and four combinations of soybean meal and tuna fishmeal (diets 14 to 17) were evaluated, using a completely randomized design with four treatments replicated twice, with 20 birds per replicate.

In study III, two evaluations were completed. In the first, birds weighing more than 680 g. used in a starting period experiment were randomized among the different replicates. In the second, all the birds were sorted at random when one-day old, and offered the same diet during the starting

TABLE 1.—*Average net gain and utilization of feed for starting study I*

| Diet | Percent composition of protein sources | | | Net gain[1] | Utilization[1] |
|---|---|---|---|---|---|
| *Number* | *Soybean* | *Tuna* | *Meat* | *Grams* | *Feed/gain ratio* |
| 6 | 10 | 20 | 0 | 773 a | 3.02 a |
| 4 | 20 | 10 | 0 | 714 ab | 2.75 a |
| 9 | 0 | 10 | 20 | 632 abc | 3.79 a |
| 8 | 10 | 0 | 20 | 618 abc | 3.69 a |
| 7 | 0 | 20 | 10 | 609 abc | 3.33 a |
| 5 | 20 | 0 | 10 | 573 bc | 2.42 a |
| 2 | 0 | 30 | 0 | 505 c | 3.42 a |
| 1 | 30 | 0 | 0 | 468 c | 2.79 a |
| 3 | 0 | 0 | 30 | 232 d | 10.18 b |

[1] Means followed by same letters do not differ significantly ($P < .05$).

period. In both evaluations six combinations of soybean meal, tuna fishmeal, and meat meal with bone (diets 18 to 23) were evaluated using a partially-balanced incomplete block design with six treatments replicated four times. Each replicate included nine birds.

A combined study IV (table 3) was conducted to further evaluate the possibility of substituting fishmeal with high quality meat meal (50-percent crude protein) in starting and fattening diets. Five combinations of tuna and meat meals were evaluated using a random complete-block design with five treatments, replicated four times. The birds received the same proportion of protein sources in both the starting (0 to 5th week) and fattening (6th to 7th week) periods within both the starting and the fattening periods. All diets were equalized in nitrogen, calories, calcium, and phosphorus. The maximum levels of tuna and meat meals that were used in the diets were limited by their calcium content so as not to surpass the 1-percent calcium tolerance level for birds.

Vantress-Pilch chicks were used in all studies conducted at the Main Station (Río Piedras). Feed and water were offered free choice in all studies. Growth rate and utilization of feed were used as the criteria for com-

TABLE 2.—*Average net gain and utilization of feed during the fattening period*

| Diet number | Percent composition of protein sources | | | Net gain[1]—grams | Utilization[1]—feed/gain ratio |
|---|---|---|---|---|---|
| | Soybean | Meat | Tuna | | |
| | | | *Study II A* | | |
| 10 | 30 | 0 | 0 | 659 a | 2.54 a |
| 11 | 20 | 10 | 0 | 659 a | 2.59 a |
| 12 | 10 | 20 | 0 | 582 a | 2.94 b |
| 13 | 0 | 30 | 0 | 445 b | 3.56 c |
| | | | *Study II B* | | |
| 14 | 30 | 0 | 0 | 559 a | 2.71 a |
| 15 | 20 | 0 | 10 | 573 a | 2.74 a |
| 16 | 10 | 0 | 20 | 541 a | 2.86 ab |
| 17 | 0 | 0 | 30 | 518 a | 3.12 b |
| | | | *Study III A* | | |
| 21 | 12 | 12 | 0 | 426 a | 3.80 a |
| 18 | 24 | 0 | 0 | 418 a | 3.58 a |
| 22 | 12 | 0 | 12 | 395 ab | 4.02 a |
| 23 | 0 | 12 | 12 | 391 ab | 4.70 a |
| 19 | 0 | 24 | 0 | 327 b | 4.74 a |
| 20 | 0 | 0 | 24 | 241 c | 6.38 b |
| | | | *Study III B* | | |
| 21 | 12 | 12 | 0 | 482 a | 3.44 a |
| 18 | 24 | 0 | 0 | 477 a | 3.35 a |
| 23 | 0 | 12 | 12 | 454 a | 3.42 a |
| 22 | 12 | 0 | 12 | 436 a | 3.78 ab |
| 19 | 0 | 24 | 0 | 332 b | 4.58 bc |
| 20 | 0 | 0 | 24 | 305 b | 5.42 c |

[1] Means followed by the same letters do not differ significantly ($P < .05$).

parison. The statistical evaluation of the data was based on the methods of Bose *et al.* (*6*), Snedecor (*25*), and Zelem (*31*), using the program developed by the Statistical Section for Computers 1620 and 1130. The basal diets used in these studies are described in table 4.

## RESULTS AND DISCUSSION

The data corresponding to the starting period is shown in table 1. In study I, the group receiving meat meal as the only protein source (diet 3)

TABLE 3.—*Average net gain, utilization of feed, and comparative feed costs of the different diets used in the studies conducted during the starting, fattening, and combined periods in study IV*

| Diet number | Percent composition of protein sources | | | Net gain[1]—grams | Cost per pound of feed[2]—cents | Utilization[1]—feed/gain ratio | Feed cost per pound produced[3]—cents |
|---|---|---|---|---|---|---|---|
| | Soybean | Tuna | Meat | | | | |
| | | | *Starting period* | | | | |
| 24 | 21.9 | 12.0 | 0.0 | 817 a | 5.79 | 1.87 a | 10.83 |
| 25 | 22.2 | 9.0 | 3.0 | 813 a | 5.76 | 1.86 a | 10.71 |
| 26 | 22.5 | 6.0 | 6.0 | 795 ab | 5.73 | 1.93 a | 11.06 |
| 27 | 22.7 | 3.0 | 9.0 | 804 ab | 5.69 | 1.75 a | 9.96 |
| 28 | 23.0 | 0.0 | 12.0 | 763 b | 5.66 | 1.90 a | 10.76 |
| | | | *Fattening period* | | | | |
| 29 | 13.1 | 11.0 | 0.0 | 395 b | 5.15 | 2.40 a | 12.36 |
| 30 | 13.4 | 8.3 | 2.8 | 427 a | 5.12 | 2.29 a | 11.73 |
| 31 | 13.7 | 5.5 | 5.5 | 409 a | 5.09 | 2.44 a | 12.42 |
| 32 | 13.9 | 2.8 | 8.3 | 400 b | 5.06 | 2.50 a | 12.66 |
| 33 | 14.2 | 0.0 | 1.0 | 400 b | 5.04 | 2.29 a | 11.54 |
| | | | *Combined periods—starting and fattening* | | | | |
| 24/29[4] | 22/13[4] | 12/11[4] | 0/0[4] | 1212 a | 5.56 | 2.04 a | 11.34 |
| 25/30 | 22/13 | 9/8 | 3/3 | 1240 a | 5.50 | 2.01 a | 11.06 |
| 26/31 | 23/14 | 6/6 | 6/6 | 1204 a | 5.46 | 2.11 a | 11.52 |
| 27/32 | 23/14 | 3/3 | 9/8 | 1204 a | 5.43 | 2.00 a | 10.85 |
| 28/33 | 23/14 | 0/0 | 12/11 | 1163 a | 5.43 | 2.03 a | 11.02 |

[1] Means followed by the same letters do not differ significantly ($P < .05$).

[2] Based on values calculated using average prices paid by the Agricultural Experiment Station during 1967 for the ingredients used in preparing all diets, plus $0.50 for mixing and handling costs. The commercial equivalent costs $6.30 and $6.08 per hundredweight for the starting and growing mashes, respectively.

[3] Obtained by multiplying the efficiencies by the values described under average cost per pound of feed.

[4] Starting/fattening.

had the poorest performance. The results agree with the work of Choppe and Kratzer (*7*), Gupta (*11*), and March *et al.* (*17*). The overall growth rate of the groups receiving a combination of protein sources (diets 4 to 9) was superior to that of those receiving single sources (diets 1 to 3). These findings agree with the work of Clark *et al.* (*8*) and Van Landingham *et al.* (*29*). Among the different diet combinations, the ones consisting of soybean and tuna fishmeal (diets 4 and 6) were superior, on the basis of weight gained.

The results obtained during the fattening period are shown in table 2. The lack of agreement as to the nutritional value of the protein sources

TABLE 4.—*Basal broiler diets used during the starting and fattening periods of studies I thru IV*[1]

| Ingredients | Composition of diets, percent | |
|---|---|---|
| | Starting studies I and IV | Fattening studies II, III and IV |
| Corn, Dent No. 2, ground | 66.0 | 71.5 |
| Combination of protein sources[2] | 30.0 | 24.0 |
| Soybean meal | | |
| Tuna fishmeal | | |
| Meat meal | | |
| Animal fat, stabilized | .0 | 3.5 |
| Skimmed milk, dried | 2.0 | .0 |
| Dicalcium phosphate | .5 | .0 |
| Limestone, feed grade | .5 | .0 |
| NaCl | .5 | .5 |
| Premix[3] | .5 | .5 |

[1] All ingredients and the mixed diet were analyzed following the methods of the A.O.A.C. (*3*). The ingredients were adjusted following the analyses and tabulated values (*21*) to meet the minimum requirements for calcium, phosphorus, methionine and choline set by the National Research Council (*20*).

[2] For specific combinations of soybean, tuna and meat meals see tables 1, 2, and 3. The tuna fishmeal was obtained from a Mayagüez tuna processing plant, while the meat meal was obtained from a rendering plant at Trujillo Alto.

[3] Contains 0.0006 vitamin A/$D_2$ (500,000/100,000 I.U./g.); 0.0002 riboflavin; 0.0005 calcium pantothenate; 0.0020 niacin; 0.0250 manganese sulfate (75 percent); 0.1000 choline chloride (25 percent); 0.0750 coccidiostat (Amprolium); 0.1700 terramycin (7.7 g. oxytetracycline and 5.5 mg. vitamin $B_{12}$/kg.). No coccidiostat was used in the fattening period.

used in studies II A and II B suggested the convenience of conducting a study including all combinations simultaneously during a standard period of comparison. Studies III A and III B were designed with these purposes in mind.

The results of evaluations A and B in study III (table 2) agree markedly. When weight gain was used as the criterion of comparison, the ranking of the experimental groups of both studies coincided, except for groups 22 and 23 which switched places.

A combination of soybean and tuna fishmeal (diet 21) gave the best results under our conditions. This agrees with our findings during the starting period (study I, diets 6 and 4). The poor results obtained during the fattening period with the diets based on meat (diet 20) and fishmeal (diet 19) alone confirmed our findings from preliminary evaluations (study II, diets 13 and 17).

The observations with combinations of meat meal with soybean (diet 22) and tuna (diet 23) meals may have an explanation on the poor availability of lysine present in both diets as reported by Choppe and Kratzer (*7*), Gupta (*11*) and March *et al.* (*17*).

The results obtained in the combined study are described in table 3. The data were calculated and evaluated separately for the starting and fattening periods, then combined. There were no statistical differences in the combined data in either of the criteria evaluated. There were no significant differences in utilization of feed either during the initial, the fattening, or the combined periods. When net gain was used as the criterion for comparison, there were some significant differences in the starting and fattening periods. Diets 24 and 25 were superior ($P < .05$) during the starting period, and diet 30 ($P < .01$) during the fattening period. When the overall or combined gain was used, however, the partial differences were cancelled. These results demonstrate that satisfactory performance was achieved with either combination when balanced diets containing high quality meat meal with bone were used (at least 50-percent crude protein and a calcium content below 10 percent) and the 1-percent calcium tolerance level of the birds was not exceeded. When a total substitution of the tuna fishmeal by a high quality meat meal was made (diet 28, combination 28/33, table 3), the growth rate was consistently poorer in the starting and total periods than in the groups receiving other combinations.

It is worth mentioning that although the tuna fishmeal samples used in this study contained 7.49 percent calcium the average values reported for tuna meals is 5.30 percent. This points out the great variability encountered when using different samples of tuna meals in nutritional studies such as those reported herein.

The cost of the different diets evaluated are described in table 3. As the level of meat meal increased, the cost per unit of feed decreased in both the starting ($5.79 to 5.66) and the fattening ($5.15 to 5.04) periods. Although meat meal costs $90.00/ton, or approximately $50.00/ton less than tuna fishmeal, and both contain approximately 50-percent crude protein, erratic feed utilization results reduced the apparent economical advantages of the low cost rations, which in the case of the combined periods, diet 26/31, resulted in the highest feed cost per pound of liveweight produced.

Quality and availability of amino acids are affected by processing meat meal. Particular care thus should be used in the selection of meat meal because this ingredient is more variable than many others on the market. It is not only important to produce least-cost rations by using the maximum amount permissible of the lowest cost ingredients, but the diet so formulated must maintain proper rate of growth and efficiency of conversion in the animals receiving it.

The amount of sodium chloride in tuna fishmeal has not been taken into consideration in most nutritional studies. Commercial laboratories report that tuna fishmeal on the average contains 1 percent of sodium chloride. Our laboratory results give an average value of 0.47 percent. When the reported commercial values are used, the maximum level of tuna fishmeal used in our study provided only 0.12 percent of sodium chloride to the diet which, together with the 0.50 routinely added, caused no apparent adverse effect as determined by lack of wet feces typical when excess salt is in the diets.

## SUMMARY

Four studies of six evaluations were conducted during the starting and fattening periods of broiler chicks. Different combinations of soybean meal, tuna fishmeal, and meat meal were evaluated. Net gain in weight and feed utilization were used as criteria for comparison.

Proportions from 2:1 to 1:2 of soybean and tuna fishmeals gave best results in preliminary screening studies. In successive studies, when diets were equalized as to nitrogen, calories, phosphorus, and calcium, in which the latter did not exceed the 1-percent tolerance level, high quality meat meal containing 50-percent crude protein satisfactorily substituted up to 75 percent of the tuna fishmeal in the diets without adversely affecting the overall performance of the birds. The amount of sodium chloride supplied by the highest level of tuna fishmeal used in this study did not cause apparent adverse effects.

## RESUMEN

Se efectuaron cuatro estudios en el que se hicieron seis evaluaciones durante el período inicial y el de engorde de aves para asar. Se evaluaron diferentes combinaciones de harinas de soja, atún y carne usando como criterios de comparación la ganancia neta en peso y la utilización del alimento.

Las combinaciones de harina de soja y de atún en proporciones de 2:1 a 1:2 dieron los mejores resultados en los estudios preliminares. En estudios posteriores, cuando se evaluaron dietas de similar contenido de nitrógeno, calorías, fósforo y calcio, en las que este último no excedió la tolerancia máxima del 1 por ciento, la harina de carne de buena calidad con un con-

tenido proteico de 50 por ciento sustituyó hasta el 75 por ciento de la harina de atún, sin afectar adversamente el ritmo de crecimiento ni la utilización del alimento. La cantidad de cloruro de sodio suministrado por el alto nivel de harina de atún que se usó en nuestras dietas, aparentemente no tuvo efectos adversos en las aves.

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