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Broiler Production with High-Protein Feeds

By H. D. POLK and C. E. BARNETT

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BROILER PRODUCTION WITH HIGH-PROTEIN FEEDS

By H. D. POLK and C. E. BARNETT
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The production of broilers has increased rather rapidly in Mississippi during recent years. At several production centers, markets and other facilities have been provided, and relatively large numbers of broilers are being produced. In addition, numerous persons are producing broilers in lots of 50 to 100 for home use. In view of the meat scarcity and of war needs for food, it is believed that broiler production may be further and more rapidly increased.

To an extent greater, perhaps, than any other phase of animal production, proper feeding is important in broiler production. Beef cattle, dairy cattle, hogs, and sheep may be produced at least fairly satisfactorily by the use of simple feed mixtures containing few ingredients and most of them home-grown. For successful broiler production, a variety of feed ingredients is necessary, many of which are not home-grown. Adding further to the difficulty, many of the commonly recommended sources of protein are high in cost and are not carried in stock except by the larger feed supply stores.

There are numerous high-protein sources on the market, both animal and vegetable. Those of animal origin include meat scraps, fish meal, shrimp meal (sun-dried and machine-dried), and the various milk by-products, either whole or concentrated by dehydration. High-protein feeds of vegetable origin include cottonseed meal, linseed meal, peanut meal, and soybean meal.

Of the high-protein feeds, only cottonseed meal is readily available to farmers throughout Mississippi. In addition to its widespread availability, cottonseed meal is usually the cheapest protein concentrate available, and its high efficiency as a sole or major source of protein has been well established in feeding both dairy and beef animals. In the case of poultry, and especially for broiler production, cottonseed meal is usually recommended as one of several sources of protein and to supply only a part of the protein in the poultry ration.

Due, perhaps, to its low cost, its availability, and the general familarity with its efficient use as a principal source of protein for cattle, the question is often asked: "If I can replace part of the animal protein for chicks with cottonseed meal, why can't I feed all cottonseed meal?"

The Mississippi Station and other experiment stations have fed cottonseed meal to poultry of all ages, and with good results. But it has not been recommended that cottonseed meal be used to replace all of the animal protein or to supply all of the protein supplement in the poultry ration.

In view of the increasing importance of broiler production, it seemed desirable to conduct a series of experiments in which a number of feed mixtures might be tested at various seasons of the year. The poultry department of the Mississippi Station, therefore, set up in 1940 a test to utilize and measure the value of available high-protein feed sources for supplementing commonly-used sources of carbohydrates in chick rations, so that farmers desiring to home-mix poultry feeds might have a rather definite idea of results to be expected.

Since the purpose of this experiment was to determine the efficiency of protein sources available to Mississippi poultrymen for home-mixing chick rations, all the feed materials used were similar in proportions except the high-protein sources. Proteins added to the

basic feed mixtures were obtained from cottonseed meal, soybean meal, meat scraps, and shrimp meals. The formulas are given in table 1.

Rations Used in Test

In all of the seven rations tested, yellow corn meal, wheat shorts, ground whole oats, alfalfa leaf meal, and cod-liver oil were used; and wheat bran, dried skim milk, and salt were used in six of the seven rations. Oystershell flour and steamed bonemeal were used to supply minerals where needed, and while the feed ingredients listed were used in rather uniform quantities, there were some variations due to the difference in constituency of the protein sources, to the end that all of the rations were properly balanced. The principal difference throughout was in the high-protein source.

Ration 1 included machine-dried shrimp meal 10 percent and cottonseed meal 9 percent as the high-protein sources.

Ration 2 included cottonseed meal 22 percent as the sole high-protein source.

Ration 3 included sun-dried shrimp meal 19 percent as the sole high-protein source.

Ration 4 included soybean oil meal 22 percent as the sole high-protein source.

Ration 5 included meat scraps 17 percent as the sole high-protein source.

Ration 6 included machine-dried shrimp meal as the sole high-protein source.

Ration 7 included machine-dried shrimp meal 12 percent, soybean oil meal 5 percent, and cottonseed meal 8 percent, as high-protein sources.

Chemical analyses of the various rations used during the three feeding periods are shown in table 2.

It should be noted from the chemical analyses that the shrimp meals, when used with the other ingredients, carry sufficient minerals and at the proper ratio for normal devolpment of chicks. It should also be noticed that phosphorus and calcium in the meat scraps (ration 5) were considerably higher than in the other rations but approached the desired ratio of two parts calcium to one part phosphorus. It was necessary to add manganese sulphate to the meat scraps ration in the spring and summer of 1942 to prevent perosis or slipped tendons.

At the beginning of the experiment, dried milk was purchased at a cost of approximately 4 cents per pound, but in the spring and summer of 1942 dried

Table 1. Composition of rations used in the experiments.

Feeds	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6	Ration 7
Yellow corn meal	36.5	34.5	38.5	34.5	38.5	38.5	38.0
Wheat bran	10.0	10.0	10.0	10.0	10.0	10.0	—
Wheat shorts	10.0	10.0	10.0	10.0	10.0	10.0	12.0
Ground whole oats	10.0	10.0	10.0	10.0	10.0	10.0	15.0
Dried skim milk	7.5	7.5	7.5	7.5	7.5	7.5	—
Shrimp meal, sun-dried	—	—	19.0	—	—	—	—
Shrimp meal, machine-dried	10.0	—	—	—	—	17.0	12.0
Soybean oil meal	—	—	—	22.0	—	—	5.0
Cottonseed meal	9.0	22.0	—	—	—	—	8.0
Meat scraps	—	—	—	—	17.0	—	—
Alfalfa leaf meal	7.5	7.5	7.5	7.5	7.5	7.5	10.0
Oystershell flour	—	2.5	—	2.5	—	—	—
Steamed bonemeal	—	1.0	—	1.0	—	—	—
Manganese sulphate	—	—	—	—	2.5	—	—
					grams		
Salt	.5	.5	—	.5	.5	.5	.5
Cod-liver oil	.5	.5	.5	.5	.5	.5	.5

Table 2. Chemical analyses of rations used in three poultry-feeding experiments.

Series 1, fed in spring of 1941.

Nutrients	Chemical analysis of rations				
	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5
	%	%	%	%	%
Moisture	8.20	7.76	8.64	8.50	7.50
Crude fiber	6.07	5.31	4.26	4.19	4.06
Crude fat	4.70	5.23	4.30	4.85	6.20
Ash	7.53	6.60	8.54	6.95	9.15
Protein	21.56	19.94	20.81	20.31	20.19
Nitrogen-free extract	51.94	55.16	53.45	55.20	52.90
Calcium	1.35	1.54	1.55	1.67	2.08
Phosphorus	.81	.88	.77	.71	1.09

Series 2, fed in winter of 1941-1942.

Nutrients	Chemical analysis of rations						
	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6	Ration 7
	%	%	%	%	%	%	%
Moisture	8.55	8.16	9.33	8.27	8.15	7.71	7.87
Crude fat	5.01	4.87	4.78	4.35	5.77	4.70	4.65
Crude fiber	5.66	5.08	5.23	4.51	3.69	6.06	7.23
Ash	7.16	8.42	8.80	7.46	10.08	8.17	6.71
Protein	21.44	21.81	20.88	22.00	21.50	20.94	19.88
Nitrogen-free extract	52.18	51.66	50.98	53.41	50.81	50.42	53.66
Calcium	1.21	1.73	1.54	1.68	1.97	1.88	1.31
Phosphorus	.78	.93	.77	.79	1.34	.84	.66

Series 3, fed in summer of 1942.

Nutrients	Chemical analysis of rations						
	Ration 1	Ration 2	Ration 3	Ration 4	Ration 5	Ration 6	Ration 7
	%	%	%	%	%	%	%
Moisture	8.74	8.27	9.81	8.20	8.11	7.93	7.91
Crude fat	5.13	4.98	4.62	4.79	5.94	4.91	4.70
Crude fiber	7.28	6.07	6.78	5.89	5.17	7.41	8.40
Ash	6.36	7.14	8.45	6.97	8.67	7.60	6.49
Protein	18.81	19.63	18.94	19.88	21.19	20.81	20.06
Nitrogen-free extract	53.68	53.91	51.40	54.27	50.92	51.34	52.44
Calcium	1.17	1.55	1.66	1.62	1.91	1.85	1.35
Phosphorus	.80	.90	.89	.77	1.26	.79	.73

milk was more than double the cost during the first series, selling for an average of 10 cents per pound. Therefore, dried milk was not included in ration 7, for the purpose of determining whether a saving could be made in feed cost by eliminating milk without adversely affecting the condition and growth of the chicks.

Shrimp meal is a by-product of the shrimp-packing industry. It consists of shrimp hulls, which are dried by two different processes, and ground. Shrimp hulls dried in the sun are commonly salted; and the use of salt for the purpose of preservation increases the salt content of sun-dried shrimp hulls to around 9 percent and the content of crude protein is thereby reduced to around 45 percent. In machine-dried shrimp meal the dehydration is done by heat artificially applied, and no salt is used; the salt content of machine-dried shrimp meal is approximately 2 percent, and the average content of crude protein is 50 percent. Because of these differences, both sun-dried and machine-dried shrimp meals were included in the comparisons.

Granite grit was made available to the chicks throughout each series of the test.

Methods of Handling Chicks

The chicks used in this experiment were hybrids, New Hampshire males x White Leghorn females. Both the New Hampshire male parents and the White Leghorn female parents of the chicks were from stock with trap nest records of 200 eggs or better.

Fifty chicks were used in each of the five lots fed during the spring of 1941 and in the seven lots fed during the winter of 1942. The number was reduced to 30 chicks during the summer series, due to hot weather and to prevent crowding.

All chicks were grown in starting batteries to 4 weeks of age. The batteries were heated by natural gas burners stationed in the center of each compartment of the battery, and heat was thus supplied as long as it was necessary for the chicks to receive heat. At 4 weeks of age, the chicks were transferred to finishing batteries located in the same battery room and held there for the duration of the experiment.

The chicks were weighed individually at the beginning of the test and weekly thereafter for a period of 9 weeks. A weekly record was kept of feed consumption, mortality, mineral and nutritional deficiencies, feather picking, and condition of birds. At no period of the experiment were artificial lights used.

Feed materials used in mixing the rations were purchased from local feed stores in most cases; however, it was necessary to place special orders for some of the feed materials. All rations were calculated from average chemical analyses for feed nutrients, minerals, and vitamins. The chemical analyses established by Titus in the authoritative book, "Scientific Feeding of Chickens" (1941), were used to calculate and properly balance the rations. The feed

Figure 1. Equipment used in brooding experimental chicks.

materials in each ration were carefully weighed and were mixed in a power-driven feed mixer. Rations used in each series of the experiment were analyzed by the chemical department of the Experiment Station, as shown in table 2. The high-protein source, or sources, of each ration was calculated and supplied in such quantity as to give a ration carrying approximately 21 percent protein.

Altogether, the experiment consisted of three series, conducted during three separate periods. Five lots of 50 chicks each were fed on 5 rations in the spring of 1941; 7 lots of 50 chicks each were fed on 7 rations in the winter of 1942; and 7 lots of 30 chicks each were fed on 7 rations in the summer of 1942.

Results of the feeding experiments are shown in tables as follows: table 3-A, series 1, fed in spring of 1941; table 3-B, series 2, fed in winter of 1941-1942; and table 3-C, series 3, fed in the summer of 1942.

Results of First Series: Chicks Fed Spring of 1941

For the first series, consisting of 5 lots of 50 chicks each, detailed results are shown in table 3-A. Mortality records show one chick lost by death from the soybean oil meal lot, two chicks lost from the meat scraps lot, two chicks lost from the cottonseed meal lot, three chicks lost from the machine-dried shrimp meal plus cottonseed meal lot, and five chicks lost from the sun-dried shrimp meal lot.

Chicks receiving sun-dried shrimp meal as the sole high-protein source (ration 3) weighed slightly less at the end of the test than those on ration 1, but

Table 3-A. Summary of results of feeding sun-dried shrimp meal, cottonseed meal, soybean oil meal, and meat scraps as high-protein sources in rations for chicks from 1 to 9 weeks of age during January, February, and March, 1941.

Rations	Ration 1 Machine-dried shrimp meal 10 lbs. C. S. meal 9 lbs.	Ration 2 Cotton-seed meal 22 lbs.	Ration 3 Sun-dried shrimp meal 19 lbs.	Ration 4 Soybean oil meal 22 lbs.	Ration 5 Meat scraps 17 lbs.
Number of birds	50.00	50.00	50.00	50.00	50.00
Mortality	3.00	2.00	5.00	1.00	2.00
Feed consumed in lbs.	287.81	308.29	274.25	309.90	287.98
Feed consumed per bird	6.12	6.42	6.09	6.32	6.00
Feed per lb. of gain	2.90	3.06	2.71	2.95	2.72
Feed cost per 100 lbs.	2.18	2.10	2.25	2.14	2.20
Cost per lb. of gain	6.32	6.62	6.10	6.31	5.98
Number of males	24.00	17.00	22.00	22.00	22.00
Av. wt. of males, ozs.	36.43	31.49	35.47	35.04	30.69
Number of females	23.00	31.00	23.00	27.00	26.00
Av. wt. of females, ozs.	30.90	26.31	30.74	29.64	27.94
Av. wt. all chicks, ozs.	33.74	28.14	33.05	32.06	29.02
Slipped tendons	1.00	1.00	0.00	2.00	18.00
Rejects	1.00	2.00	0.00	2.00	10.00

Table 3-B. Summary of results of feeding sun-dried shrimp meal, machine-dried shrimp meal, cottonseed meal, soybean oil meal, and meat scraps as high-protein sources in rations for chicks from 1 to 9 weeks of age during March, April, and May, 1942.

Rations	Ration 1 Machine-dried shrimp meal 10 lbs. C. S. meal 9 lbs.	Ration 2 Cotton-seed meal 22 lbs.	Ration 3 Sun-dried shrimp meal 19 lbs.	Ration 4 Soybean oil meal 22 lbs.	Ration 5 Meat scraps 17 lbs.	Ration 6 Machine-dried shrimp meal 17 lbs.	Ration 7 Mch.-dried shrimp meal 12 lbs. soy-bean meal 5 lbs. cot-tonseed meal 8 lbs.
Number of birds	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Mortality	0.00	0.00	1.00	1.00	0.00	1.00	0.00
Feed consumed in lbs.	322.75	294.50	307.50	293.50	286.00	289.00	324.00
Feed consumed per bird	6.46	5.89	6.28	5.88	5.72	5.90	6.48
Feed per lb. of gain	3.10	3.18	3.20	2.96	2.77	2.80	3.30
Feed cost per 100 lbs.	2.84	2.83	2.89	2.83	2.95	2.90	2.34
Cost per lb. of gain	8.83	9.00	9.25	8.36	8.17	8.12	7.72
Number of males	31.00	27.00	25.00	23.00	24.00	21.00	30.00
Av. wt. of males, ozs.	36.14	37.54	34.95	34.99	35.22	36.51	33.80
Number of females	19.00	23.00	24.00	26.00	26.00	28.00	20.00
Av. wt. of females, ozs.	28.71	26.23	27.69	29.90	28.60	31.35	27.88
Av. wt. all chicks, ozs.	33.33	29.64	31.39	31.84	31.77	33.56	31.43
Slipped tendons	0.00	5.00	0.00	2.00	0.00	0.00	0.00
Rejects	0.00	2.00	0.00	2.00	0.00	2.00	2.00

Table 3-C. Summary of results of feeding sun-dried shrimp meal, machine-dried shrimp meal, cottonseed meal, soybean oil meal, and meat scraps as high-protein sources in rations for chicks from 1 to 9 weeks of age during July, August, and September, 1942.

Rations	Ration 1 Machine-dried shrimp meal 10 lbs. C. S. meal 9 lbs.	Ration 2 Cotton-seed meal 22 lbs.	Ration 3 Sun-dried shrimp meal 19 lbs.	Ration 4 Soybean oil meal 22 lbs.	Ration 5 Meat scraps 17 lbs.	Ration 6 Machine-dried shrimp meal 17 lbs.	Ration 7 Mch.-dried shrimp meal 12 lbs. soy-bean meal oil 5 lbs. cot-tonseed meal 8 lbs.
Number of birds	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Mortality	1.00	1.00	2.00	1.00	1.00	2.00	2.00
Feed consumed in lbs.	154.25	144.00	146.00	154.25	145.00	176.25	154.25
Feed consumed per bird	5.23	4.88	5.09	5.22	4.94	6.03	5.34
Feed per lb. of gain	2.97	3.20	3.08	3.05	3.01	3.40	2.95
Feed cost per 100 lbs.	2.98	2.91	3.19	2.91	3.26	3.08	2.59
Cost per lb. of gain	8.85	9.31	9.67	8.87	9.80	10.47	7.64
Number of males	11.00	12.00	16.00	12.00	10.00	13.00	13.00
Av. wt. of males, ozs.	31.80	26.58	28.38	31.25	29.78	33.13	31.63
Number of females	18.00	17.00	12.00	17.00	19.00	15.00	15.00
Av. wt. of females, ozs.	26.22	22.38	24.11	24.56	24.42	24.27	27.02
Av. wt. all chicks, ozs.	28.34	24.12	26.55	27.33	26.27	28.38	29.16
Slipped tendons	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rejects	0.00	0.00	0.00	2.00	0.00	0.00	0.00

weighed more than the chicks on other rations in the test. The chicks on ration 3 had the lowest requirement of feed per pound of gain, though the difference between rations 3 and 5 in this respect was not significant. The cost per pound of gain for this lot was slightly higher than that of lot 5 but lower than any of the other three lots.

Ration 1, the check lot in which machine-dried shrimp meal plus cottonseed meal were used as the high-protein sources, produced the largest chicks in this series, but slightly more feed was consumed per pound of gain than in rations 3 and 5; and gains were made at a slightly larger cost per pound of gain than rations 3, 4, and 5.

Chicks on ration 5, receiving meat scraps as a sole high-protein source, averaged in weight only slightly more than the lowest or cottonseed meal group, and were exceeded in weight by the other three groups. Feed consumed per pound of gain was less in three of the four remaining groups. The cost per pound of gain was lowest for the meat scraps group. However, slipped tendons affected 18 birds, and 10 birds were rejects, in this group of 50 chicks.

Chicks receiving soybean oil meal as the sole high-protein source (ration 4) averaged in weight at the end of the test slightly less than those receiving rations 1 and 3 but somewhat more than those receiving rations 2 and 5. The cost per pound of gain was the second lowest of the five lots. Two birds in this group of 50 were affected by slipped tendons, and 2 were rejects.

Chicks receiving ration 2, in which cottonseed meal was the sole source of high protein, were the lightest of the five groups at the end of the test, consumed more feed per pound of gain than any other group, and made gains at the highest cost per pound of any of the five groups.

In this series, it was observed that three chicks which died in the sun-dried shrimp meal lot had their abdominal cavities filled with a yellowish fluid. Record, Bethke, Wilder, and Kennard reported in 1930 a similar condition from

feeding shrimp meals. These workers also report leg weakness in chicks on this feed.

Notwithstanding the difficulties mentioned, it appears that best results in this series were secured from the sun-dried shrimp meal as the sole high-protein source. It appears also that the poorest results were received from the cottonseed meal lot. However, the combination of machine-dried shrimp meal and cottonseed meal (ration 1) as high-protein sources gave generally favorable results.

Results of Second Series: Chicks Fed Winter of 1941-42

In the first series of the tests recorded above, no comparison was made of machine-dried shrimp meal as a sole high-protein source, and ration 6 was added to provide such a comparison. Also, due to scarcity and high cost of dried milk, this material was omitted from ration 7, and chicks on this ration received protein from a combination of machine-dried shrimp meal, soybean oil meal, and cottonseed meal.

Ration 7 was designed for an all-purpose ration. Therefore, it was simplified as much as possible to reduce cost and numbers of feed materials used.

Machine-dried shrimp meal (ration 6) produced chicks weighing an average of 33.56 ounces, which was high for series 2, although there was little advantage in final weights over ration 1. Detailed results are shown in table 3-B. In feed per pound of gain, chicks on ration 6 were about average, but these chicks were next to the lowest in cost per pound of gain.

Cottonseed meal chicks (ration 2) again were lowest as in series 1, averaging only 29.64 ounces per chick; in addition to lightest weight, the cottonseed meal chicks were next to the highest in cost per pound of gain.

The meat scraps lot (ration 5) soybean oil meal lot (ration 4), and the sun-dried shrimp meal lot (ration 3) were approximately equal in final weight, being somewhat lighter than chicks receiving rations 1 and 6 and somewhat heavier than chicks receiving ration 2. The sun-dried shrimp meal lot cost 9.25 cents per pound of gain, the soybean oil meal lot 8.36 cents, and the meat scraps lot 8.17 cents.

Chicks receiving ration 1, with proteins derived from sun-dried shrimp meal and cottonseed meal were very slightly exceeded in final weight by those receiving ration 6, and more economical gains were made by chicks on rations 4, 5, 6, and 7.

Chicks on ration 7, in which protein was derived from 12 pounds of machine-dried shrimp meal plus 5 percent soybean oil meal plus 8 percent cottonseed meal, were slightly exceeded in weight by chicks on rations 1, 4, 5, and 6, and consumed more feed per pound of gain than any other lot in the test. However, ration 7 cost considerably less per 100 pounds of feed, and gains were made at the lowest cost of any of the lots.

In this, the spring series, mortality was very low and did not exceed 4 percent with any ration. Slipped tendons accounted for 10 percent of the cottonseed meal chicks. It is interesting to note that by adding 2.5 grams of manganese sulphate, perosis (which accounted for 18 chicks or 36 percent of the chicks in the previous test) was completely eliminated. Two chicks on ration 3 (sun-dried shrimp meal) died, and it was observed that their abdominal cavities were filled with a yellowish fluid; two additional chicks exhibited symptoms of the same condition but overcame this condition in about 14 days.

Results of Third Series: Chicks Fed Summer of 1942

The summer series in this broiler feeding experiment was conducted during the months of July and August and the

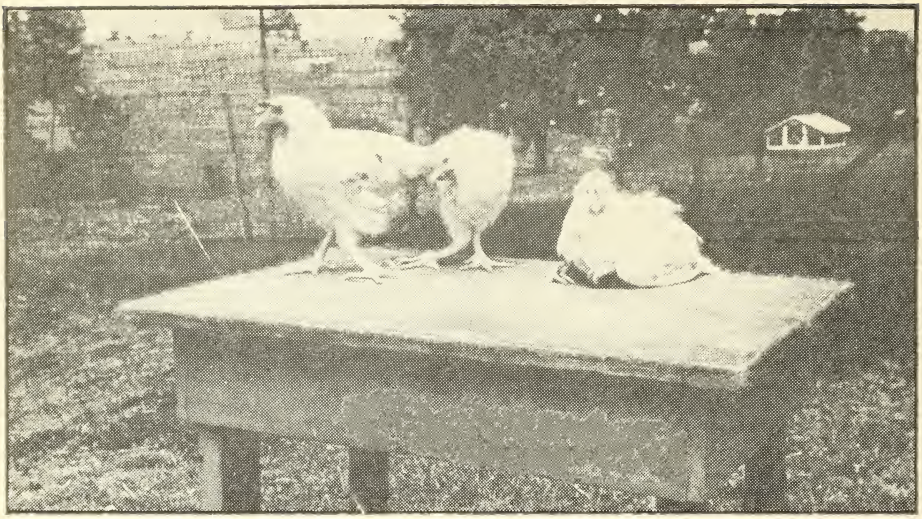

Figure 2. Nutritional disturbances which affected some of the experimental chicks: 2 chicks at left, slipped tendons (perosis); 1 chick at right, curl toe paralysis.

first week in September. During the 9 weeks of this series, the weather was extremely hot and dry, which is normal for this area except for the lack of rainfall. In addition to the difficult weather, all of the chicks in this series of the test contracted bronchitis at 7 weeks of age, which probably lowered the average weight of chicks on each of the rations.

Mortality in this series was considered as low and not above that normally expected with chicks brooded under more favorable climatic conditions. In this series no trouble was encountered in the sun-dried shrimp meal ration on account of abdominal cavities being filled with fluid, no chicks in any of the several lots came down with slipped tendons, and there were no rejects. Detailed results are shown in table 3-C.

Chicks receiving rations 7, 6, 4, and 1 were rather uniform in weight, the difference between the highest and lowest being less than 2 ounces. Chicks in rations 3 and 5 averaged nearly 3 ounces less than those receiving ration 7, and chicks receiving ration 2 averaged in weight over 5 ounces less than those receiving ration 7.

As in the previous series, chicks receiving cottonseed meal as a sole high-protein source (ration 2) were lowest in average weight. Differing from results in the first series, chicks receiving sun-dried shrimp meal weighed somewhat less than those receiving other rations, and gains in weight cost considerably more per pound of gain. Chicks receiving machine-dried shrimp meal as the high-protein source ranked second in average weight at the end of the test, but more economical gains were made by chicks on three other rations. The meat scraps lot was high for all rations in cost per pound of gain.

Ration 7, in which protein was derived from machine-dried shrimp meal plus soybean oil meal plus cottonseed meal, produced the highest average weight per chick in the summer series, and gains in weight at the lowest cost per pound of gain.

Differences in cost per pound of gain were significant in this, the summer

series except rations 1 and 4. The costs per pound of gain were as follows: ration 4, 8.87 cents; ration 2, 9.31 cents; ration 3, 9.67 cents; ration 5, 9.80 cents; and ration 6, 10.47 cents.

Summarized Results of Tests of Five High-Protein Sources for Chicks

A summary for the three series of this experiment is given in table 4. The percent of mortality for chicks on each ration is considered as low and within the mortality rate normally expected. All deaths of chicks were due to weak chicks except those fed the sun-dried shrimp meal ration.

Sun-dried shrimp meal had another objectionable feature, in that the droppings were watery throughout each series of the experiment. This is probably due to the excessive salt in the shrimp meal, which caused the chicks to drink more water than those on the other rations. The excessive water in the droppings is objectionable from the standpoint of cleaning the pan, and caused high depreciation on the equipment, especially on the dropping pans.

Machine-dried shrimp meal fed as the sole high-protein source was the most satisfactory of all single high-protein sources from the standpoint of average weight per chick, being only 0.65 ounce below the control ration and 0.67 ounce above the sun-dried shrimp meal ration. Only one case of slipped tendons developed where machine-dried shrimp meal was fed in combination with vegetable proteins, with or without milk. There was no significant difference in average weights per chick for rations 3, 4, and 7.

Cottonseed meal fed at the rate of 22 pounds in 100 pounds of the feed mixture was the least satisfactory of all high-protein feeds from the standpoint of average weight per chick, slipped tendons, vigor, and condition.

Cottonseed meal chicks' feathers were ruffled and the birds lacked vigor and condition when compared with the chicks

Table 4. Summary of tables 3-A, 3-B and 3-C of feeding sun-dried shrimp meal, machine-dried shrimp meal, cottonseed meal, soybean oil meal, and meat scraps as high-protein sources in rations for chicks from 1 to 9 weeks of age, through winter, spring, and summer seasons, 1941 and 1942.

Rations	Ration 1 Machine-dried shrimp meal 10 lbs. C. S. meal 9 lbs.	Ration 2 Cotton-seed meal 22 lbs.	Ration 3 Sun-dried shrimp meal 19 lbs.	Ration 4 Soybean oil meal 22 lbs.	Ration 5 Meat scraps 17 lbs.	Ration 6 Machine-dried shrimp meal 17 lbs.	Ration 7 Mch.-dried shrimp meal 12 lbs. soybean meal 5 lbs. cottonseed meal 8 lbs.
Number of birds	130.00	130.00	130.00	130.00	130.00	80.00*	80.00*
Percent mortality	3.88	2.31	6.15	2.31	2.31	3.75	2.50
Feed consumed in lbs.	254.94	248.93	262.50	252.55	239.66	232.63	239.25
Feed consumed per bird	5.88	5.75	5.60	5.83	5.53	5.82	5.98
Feed per lb. of gain	2.99	3.37	3.06	3.07	3.08	3.16	3.13
Feed cost per 100 lbs.	2.67	2.61	2.87	2.63	3.31	2.99	2.47
Cost per lb. of gain	7.98	8.80	8.77	8.07	10.19	9.45	7.73
Number of males	66.00	56.00	63.00	57.00	56.00	34.00	43.00
Av. wt. of males, ozs.	35.53	30.96	33.46	34.22	31.99	35.22	33.15
Number of females	60.00	71.00	59.00	70.00	71.00	43.00	35.00
Av. wt. of females, ozs.	28.40	25.34	28.15	28.13	26.82	27.95	27.51
Av. wt. all chicks, ozs.	32.33	27.81	30.89	30.94	29.54	31.68	30.62
Number slipped tendons	1.00	6.00	0.00	4.00	18.00	0.00	0.00
Number rejects	1.00	4.00	0.00	6.00	10.00	2.00	2.00

*Only two series conducted on rations 6 and 7.

on other rations. Two of the cottonseed meal chicks came down with a form of leg paralysis in series 1 and one chick in series 2. The toes were curled, exhibiting typical symptoms of curl toe paralysis. This condition was probably caused by some factor in cottonseed meal which prevented the chicks from utilizing available vitamins, probably vitamin G. However, cottonseed meal when used to supplement other high-protein sources, as in rations 1 and 7, was fed with good results.

Meat scraps under the conditions of this experiment was supplemented with manganese sulphate to prevent slipped tendons. The poor showing of this ration was due to slipped tendons in series 1. In addition, this meat scraps ration produced chicks which "feather picked" more than chicks receiving the other rations.

Soybean oil meal, when supplemented with minerals in the form of oystershell flour and steamed bonemeal, compares favorably with the other high-protein rations. The chicks on soybean oil meal and cottonseed meal included more that were classed as grading below C grade, and in general did not carry the finish evidenced by the chicks on the other rations.

It should be noted that only two series were conducted on rations 6 and 7, these being added only after the first series of five rations had been completed. The cost per pound of gain from rations 6 and 7 is apparently higher than some of the other rations, but in reality this is not so. The fact that it appears so is due to low feed prices prevailing at the time the first series was conducted. Feed prices were averaged for all rations for each of the three series, and since rations 6 and 7 were not included in the comparatively low cost schedule of the first series, feed costs, rations 6 and 7 were actually higher than for the other five rations.

Soybean oil meal was more economical to feed as the sole high-protein source than cottonseed meal or sun-dried shrimp meal. Soybean meal was efficiently used to supply a part of the protein as in ration 7.

More economical gains were secured from rations receiving proteins from animal and vegetable sources than from rations receiving proteins from one source only. Ration 7 which includes proteins from machine-dried shrimp meal, soybean oil meal, and cottonseed meal, was the most economical in cost per 100 pounds of feed; and ration 7 produced gains at the least cost per pound. Ration 1, in which proteins were secured from machine-dried shrimp meal and cottonseed meal, produced chicks weighing the most at the end of the three separate feeding periods, and was second only to chicks produced by ration 7 in economy of gains.

SUMMARY AND CONCLUSIONS

1. Shrimp meal, prepared by sun-drying or by machine-drying, carries sufficient minerals when fed as the sole high-protein source or in combination with vegetable protein at the rate of 9 to 12 pounds to practically eliminate perosis (slipped tendons).

2. Meat scraps, fed at the rate of 17 pounds, should be supplemented with manganese sulphate to prevent perosis (slipped tendons).

3. Soybean oil meal, supplemented with minerals and fed at the rate of 22 pounds compared favorably to animal protein sources in average chick weight.

4. Cottonseed meal, fed at the rate of 22 pounds and supplemented with minerals, gave the poorest results of all high-protein feeds in average chick weight, vigor, and finish.

5. Cottonsed meal, fed at the rate of 8 to 9 pounds gave good results when fed in combination with machine-dried shrimp meal and soybean oil meal.

6. Sun-dried shrimp meal is not as efficient as machine-dried shrimp meal when fed as the high-protein source, due to its higher salt content.

7. Ration 7, without milk, produced chicks which averaged 30.62 ounces at a cost of 7.73 cents per pound of gain, and was the most economical ration fed.

8. Machine-dried shrimp meal, as prepared and fed under the condition of this experiment, was utilized just as efficiently by chicks as other high protein sources.