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BULLETIN NO. 569

JANUARY 1939

## DIVISION OF POULTRY HUSBANDRY

### Comparative Values of Various Protein Feeds for Growing Chicks



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This bulletin is a report of five experiments conducted for the purpose of comparing five protein feeds to determine their relative supplemental values in chick rations. In each of nine rations employed, three of the five protein feeds—sardine meal, dried skimmed milk, meat and bone scraps, soybean oil meal, and cottonseed meal—were used in combination. Thus the supplemental values of the various feeds were readily measured.

Since all rations contained wheat gray shorts and satisfactory amounts of calcium and phosphorus, little or no trouble from slipped tendons or perosis was encountered.

The relative value of the various protein feeds was judged by the average gains in live weight of the chicks, the grams of feed required to produce a gram of gain in live weight, and the percentage of chicks that died during the experimental period.

In practically all cases, rations containing sardine meal produced larger gains in live weight and required a smaller amount of feed per gram of gain than other rations not containing this feed, regardless of whether dried skimmed milk was a constituent of the ration or not. However, a slightly larger percentage of the chicks died in groups receiving sardine meal, with the exception of the group fed sardine meal, dried skimmed milk, and soybean oil meal. This mortality was not excessive except when sardine meal was fed in combination with meat and bone scraps and soybean oil meal.

It was found that soybean oil meal and cottonseed meal could be used interchangeably in chick rations without affecting the results appreciably. Moreover, it was learned that dried skimmed milk and meat and bone scraps could be used interchangeably in chick rations in combination with soybean oil meal and cottonseed meal. Though the mortality in groups fed these combinations was very low, the gains in live weight were slightly lower and the amount of feed required to produce a gram of gain was slightly higher than that of groups fed rations containing other combinations reported in this bulletin.

From the data reported here it is seen that chick rations should contain either dried skimmed milk, sardine meal, or meat and bone scraps. Dried skimmed milk may be used in combination with sardine meal or meat and bone scraps, but sardine meal and meat and bone scraps should not be used in the same ration because of the high mortality associated with this combination when soybean oil meal is used also. However the same high mortality is not associated with the meat and bone scraps-sardine meal combination when these two feeds are fed with cottonseed meal. Further work should be done on this point.

As a result of these experiments, any of the rations reported in this bulletin, with the exception of ration 7, which contained sardine meal, meat and bone scraps, and soybean oil meal, are recommended to give satisfactory results. Cost per hundred pounds, results expected, and availability of ingredients should determine which one to use.

## CONTENTS

	PAGE
Introduction . . . . .	5
Review of Literature . . . . .	5
Method of Procedure . . . . .	8
Experimental Results . . . . .	11
Sardine Meal as a Supplement to Other Protein Feeds . . . . .	11
Soybean Oil Meal as a Supplement to Other Protein Feeds . . . . .	17
Cottonseed Meal as a Supplement to Other Protein Feeds . . . . .	22
Dried Skimmed Milk as a Supplement to Other Protein Feeds . . . . .	23
Conclusions . . . . .	26
References . . . . .	26

## COMPARATIVE VALUES OF VARIOUS PROTEIN FEEDS FOR GROWING CHICKS

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Commercial feed manufacturers and poultrymen are anxious to learn how to make their various rations more efficient. In some experimental work protein feeds have been compared, using only one in each ration. In the experiments published in this bulletin, three protein feeds were used in each ration so that the comparison of one protein feed with another was made by means of feeding it with two others. The protein feeds compared were sardine meal, soybean oil meal, cottonseed meal, dried skimmed milk, and meat and bone scraps.

Protein feeds contain various growth factors; some of the best known are the essential amino acids of the proteins, certain vitamins, and minerals. If the growth factors of one protein feed are adequately supplied by the other protein feeds furnished in the ration, the supplemental value of this feed will be less than if fed alone.

### REVIEW OF LITERATURE

It has been shown by various workers (5, 16, 24, 27, 28) that rations for growing chicks should contain 18 to 20 per cent protein for most rapid growth and efficient utilization of the feed during the first 8 to 12 weeks of age.

Roberts and Carrick (25), in a study of the amounts of protein supplements in rations for broilers, reported that the rate of growth increased as the level of protein was increased up to 20 per cent. Their ration which gave best results contained 10 per cent meat scraps, 10 per cent soybean oil meal, and 5 per cent dried milk.

Roberts and Carrick (24) reported that there was apparently little difference in the relative feeding value of dried buttermilk and dried skimmed milk. Dried milk was slightly superior to dried whey when an equal amount of each was fed; but when each supplied an equal amount of protein, they produced practically the same rate of growth.

Dried milk, meat and bone scraps, meat meal, fish meals, cottonseed meal, and soybean oil meal are the most commonly used protein supplements in chick rations. Many different combinations of these feeds have been used in tests with chicks and varying results have been reported. Prange, Carrick, and Hauge (19, 20) obtained optimum growth with meat and bone scraps and unsatisfactory growth with a commercial meat meal. They concluded that meat and bone scraps from various manufacturers did not give the same rate of growth and that nitrogen  $\times 6.25$  is not an index of protein value. Johnson and Brazie (11) fed a 14 per cent level of protein and reported that Alaska herring meal was

superior to either of two meat scraps used. Asmundson and Biely (4) reported that chicks fed rations supplemented with salmon and pilchard meals weighed just as much at eight weeks as did chicks receiving an equal amount of protein from milk.

Ringrose and Morgan (23), in a study of the use of cottonseed meal in the chick starting ration, reported that cottonseed meal satisfactorily replaced meat scraps in all proportions used in their tests.

Ackerson and co-workers (1) found that a mixture of meat scraps, fish meal, and dried buttermilk produced a higher mean net weight and greater average retention of nitrogen, calcium, and phosphorus in chicks than did meat scraps fed as the sole protein concentrate.

Daniel and McCollum (8), in growth studies with rats, reported that the proteins of certain fish meals were superior to casein and also that the fish meals proved decidedly better than commercial tankages and meat meal.

It has been shown (9, 10, 12, 13, 14, 15, 21, 22, 26, 31) that the method of manufacture and materials that make up a protein feed have a very definite effect on its feeding value. Ingvaldsen (9, 10) found that putrefaction lowered the tyrosine, tryptophane and cystine content of fish meals and should be avoided in the preparation of such products for feeding purposes, since these amino acids are essential to the diet. He also reported that temperatures higher than 190°C. cause a diminution in arginine and cystine and therefore should be avoided in the preparation of meals. Maynard and co-workers (12, 13), in growth experiments with rats, reported that vacuum-dried white fish meal was superior to steam-dried menhaden meal and that the latter was superior to flame-dried menhaden as regards protein efficiency for growth. Schneider (26), in nitrogen balance studies with rats, ranked these meals in the same order as did Maynard. Maynard found further that the vacuum-dried white fish meal was a good source of vitamin A while the other two meals were devoid of this factor, and also reported (13) that the protein of vacuum-dried haddock meal was superior to flame-dried haddock meal in both digestibility and biological value determinations. Morgan (14) showed that the protein of cereals subjected to dry heat or toasting at approximately 200°C. for 45 minutes was not well utilized for growth. Morgan and Kern (15), working with beef, said that the protein was subject to a heat injury, which increased in severity with the length of exposure and the height of the temperature reached.

Record and co-workers (21, 22), in studies with chicks, reported that the fish meals used in their experiments varied widely in their nutritive value. This they attributed to a difference in the biological value of the meals, a difference in amount of the vitamin G complex, and the use of different drying temperatures in the process of manufacture. They found that some of the vitamin G complex was removed during the process of manufacture, that the protein of vacuum-dried haddock was superior to that of flame-dried haddock, and that the fish meal proteins were significantly better than the meat scrap proteins for promoting growth in chicks.

Table 1—Percentage Composition of Feeds

Feeds	Feed numbers	Protein	Fat	Crude fibre	Nitrogen free extract	Water	Ash	Calcium	Phosphorus	Magnesium	Insoluble Ash
Dried skimmed milk	239	35.17	0.98	0.42	48.54	7.18	7.71	1.31	0.90	0.09	0.09
67% Protein sardine meal	243	72.56	2.87	1.03	4.40	6.78	12.36	3.57	2.35	0.10	0.37
67% Protein sardine meal	245	70.47	2.73	0.75	5.58	6.93	13.54	4.00	2.40	0.04	0.30
67% Protein sardine meal	271	67.02	5.74	0.71	4.03	7.82	14.68	4.32	2.70	0.15	0.14
50% Protein meat and bone scraps	223	51.34	9.26	2.88	0.00	5.86	30.66	10.75	5.30	0.18	0.59
50% Protein meat and bone scraps	273	50.98	9.42	2.55	0.13	6.74	30.18	9.61	4.97	0.25	0.54
43% Protein cottonseed meal	236	45.54	6.89	10.11	23.97	7.28	6.21	0.17	1.15	0.55	0.10
43% Protein cottonseed meal	270	43.71	7.03	10.05	24.63	7.73	6.85	0.22	1.36	0.69	0.10
41% Protein soybean oil meal	244	43.35	0.46	5.93	35.27	8.76	6.23	0.26	0.72	0.24	0.13
41% Protein soybean oil meal	246	42.08	5.00	6.63	33.12	7.59	5.58	0.21	0.60	0.23	0.10
41% Protein soybean oil meal	260	43.07	5.80	5.98	28.46	10.25	6.44	0.21	0.71	0.27	0.70
41% Protein soybean oil meal	331	45.07	1.03	5.76	30.98	10.63	6.53	0.30	0.59	0.34	0.06
Wheat gray shorts	242	17.44	4.18	6.06	57.60	10.20	4.52	0.11	0.93	0.34	0.11
Wheat gray shorts	269	17.60	5.18	6.33	54.01	12.36	4.52	0.11	0.90	0.36	0.10
Wheat gray shorts	324	19.51	4.45	5.62	54.41	11.11	4.90	0.14	0.86	0.32	0.15
Poultry bone meal	235	27.11	2.27	1.28	0.92	7.28	61.14	23.10	10.85	0.21	0.14
Poultry bone meal	308	26.90	3.08	0.98	0.71	6.46	61.87	22.53	10.61	0.28	0.05
Chick size oyster shell	227							38.67	0.02	0.19	0.07
Ground yellow corn	241	9.41	4.58	2.43	69.43	12.55	1.60	0.11	0.28	0.11	0.03
Ground yellow corn	258	9.87	5.17	2.04	69.24	12.32	1.36	0.03	0.29	0.11	0.09
Dehydrated alfalfa leaf meal	200	24.40	3.44	18.93	36.19	6.97	10.07	1.14	0.29	0.46	1.62
Dehydrated alfalfa leaf meal	307	20.26	3.38	21.06	36.78	7.64	10.88	1.37	0.29	0.39	2.50

## METHOD OF PROCEDURE

The chicks used in these experiments were New Hampshires of like breeding that were fed in battery brooders. All groups were kept under as nearly uniform conditions as possible. Experiments 24 and 25 were conducted during the late fall and early winter. Experiments 41 and 42 were conducted during the late spring and early summer, and experiment 49 during the following fall. Experiments 24, 41, and 49 were run in duplicate with 25-26 chicks in each group. Experiments 25 and 42 were not run in duplicate and had 40 and 28 chicks, respectively. The experimental period for experiments 24, 25, and 49 was ten weeks and for experiments 41 and 42 was eight weeks. All groups were rotated in the cages every two weeks, so that no group occupied the same position in the building for longer than this period of time. The chicks were weighed individually at the beginning and at the close of the experiments and at intervals of two weeks during the experiments. They were weighed early in the forenoon after the feed had been withheld since 6 o'clock the preceding afternoon.

The feed was weighed to the chicks daily. Lights were supplied and the chicks were fed as much as they would consume in a 14-hour feeding period each day. Tap water was before them at all times.

Samples of all feeds used in these experiments were analyzed by the Division of Chemistry. These analyses are given in Table 1. It may be noted from this table that there is a wide variability in the chemical composition of different lots of the same feed. To illustrate this, sardine meal lot No. 271 contained only 67.02 per cent protein while lot No. 243 contained 72.56 per cent. Wheat gray shorts lot No. 242 contained only 17.44 per cent protein while lot No. 324 contained 19.51 per cent protein. Such differences in the chemical composition of the same feeds may account for some of the variations between the results of workers using similar formulas.

The percentage of the different feeds used in the rations and the chemical composition computed from Table 1 are given in Tables 2, 3, 4, and 5.

It is noted from these tables that these experiments were studies of the supplemental action of one protein feed when used with two other protein feeds rather than a comparison of one protein feed with another when used alone. Six pounds of three different protein feeds were used in each ration. It is noted from these tables that the difference in the amount of calcium and phosphorus in the various rations of each experiment was very small; no effort was made to balance the organic nutrients.

Average gain in live weight in grams of cockerels and pullets, grams of feed required to produce a gram of gain in live weight, and percentage of chicks that died during the experimental period were used as criteria in arriving at the values of the different feeds in the various rations. Statistical constants were figured on the average gains in live weight and consulted while the bulletin was being written, but in order to simplify it these were not included in the bulletin. Since there were no outbreaks



of disease and all comparable lots were fed in the same season, percentages (from 0 to 7.5) of chicks that died were considered as normal and not caused by the feed; and those above 7.5 per cent were considered as excessive and caused by the ration fed.

**Table 2. Percentage of Ingredients and Calculated Chemical Analysis of Rations Fed in Experiment 24**

Feeds	Feed*	Percentage Ingredients of Rations					
		1	2	3	4	5	6
Dried skimmed milk.....	239*	6	6	6	6	6	.....
67% Protein sardine meal...	243	.....	.....	6	6	.....	6
50% Protein meat and bone scraps.....	223	6	.....	.....	.....	6	.....
43% Protein cottonseed meal	236	6	.....	6	.....	.....	6
41% Protein soybean oil meal	244	.....	6	.....	.....	.....	6
Wheat gray shorts.....	242	30	30	30	30	30	30
Poultry bone meal.....	235	.....	2.7	1.5	1.8	.3	1.7
Chick size oyster shell.....	227	1.5	1.5	1.6	1.4	1.3	1.5
Ground yellow corn.....	241	46.37	43.67	44.77	44.67	46.27	44.67
Dehydrated alfalfa leaf meal	200	3	3	3	3	3	3
Salt.....	.....	1	1	1	1	1	1
Cod liver oil.....	.....	.13	.13	.13	.13	.13	.13

Nutrient	Calculated chemical analysis of rations					
	1	2	3	4	5	6
Protein.....	18.25	18.25	19.78	19.72	18.19	20.32
Fat.....	4.51	3.92	4.09	3.70	4.13	4.05
Crude fiber.....	4.32	4.47	4.19	3.94	4.07	4.52
Nitrogen-free extract...	54.91	55.18	54.08	54.69	55.52	53.21
Water.....	10.31	10.34	10.27	10.37	10.41	10.37
Ash.....	5.07	5.22	4.87	5.05	5.26	4.90
Calcium.....	1.43	1.42	1.38	1.38	1.43	1.33
Phosphorus.....	0.86	0.87	0.84	0.85	0.87	0.85
Magnesium.....	0.22	0.23	0.22	0.20	0.20	0.22
Insoluble ash.....	0.14	0.12	0.13	0.13	0.15	0.13

\*For analysis of these feeds, see Table 1.

**Table 3. Percentage of Ingredients and Calculated Chemical Analysis of Rations Fed in Experiment 25**

Feeds	Feed*	Percentage Ingredients of Rations					
		1	2	3	4	5	6
Dried skimmed milk.....	239†	6	6	6	6	6	.....
67% Protein sardine meal...	245	.....	.....	6	6	.....	6
50% Protein meat and bone scraps.....	223	6	.....	.....	.....	6	.....
43% Protein cottonseed meal	236	6	6	6	.....	.....	6
41% Protein soybean oil meal	246	.....	6	.....	6	6	6
Wheat gray shorts.....	242	30	30	30	30	30	30
Poultry bone meal.....	235	.....	2.7	1.5	1.8	.3	1.7
Chick size oyster shell.....	227	1.5	1.5	1.6	1.4	1.3	1.5
Ground yellow corn.....	241	46.37	43.67	44.77	44.67	46.27	44.67
Dehydrated alfalfa leaf meal.	200	3	3	3	3	3	3
Salt.....	.....	1	1	1	1	1	1
Cod liver oil.....	.....	.13	.13	.13	.13	.13	.13

**Table 3. Percentage of Ingredients and Calculated Chemical Analysis of Rations Fed in Experiment 25—Continued**

Nutrient	Calculated chemical analysis of rations					
	1	2	3	4	5	6
Protein.....	18.25	18.17	19.65	19.52	18.11	20.11
Fat.....	4.51	4.19	4.08	3.97	4.40	4.32
Crude fiber.....	4.32	4.51	4.17	3.96	4.11	4.54
Nitrogen-free extract.....	54.91	55.05	54.15	54.63	55.39	53.16
Water.....	10.31	10.27	10.28	10.31	10.34	10.31
Ash.....	5.07	5.18	4.94	5.08	5.22	4.93
Calcium.....	1.43	1.42	1.41	1.40	1.43	1.35
Phosphorus.....	0.86	0.86	0.84	0.84	0.86	0.85
Magnesium.....	0.22	0.22	0.21	0.19	0.20	0.22
Insoluble ash.....	0.14	0.12	0.13	0.13	0.14	0.13

\*It may be noted that the percentage of ingredients in this experiment is the same as that of Experiment 24 but different lots of sardine meal and soybean oil meal were used in these experiments.

†For analysis of these feeds, see Table 1.

**Table 4. Percentage of Ingredients and Calculated Chemical Analysis of Rations Fed in Experiments 41 and 42**

Feeds	Feed*	Percentage Ingredients of Rations					
		1	2	3	4	5	6
Dried skimmed milk.....	239†	6	6	6	6	6	.....
67% Protein sardine meal...	271	.....	.....	6	6	.....	6
50% Protein meat and bone scraps.....	223	6	.....	.....	.....	6	.....
43% Protein cottonseed meal	236	6	6	6	.....	.....	6
41% Protein soybean oil meal	260	.....	6	.....	6	6	6
Wheat gray shorts.....	269	30	30	30	30	30	30
Poultry bone meal.....	235	.....	2.7	1.5	1.8	.3	1.7
Chick size oyster shell.....	227	1.5	1.5	1.6	1.4	1.3	1.5
Ground yellow corn.....	258	46.37	43.67	44.77	44.67	46.27	44.67
Dehydrated alfalfa leaf meal	200	3	3	3	3	3	3
Salt.....	.....	1	1	1	1	1	1
Cod liver oil.....	.....	.13	.13	.13	.13	.13	.13

Nutrient	Calculated chemical analysis of rations					
	1	2	3	4	5	6
Protein.....	18.51	18.48	19.70	19.62	18.43	20.40
Fat.....	5.08	4.80	4.82	4.76	5.02	5.11
Crude fiber.....	4.22	4.38	4.07	3.83	3.97	4.41
Nitrogen-free extract.....	53.75	53.61	52.89	53.10	53.95	51.62
Water.....	10.85	10.98	10.88	11.07	11.04	11.07
Ash.....	4.96	5.12	4.90	5.10	5.16	4.94
Calcium.....	1.39	1.39	1.39	1.39	1.39	1.34
Phosphorus.....	0.85	0.86	0.86	0.86	0.86	0.87
Magnesium.....	0.22	0.23	0.22	0.21	0.21	0.24
Insoluble ash.....	0.17	0.18	0.14	0.18	0.20	0.18

\*It may be noted that the percentage of ingredients in this experiment is the same as that of Experiments 24 and 25 but different lots of sardine meal, soybean oil meal, wheat gray shorts, and ground yellow corn were used in these experiments.

†For analysis of these feeds, see Table 1.

Table 5. Percentage of Ingredients and Calculated Chemical Analysis of Rations Fed in Experiment 49

Feeds	Feed*	Percentage Ingredients of Rations					
		2	4	6	7	8	9
Dried skimmed milk	239†	6	6				
41% Protein soybean oil meal	331	6	6	6	6	6	
43% Protein cottonseed meal	270	6		6			6
67% Protein sardine meal	271		6	6	6		6
50% Protein meat and bone scraps	273				6	6	6
Wheat gray shorts	324	30	30	30	30	30	30
Dehydrated alfalfa leaf meal	307	3	3	3	3	3	3
Salt		1	1	1	1	1	1
Cod liver oil		.13	.13	.13	.13	.13	.13
Poultry bone meal	308	3.37	2.70	2.44	0.38	1.13	
Chick size oyster shell	227	1.76	1.50	1.76	1.53	1.73	1.75
Ground yellow corn	258	42.74	43.67	43.67	45.96	45.01	46.12

Nutrient	Calculated chemical analysis of rations					
	2	4	6	7	8	9
Protein	19.04	20.35	20.79	20.90	19.61	20.73
Fat	4.30	4.25	4.60	4.80	4.86	5.16
Crude fiber	4.20	3.65	4.23	3.80	4.35	4.06
Nitrogen-free extract	53.38	52.79	51.35	51.45	52.03	51.18
Water	10.59	10.67	10.69	10.78	10.70	10.60
Ash	5.73	5.80	5.59	5.74	5.72	5.53
Calcium	1.65	1.64	1.62	1.63	1.63	1.62
Phosphorus	0.92	0.93	0.93	0.94	0.93	0.94
Magnesium	0.23	0.20	0.24	0.21	0.24	0.23
Insoluble ash	0.18	0.18	0.18	0.21	0.20	0.21

\*It may be noted that rations 2, 4, and 6 have the same percentage composition as those of Experiments 24, 25, 41, and 42, except that different lots of sardine meal, soybean oil meal, wheat gray shorts, and ground yellow corn were used. Rations 7, 8, and 9 have a different percentage composition from that of any previous ration.  
 †For analysis of these feeds, see Table 1.

## EXPERIMENTAL RESULTS

### Sardine Meal as a Supplement to Other Protein Feeds

The sardine meal used in this series of experiments was a vacuum-dried meal. As pointed out in the "Review of Literature," fish meals manufactured by this process have a higher biological value and contain more vitamin A and vitamin G than meals cooked and dried at higher temperatures.

Sardine meal was a more desirable supplement to soybean oil meal and dried milk, cottonseed meal and dried milk, or soybean oil meal and cottonseed meal in chick rations than was meat and bone scraps. Sardine meal produced larger gains in live weight in both cockerels and pullets, with the exception of the pullets in experiment 24, and required a smaller amount of feed per gram of gain than did meat and bone scraps when these feeds were supplementing soybean oil meal and dried skimmed milk (Table 6). A smaller percentage of the chicks died in the groups receiving

Table No. 6. Sardine Meal as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Dried Skimmed Milk

	Ration 4 Sardine meal	Ration 5 Meat and bone scraps	Advantages of Sardine meal
	Average	gain in live weight	t in grams
<b>COCKERELS</b>			
Experiment 24.....	1186.2	1142.0	44.2
Experiment 25.....	1176.3	1036.9	139.4
Mean of Experiments 24 and 25....	1181.7	1090.8	90.9
Experiment 41.....	624.9	600.4	24.5
Experiment 42.....	657.9	587.5	70.4
Mean of Experiments 41 and 42....	635.1	596.3	38.8
<b>PULLETS</b>			
Experiment 24.....	983.3	1007.0	-23.7
Experiment 25.....	993.1	954.7	38.4
Mean of Experiments 24 and 25....	987.3	986.8	0.5
Experiment 41.....	579.6	521.8	57.8
Experiment 42.....	629.2	476.0	153.2
Mean of Experiments 41 and 32....	599.7	502.5	97.2
	Grams of feed r	equired to produc	e 1 gram of gain
Experiment 24.....	3.23	3.32	.09
Experiment 25.....	3.41	3.50	.09
Mean of Experiments 24 and 25....	3.31	3.39	.08
Experiment 41.....	3.18	3.44	.26
Experiment 42.....	2.95	3.49	.54
Mean of Experiments 41 and 42....	3.10	3.44	.34
	Percentage of ch	icks that died dur	ing the experiment
Experiment 24.....	0.0	4.0	4.0
Experiment 25.....	2.5	5.3	2.8
Mean of Experiments 24 and 25....	1.1	4.5	3.4
Experiment 41.....	1.9	4.2	2.3
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42....	1.3	2.7	1.4

sardine meal than in the groups receiving meat and bone scraps in the above comparison, with the exception of experiment 42, where there was no difference. When sardine meal and meat and bone scraps were used to supplement cottonseed meal and dried milk or soybean oil meal and cottonseed meal, sardine meal produced larger gains in live weight in both cockerels and pullets and required less feed per gram of gain than

Table No. 7. Sardine Meal as Compared with Meat and Bone Scraps when Fed with Cottonseed Meal and Dried Skimmed Milk

	Ration 3 Sardine meal	Ration 1 Meat and bone scraps	Advantages of Sardine meal
	Average	gain in live weight	t in grams
<b>COCKERELS</b>			
Experiment 24.....	1207.6	1102.8	104.8
Experiment 25.....	1178.4	1075.4	103.0
Mean of Experiments 24 and 25...	1196.3	1090.5	105.8
Experiment 41.....	650.1	543.7	106.4
Experiment 42.....	695.8	595.9	99.9
Mean of Experiments 41 and 42...	666.6	562.7	103.9
<b>PULLETS</b>			
Experiment 24.....	990.1	888.8	101.3
Experiment 25.....	966.5	900.2	66.3
Mean of Experiments 24 and 25...	978.5	893.6	84.9
Experiment 41.....	587.7	444.5	143.2
Experiment 42.....	591.1	434.7	156.4
Mean of Experiments 41 and 42...	589.0	441.0	148.0
	Grams of feed required to produce	1 gram of gain	
Experiment 24.....	3.23	3.30	.07
Experiment 25.....	3.40	3.87	.47
Mean of Experiments 24 and 25...	3.30	3.55	.25
Experiment 41.....	3.13	3.48	.35
Experiment 42.....	3.02	3.48	.46
Mean of Experiments 41 and 42...	3.09	3.48	.39
	Percentage of chicks that died during	the experiment	
Experiment 24.....	2.2	0.0	-2.2
Experiment 25.....	5.3	2.3	-3.0
Mean of Experiments 24 and 25...	3.6	1.1	-2.5
Experiment 41.....	4.1	0.0	-4.1
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	2.6	0.0	-2.6

Table No. 8. Sardine Meal as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Cottonseed Meal

Experiment 49	Ration 6 Sardine meal	Ration 8 Meat and bone scraps	Advantages of Sardine meal
<b>COCKERELS</b>			
Average gain in live weight in grams	1158.6	1002.4	156.2
<b>PULLETS</b>			
Average gain in live weight in grams	874.9	778.1	96.8
Grams of feed required to produce 1 gram of gain.....	3.43	3.56	.13
Percentage of chicks that died during the experiment.....	2.1	0.0	-2.1

did meat and bone scraps (Tables 7 and 8). However, a slightly larger percentage of the chicks died in the groups receiving sardine meal than in those receiving meat and bone scraps, with the exception of experiment 42, where there was no difference. The mortality, though not excessive, was consistently higher in all groups receiving sardine meal, with the ex-

**Table No. 9. Sardine Meal as Compared with Soybean Oil Meal when Fed with Cottonseed Meal and Dried Skimmed Milk**

	Ration 3 Sardine meal	Ration 2 Soybean oil meal	Advantages of Sardine meal
	Average gain in live weight		in grams
<b>COCKERELS</b>			
Experiment 24.....	1207.6	1040.9	166.7
Experiment 25.....	1178.4	1050.8	127.6
Mean of Experiments 24 and 25...	1196.3	1044.7	151.6
Experiment 41.....	650.1	585.4	64.7
Experiment 42.....	695.8	571.4	124.4
Mean of Experiments 41 and 42...	666.6	580.4	86.2
<b>PULLETS</b>			
Experiment 24.....	990.1	879.4	110.7
Experiment 25.....	966.5	877.8	88.7
Mean of Experiments 24 and 25...	978.5	878.6	99.9
Experiment 41.....	587.7	478.1	109.6
Experiment 42.....	591.1	409.7	181.4
Mean of Experiments 41 and 42...	589.0	454.2	134.8
	Grams of feed required to produce		1 gram of gain
Experiment 24.....	3.23	3.44	.21
Experiment 25.....	3.40	3.49	.09
Mean of Experiments 24 and 25...	3.30	3.46	.16
Experiment 41.....	3.13	3.25	.12
Experiment 42.....	3.02	3.37	.35
Mean of Experiments 41 and 42...	3.09	3.29	.20
	Percentage of chicks that died during the experiment		
Experiment 24.....	2.2	0.0	-2.2
Experiment 25.....	5.3	2.3	-3.0
Mean of Experiments 24 and 25...	3.6	1.1	-2.5
Experiment 41.....	4.1	0.0	-4.1
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	2.6	0.0	-2.6

**Table No. 10. Sardine Meal as Compared with Soybean Oil Meal when Fed with Meat and Bone Scraps and Cottonseed Meal**

Experiment 49	Ration 9 Sardine meal	Ration 8 Soybean oil meal	Advantages of Sardine meal
<b>COCKERELS</b>			
Average gain in live weight in grams	1018.2	1002.4	15.8
<b>PULLETS</b>			
Average gain in live weight in grams	876.4	778.1	98.3
Grams of feed required to produce 1 gram of gain.....	3.36	3.56	.20
Percentage of chicks that died during the experiment.....	2.1	0.0	-2.1

ception of experiment 42 (Table 7) in which this feed was supplementing cottonseed meal and dried skimmed milk or soybean oil meal and cottonseed meal (Tables 7 and 8).

Sardine meal proved to be a better supplement to cottonseed meal and dried skimmed milk or meat and bone scraps and cottonseed meal than did soybean oil meal. Sardine meal produced much larger gains in live

Table No. 11. Sardine Meal as Compared with Cottonseed Meal when Fed with Dried Skimmed Milk and Soybean Oil Meal

	Ration 4 Sardine meal	Ration 2 Cottonseed meal	Advantages of Sardine meal
	Average gain in live weight in grams		
<b>COCKERELS</b>			
Experiment 24.....	1186.2	1040.9	145.3
Experiment 25.....	1176.3	1050.8	125.5
Mean of Experiments 24 and 25...	1181.7	1044.7	137.0
Experiment 41.....	624.9	585.4	39.5
Experiment 42.....	657.9	571.4	86.5
Mean of Experiments 41 and 42...	635.1	580.4	54.7
Experiment 49.....	1145.1	1001.0	144.1
<b>PULLETS</b>			
Experiment 24.....	983.3	879.4	103.9
Experiment 25.....	993.1	877.8	115.3
Mean of Experiments 24 and 25...	987.3	878.6	108.7
Experiment 41.....	579.6	478.1	101.5
Experiment 42.....	629.2	409.7	219.5
Mean of Experiments 41 and 42...	599.7	454.2	145.5
Experiment 49.....	841.0	780.7	60.3
	Grams of feed required to produce 1 gram of gain		
Experiment 24.....	3.23	3.44	.21
Experiment 25.....	3.41	3.49	.08
Mean of Experiments 24 and 25...	3.31	3.46	.15
Experiment 41.....	3.18	3.25	.07
Experiment 42.....	2.95	3.37	.42
Mean of Experiments 41 and 42...	3.10	3.29	.19
Experiment 49.....	3.41	3.64	.23
	Percentage of chicks that died during experiment		
Experiment 24.....	0.0	0.0	0.0
Experiment 25.....	2.5	2.3	-0.2
Mean of Experiments 24 and 25...	1.1	1.1	0.0
Experiment 41.....	1.9	0.0	-1.9
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	1.3	0.0	-1.3
Experiment 49.....	0.0	2.0	2.0

Table No. 12. Sardine Meal as Compared with Cottonseed Meal when Fed with Soybean Oil Meal and Meat and Bone Scraps

Experiment 49	Ration 7 Sardine meal	Ration 8 Cottonseed meal	Advantages of Sardine meal
<b>COCKERELS</b>			
Average gain in live weight in grams	1057.7	1002.4	55.3
<b>PULLETS</b>			
Average gain in live weight in grams	873.4	778.1	95.3
Grams of feed required to produce 1 gram of gain.....	3.39	3.56	.17
Percentage of chicks that died during the experiment.....	16.7	0.0	-16.7

weight in both cockerels and pullets, with the exception of the cockerels in experiment 49 (Table 10), and required from 0.09 to 0.35 grams less feed to produce a gram of gain than did soybean oil meal (Tables 9 and 10). However, a larger percentage of the chicks died in the groups receiving sardine meal than in those receiving soybean oil meal, with the exception of experiment 42 (Table 9). This is unexplainable from the data available.

Sardine meal was superior to cottonseed meal when these feeds were used to supplement dried skimmed milk and soybean oil meal or soybean oil meal and meat and bone scraps. Sardine meal produced significantly larger gains in live weight in both cockerels and pullets than did cottonseed meal. The advantages of sardine meal varied from 39.5 to 145.3 grams in the cockerels and from 60.3 to 219.5 grams in the pullets. Sardine meal required from 0.07 to 0.42 grams less feed to produce a gram of gain than did cottonseed meal when these feeds were used to supplement dried milk and soybean oil meal or soybean oil meal and meat and bone scraps (Tables 11 and 12). The percentage of the chicks that died in the groups of this comparison varied from 0.0 per cent to 2.5 per cent in the sardine meal and cottonseed meal groups when these feeds were used to supplement dried skimmed milk and soybean oil meal (Table 11). This mortality probably could not be attributed to either of these feeds. However, when these feeds were used to supplement soybean oil meal and meat and bone scraps, there was a mortality of 16.7 per cent in the sardine meal groups as compared with 0.0 per cent in the cottonseed meal groups (Table 12). The high mortality of the sardine meal group in this case occurred when this feed was used in a ration with meat and bone scraps. The gains in live weight and grams of feed per gram of gain were satisfactory in this group, but the percentage of chicks that died was too high to recommend the use of six per cent sardine meal and six per cent meat and bone scraps in the same chick ration when soybean oil meal is the other protein feed used to make up the ration.

When sardine meal and dried skimmed milk were used as supplements to cottonseed meal and soybean oil meal, the results were somewhat conflicting. Sardine meal produced larger gains in live weight in both cockerels and pullets, with the exception of the cockerels in experiment 41 (Table 13), and required less feed to produce a gram of gain in experiments 24, 25, and 49. On the other hand, the groups receiving dried skimmed milk required less feed to produce a gram of gain in experiments 41 and 42, and a smaller percentage of the chicks died in the groups receiving dried skimmed milk than in those receiving sardine meal, with the exception of experiment 25, in which these feeds were used to supplement cottonseed meal and soybean oil meal. The percentage of chicks that died varied from 0.0 to 7.1 per cent in the sardine meal groups and from 0.0 to 2.3 per cent in the dried skimmed milk groups (Table 13).



Table No. 13. Sardine Meal as Compared with Dried Skimmed Milk when Fed with Cottonseed Meal and Soybean Oil Meal

	Ration 6 Sardine meal	Ration 2 Dried skimmed milk	Advantages of Sardine meal
	Average gain in live weight		in grams
<b>COCKERELS</b>			
Experiment 24 .....	1183.4	1040.9	142.5
Experiment 25 .....	1144.8	1050.8	94.0
Mean of Experiments 24 and 25 .....	1161.2	1044.7	116.5
Experiment 41 .....	585.0	585.4	-0.4
Experiment 42 .....	620.9	571.4	49.5
Mean of Experiments 41 and 42 .....	597.0	580.4	16.6
Experiment 49 .....	1158.6	1001.0	157.6
<b>PULLETS</b>			
Experiment 24 .....	951.8	879.4	72.4
Experiment 25 .....	963.5	877.8	85.7
Mean of Experiments 24 and 25 .....	955.5	878.6	76.9
Experiment 41 .....	523.7	478.1	45.6
Experiment 42 .....	549.3	409.7	139.6
Mean of Experiments 41 and 42 .....	533.7	454.2	79.5
Experiment 49 .....	874.9	780.7	94.2
	Grams of feed required to produce		1 gram of gain
Experiment 24 .....	3.26	3.44	.18
Experiment 25 .....	3.44	3.49	.05
Mean of Experiments 24 and 25 .....	3.34	3.46	.12
Experiment 41 .....	3.55	3.25	-.30
Experiment 42 .....	3.49	3.37	-.12
Mean of Experiments 41 and 42 .....	3.51	3.29	-.22
Experiment 49 .....	3.43	3.64	.21
	Percentage of chicks that died during		experiment
Experiment 24 .....	2.1	0.0	-2.1
Experiment 25 .....	0.0	2.3	2.3
Mean of Experiments 24 and 25 .....	1.2	1.1	-0.1
Experiment 41 .....	4.3	0.0	-4.3
Experiment 42 .....	7.1	0.0	-7.1
Mean of Experiments 41 and 42 .....	5.3	0.0	-5.3
Experiment 49 .....	2.1	2.0	-0.1

### Soybean Oil Meal As a Supplement to Other Protein Feeds

It was the plan of these experiments to test soybean oil meal against other protein feeds in chick rations. In all cases, as in the experiments already reported, two other protein feeds were used.

It may be noted from Tables 14, 15, and 16 in the comparison of soybean oil meal with cottonseed meal that the data are not consistent. The results seem to indicate that the supplementary action of these feeds is controlled somewhat by the protein feeds which they are supplementing. For example soybean oil meal produced larger gains in live weight in the pullets with very little difference in the cockerels, required less feed per unit of gain in experiment 25, and gave a higher mortality than did cottonseed meal, with the exception of experiment 42 (Table 14), in which these feeds were used to supplement dried skimmed milk and meat and bone scraps (Table 14). There was very little difference in the results produced by soybean oil meal and cottonseed meal when these feeds were supplementing dried skimmed milk and sardine meal, except that a smaller

Table No. 14. Soybean Oil Meal as Compared with Cottonseed Meal when Fed with Dried Skimmed Milk and Meat and Bone Scraps

	Ration 5 Soybean oil meal	Ration 1 Cottonseed meal	Advantages of Soybean oil meal
	Average	gain in live weight	t in grams
<b>COCKERELS</b>			
Experiment 24.....	1142.0	1102.8	39.2
Experiment 25.....	1036.9	1075.4	-38.5
Mean of Experiments 24 and 25...	1090.8	1090.5	0.3
Experiment 41.....	600.4	543.7	56.7
Experiment 42.....	587.5	595.9	-8.4
Mean of Experiments 41 and 42...	596.3	562.7	33.6
<b>PULLETS</b>			
Experiment 24.....	1007.0	888.8	118.2
Experiment 25.....	954.7	900.2	54.5
Mean of Experiments 24 and 25...	986.8	893.6	93.2
Experiment 41.....	521.8	444.5	77.3
Experiment 42.....	476.0	434.7	41.3
Mean of Experiments 41 and 42...	502.5	441.0	61.5
	Grams of feed required to produce	1 gram of gain	
Experiment 24.....	3.32	3.30	-.02
Experiment 25.....	3.50	3.87	.37
Mean of Experiments 24 and 25...	3.39	3.55	.16
Experiment 41.....	3.44	3.48	.04
Experiment 42.....	3.49	3.48	-.01
Mean of Experiments 41 and 42...	3.44	3.48	.04
	Percentage of chicks that died during experiment		
Experiment 24.....	4.0	0.0	-4.0
Experiment 25.....	5.3	2.3	-3.0
Mean of Experiments 24 and 25...	4.5	1.1	-3.4
Experiment 41.....	4.2	0.0	-4.2
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	2.7	0.0	-2.7

percentage of the chicks died in the groups receiving soybean oil meal, with the exception of experiment 42, where there was no difference (Table 15). When these two feeds were used to supplement sardine meal and meat and bone scraps, 16.7 per cent of the chicks died in the groups receiving soybean oil meal and only 2.1 per cent of those in the cottonseed meal groups died (Table 16). The mortality in the first case is excessive. Again it probably is not desirable to use meat and bone scraps and sardine meal in the amounts used in these tests in the same ration for chicks; but if these two feeds are used in the same ration, cottonseed meal is a much more desirable supplement to them than is soybean oil meal.

Soybean oil meal did not produce as rapid gains in live weight as did dried skimmed milk when these feeds were used as supplements to sardine meal and cottonseed meal (Table 17). There was very little difference in the grams of feed required to produce a gram of gain in experiments 24 and 25, but in experiments 41 and 42 the groups receiving dried skimmed milk required almost one half of a gram less feed to produce a gram of gain than did the soybean oil meal groups. The results on the percentage of chicks that died in these two groups are conflicting. In experiments 24 and 25, there was a higher mortality in the dried skimmed milk

Table No. 15. Soybean Oil Meal as Compared with Cottonseed Meal when Fed with Dried Skimmed Milk and Sardine Meal

	Ration 4 Soybean oil meal	Ration 3 Cottonseed meal	Advantages of Soybean oil meal
	Average	gain in live weight	in grams
<b>COCKERELS</b>			
Experiment 24.....	1186.2	1207.6	-21.4
Experiment 25.....	1176.3	1178.4	-2.1
Mean of Experiments 24 and 25.....	1181.7	1196.3	-14.6
Experiment 41.....	624.9	650.1	-25.2
Experiment 42.....	657.9	695.8	-37.9
Mean of Experiments 41 and 42.....	635.1	666.6	-31.5
<b>PULLETS</b>			
Experiment 24.....	983.3	990.1	-6.8
Experiment 25.....	993.1	966.5	26.6
Mean of Experiments 24 and 25.....	987.3	978.5	8.8
Experiment 41.....	579.6	587.7	-8.1
Experiment 42.....	629.2	591.1	38.1
Mean of Experiments 41 and 42.....	599.7	589.0	10.7
	Grams of feed required to produce	1 gram of gain	
Experiment 24.....	3.23	3.23	0
Experiment 25.....	3.41	3.40	-.01
Mean of Experiments 24 and 25.....	3.31	3.30	-.01
Experiment 41.....	3.18	3.13	-.05
Experiment 42.....	2.95	3.02	-.07
Mean of Experiments 41 and 42.....	3.10	3.09	-.01
	Percentage of chicks that died during	experiment	
Experiment 24.....	0.0	2.2	2.2
Experiment 25.....	2.5	5.3	2.8
Mean of Experiments 24 and 25.....	1.1	3.6	2.5
Experiment 41.....	1.9	4.1	2.2
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42.....	1.3	2.6	1.3

Table No. 16. Soybean Oil Meal as Compared with Cottonseed Meal when Fed with Meat and Bone Scraps and Sardine Meal

Experiment 49	Ration 7 Soybean oil meal	Ration 9 Cottonseed meal	Advantages of Soybean oil meal
<b>COCKERELS</b>			
Average gain in live weight in grams	1057.7	1018.2	39.5
<b>PULLETS</b>			
Average gain in live weight in grams	873.4	876.4	-3.0
Grams of feed required to produce 1 gram of gain.....	3.39	3.36	-.03
Percentage of chicks that died during the experiment.....	16.7	2.1	-14.6

groups, while in experiments 41 and 42 there was a higher mortality in the soybean oil meal groups (Table 17). From the data available it is impossible to explain this inconsistency.

When soybean oil meal and meat and bone scraps were fed as supplements to dried skimmed milk and cottonseed meal, the meat and bone scraps produced larger gains in live weight in both cockerels and pullets,

**Table No. 17. Soybean Oil Meal as Compared with Dried Skimmed Milk when Fed with Sardine Meal and Cottonseed Meal**

	Ration 6 Soybean oil meal	Ration 3 Dried skimmed milk	Advantages of Soybean oil meal
	Average gain in live weight		t in grams
<b>COCKERELS</b>			
Experiment 24.....	1183.4	1207.6	-24.2
Experiment 25.....	1144.8	1178.4	-33.6
Mean of Experiments 24 and 25.....	1166.2	1196.3	-30.1
Experiment 41.....	585.0	650.1	-65.1
Experiment 42.....	620.9	695.8	-74.9
Mean of Experiments 41 and 42.....	597.0	666.6	-69.6
<b>PULLETS</b>			
Experiment 24.....	951.8	990.1	-38.3
Experiment 25.....	963.5	966.5	-3.0
Mean of Experiments 24 and 25.....	955.5	978.5	-23.0
Experiment 41.....	523.7	587.7	-64.0
Experiment 42.....	549.3	591.1	-41.8
Mean of Experiments 41 and 42.....	533.7	589.0	-55.3
	Grams of feed required to produce 1 gram of gain		
Experiment 24.....	3.25	3.23	-.02
Experiment 25.....	3.44	3.40	-.04
Mean of Experiments 24 and 25.....	3.34	3.30	-.04
Experiment 41.....	3.55	3.13	-.42
Experiment 42.....	3.49	3.02	-.47
Mean of Experiments 41 and 42.....	3.51	3.09	-.42
	Percentage of chicks that died during experiment		
Experiment 24.....	2.1	2.2	0.1
Experiment 25.....	0.0	5.3	5.3
Mean of Experiments 24 and 25.....	1.2	3.6	2.4
Experiment 41.....	4.3	4.1	-0.2
Experiment 42.....	7.1	0.0	-7.1
Mean of Experiments 41 and 42.....	5.3	2.6	-2.7

with the exception of experiment 41, than did soybean oil meal. The soybean oil meal groups required a smaller amount of feed to produce a gram of gain than did the groups receiving meat and bone scraps, with the exception of experiment 24. The mortality in these groups was low and the difference probably could not be attributed to either of the two feeds under comparison (Table 18). When soybean oil meal and meat and bone scraps were fed with sardine meal and cottonseed meal, the soybean oil meal produced much larger gains in live weight in the cockerels than did meat and bone scraps (Table 19). The average gains in live weight of these two groups were 1158.6 and 1018.2 grams, respectively. In comparing the group fed soybean oil meal and that fed meat and bone scraps, there was practically no difference in the gains in live weight of the pullets and in the grams of feed required to produce a gram of gain (Table 23). There was no difference in the percentage of chicks that died between the groups receiving soybean oil meal and those receiving meat and bone scraps when these feeds were supplementing sardine meal and cottonseed meal.

From the data given above, it may be noted that soybean oil meal is satisfactory as compared with cottonseed meal and meat and bone scraps

in chick rations. It may well be used to replace either of these feeds provided the ration contains either dried milk or vacuum-dried sardine meal. This is in line with the work of Roberts and Carrick (25).

**Table No. 18. Soybean Oil Meal as Compared with Meat and Bone Scraps when Fed with Dried Skimmed milk and Cottonseed Meal**

	Ration 2 Soybean oil meal	Ration 1 Meat and bone scraps	Advantages of Soybean oil meal
	Average	gain in live weight	t in grams
<b>COCKERELS</b>			
Experiment 24.....	1040.9	1102.8	-61.9
Experiment 25.....	1050.8	1075.4	-24.6
Mean of Experiments 24 and 25...	1044.7	1090.5	-45.8
Experiment 41.....	585.4	543.7	41.7
Experiment 42.....	571.4	595.9	-24.5
Mean of Experiments 41 and 42...	580.4	562.7	17.7
<b>PULLETS</b>			
Experiment 24.....	879.4	888.8	-9.4
Experiment 25.....	877.8	900.2	-22.4
Mean of Experiments 24 and 25...	878.6	893.6	-15.0
Experiment 41.....	478.1	444.5	33.6
Experiment 42.....	409.7	434.7	-25.0
Mean of Experiments 41 and 42...	454.2	441.0	13.2
	Grams of feed required to produce	1 gram of gain	
Experiment 24.....	3.44	3.30	-.14
Experiment 25.....	3.49	3.87	.38
Mean of Experiments 24 and 25...	3.46	3.55	.09
Experiment 41.....	3.25	3.48	.23
Experiment 42.....	3.37	3.48	.11
Mean of Experiments 41 and 42...	3.29	3.48	.19
	Percentage of chicks that died during	experiment	
Experiment 24.....	0.0	0.0	0.0
Experiment 25.....	2.3	2.3	0.0
Mean of Experiments 24 and 25...	1.1	1.1	0.0
Experiment 41.....	0.0	0.0	0.0
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	0.0	0.0	0.0

**Table No. 19. Soybean Oil Meal as Compared with Meat and Bone Scraps when Fed with Sardine Meal and Cottonseed Meal**

Experiment 49	Ration 6 Soybean oil meal	Ration 9 Meat and bone scraps	Advantages of Soybean oil meal
<b>COCKERELS</b>			
Average gain in live weight in grams	1158.6	1018.2	140.4
<b>PULLETS</b>			
Average gain in live weight in grams	874.9	876.4	-1.5
Grams of feed required to produce 1 gram of gain.....	3.43	3.36	-.07
Percentage of chicks that died during the experiment.....	2.1	2.1	0.0

### Cottonseed Meal As a Protein Supplement to Other Protein Feeds

When meat and bone scraps and cottonseed meal were used as supplements to soybean oil meal and dried milk or soybean oil meal and sardine meal, the results were not consistent. With the exception of experiments 24 and 49, there was very little difference in the average gains in live weight of the cockerels in the groups receiving cottonseed meal and those receiving meat and bone scraps (Tables 20 and 21); there was a larger gain in live weight in the pullets of the groups receiving meat and bone scraps, with the exception of the pullets in experiment 49 (Table 21). The meat and bone scraps groups required less feed per gram of gain than did the cottonseed meal groups in experiment 24. The group fed cottonseed meal required a smaller amount of feed to produce a gram of gain in experiments 41 and 42 and there was practically no difference in the grams of feed per gram of gain in live weight between the groups fed cottonseed meal and those fed meat and bone scraps in experiments 25 and 49 (Tables 20 and 21). The mortality was consistently higher in the groups fed meat and bone scraps, with the exception of experiment 42 (Tables 20 and 21).

**Table No. 20. Cottonseed Meal as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Dried Skimmed Milk**

	Ration 2 Cottonseed meal	Ration 5 Meat and bone scraps	Advantages of Cottonseed meal
	Average	gain in live weight	in grams
<b>COCKERELS</b>			
Experiment 24.....	1040.9	1142.0	-101.1
Experiment 25.....	1050.8	1036.9	13.9
Mean of Experiments 24 and 25...	1044.7	1090.8	-46.1
Experiment 41.....	585.4	600.4	-15.0
Experiment 42.....	571.4	587.5	-16.1
Mean of Experiments 41 and 42...	580.4	596.3	-15.9
<b>PULLETS</b>			
Experiment 24.....	879.4	1007.0	-127.6
Experiment 25.....	877.8	954.7	-76.9
Mean of Experiments 24 and 25...	878.6	986.8	-108.2
Experiment 41.....	478.1	521.8	-43.7
Experiment 42.....	409.7	476.0	-66.3
Mean of Experiments 41 and 42...	454.2	502.5	-48.3
	Grams of feed required to produce	1 gram of gain	
Experiment 24.....	3.44	3.32	-.12
Experiment 25.....	3.49	3.50	.01
Mean of Experiments 24 and 25...	3.46	3.39	-.07
Experiment 41.....	3.25	3.44	.19
Experiment 42.....	3.37	3.49	.12
Mean of Experiments 41 and 42...	3.29	3.44	.15
	Percentage of chicks that died during experiment		
Experiment 24.....	0.0	4.0	4.0
Experiment 25.....	2.3	5.3	3.0
Mean of Experiments 24 and 25...	1.1	4.5	3.4
Experiment 41.....	0.0	4.2	4.2
Experiment 42.....	0.0	0.0	0.0
Mean of Experiments 41 and 42...	0.0	2.7	2.7

Table No. 21. Cottonseed Meal as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Sardine Meal

Experiment 49	Ration 6 Cottonseed meal	Ration 7 Meat and bone scraps	Advantages of Cottonseed meal
<b>COCKERELS</b> Average gain in live weight in grams	1158.6	1057.7	100.9
<b>PULLETS</b> Average gain in live weight in grams	874.9	873.4	1.5
Grams of feed required to produce 1 gram of gain.....	3.43	3.39	-.04
Percentage of chicks that died during the experiment.....	2.1	16.7	14.6

It may be noted from Table 22 that dried skimmed milk produced larger gains in live weight in both cockerels and pullets, with the exception of experiment 49, than did cottonseed meal when these feeds were supplementing soybean oil meal and sardine meal. The advantages of the

Table No. 22. Cottonseed Meal as Compared with Dried Skimmed Milk when Fed with Soybean Oil Meal and Sardine Meal

	Ration 6 Cottonseed meal	Ration 4 Dried skimmed milk	Advantages of Cottonseed meal
	Average gain in live weight in grams		
<b>COCKERELS</b>			
Experiment 24.....	1183.4	1186.2	- 2.8
Experiment 25.....	1144.8	1176.3	-31.5
Mean of Experiments 24 and 25...	1161.2	1181.7	-20.5
Experiment 41.....	585.0	624.9	-39.9
Experiment 42.....	620.9	657.9	-37.0
Mean of Experiments 41 and 42...	597.0	635.1	-38.1
Experiment 49.....	1158.6	1145.1	13.5
<b>PULLETS</b>			
Experiment 24.....	951.8	983.3	-31.5
Experiment 25.....	963.5	993.1	-29.6
Mean of Experiments 24 and 25...	955.5	987.3	-31.8
Experiment 41.....	523.7	579.6	-55.9
Experiment 42.....	549.3	629.2	-79.9
Mean of Experiments 41 and 42...	533.7	599.7	-66.0
Experiment 49.....	874.9	841.0	33.9
	Grams of feed required to produce 1 gram of gain		
Experiment 24.....	3.26	3.23	-.03
Experiment 25.....	3.44	3.41	-.03
Mean of Experiments 24 and 25...	3.34	3.31	-.03
Experiment 41.....	3.55	3.18	-.37
Experiment 42.....	3.49	2.95	-.54
Mean of Experiments 41 and 42...	3.51	3.10	-.41
Experiment 49.....	3.43	3.41	-.02
	Percentage of chicks that died during experiment		
Experiment 24.....	2.1	0.0	-2.1
Experiment 25.....	0.0	2.5	2.5
Mean of Experiments 24 and 25...	1.2	1.1	-0.1
Experiment 41.....	4.3	1.9	-2.4
Experiment 42.....	7.1	0.0	-7.1
Mean of Experiments 41 and 42...	5.3	1.3	-4.0
Experiment 49.....	2.1	0.0	-2.1

dried skimmed milk over cottonseed meal in the pullets of experiments 41 and 42 were 55.9 and 79.9 grams, respectively (Table 22). The advantages of other groups receiving dried skimmed milk over those fed cottonseed meal as regards gains in live weight were of a rather small magnitude, ranging from 2.8 to 39.9 grams. Between the groups fed cottonseed meal and those fed dried skimmed milk, there was practically no difference in the grams of feed required to produce a gram of gain in experiments 24, 25, and 49; but a decided advantage appeared in favor of the dried skimmed milk groups in experiments 41 and 42. The percentage of chicks that died in groups receiving dried skimmed milk was consistently higher than that of the groups receiving cottonseed meal, with the exception of experiment 25 (Table 22). It should be noted here that both of these rations contained sardine meal, which in some cases has been associated with a slight increase in the percentage of chicks that died. However, in this case the use of dried skimmed milk, soybean oil meal, and sardine meal resulted in a low mortality. This would seem to indicate that a combination of these three feeds in a chick ration will give very satisfactory growth at low feed cost per gram of gain in live weight and with a low mortality.

#### Dried Skimmed Milk As a Supplement for Other Protein Feeds for Chicks

Dried skimmed milk and meat and bone scraps were of equal value as regards average gain in grams of live weight, grams of feed required to produce a gram of gain, and percentage of chicks that died during the experimental period when these feeds were supplementing soybean oil meal and cottonseed meal (Table 23.) However, dried skimmed milk produced larger gains in live weight and a smaller percentage of deaths than did meat and bone scraps when these feeds were supplementing soybean oil meal and sardine meal. The mortality of the groups receiving meat and bone scraps was excessive. This is the group where this feed was fed in a combination with sardine meal and soybean oil meal (Table 24).

Table No. 23. Dried Skimmed Milk as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Cottonseed Meal

	Ration 2 Dried skimmed milk	Ration 8 Meat and bone scraps	Advantages of Dried skimmed milk
COCKERELS			
Average gain in live weight in grams	1001.0	1002.4	-1.4
PULLETS			
Average gain in live weight in grams	780.7	778.1	2.6
Grams of feed required to produce 1 gram of gain.....	3.64	3.56	-.08
Percentage of chicks that died during the experiment.....	2.0	0.0	-2.0



Table No. 24. Dried Skimmed Milk as Compared with Meat and Bone Scraps when Fed with Soybean Oil Meal and Sardine Meal

Experiment 49	Ration 4 Dried skimmed milk	Ration 7 Meat and bone scraps	Advantages of Dried skimmed milk
COCKERELS			
Average gain in live weight in grams	1145.1	1057.7	87.4
PULLETS			
Average gain in live weight in grams	841.0	873.4	-32.4
Grams of feed required to produce 1 gram of gain.....	3.41	3.39	-.02
Percentage of chicks that died during the experiment.....	0.0	16.7	16.7

## DISCUSSION

From the data discussed earlier, it is seen that chick rations should contain either sardine meal, dried skimmed milk, or meat and bone scraps. Dried skimmed milk may be used in combination with either meat and bone scraps or sardine meal but meat and bone scraps and sardine meal should not be used in the same ration in the percentages fed in these experiments because of the high mortality that was associated with this combination when these feeds were used with soybean oil meal. When sardine meal and meat and bone scraps were used with cottonseed meal, this high mortality was not encountered.

In tests reported in this bulletin, sardine meal proved to be an outstanding feed for use in chick rations as regards rapid growth and efficient use of the feed consumed. In practically all cases, rations containing sardine meal produced larger gains in live weight at a smaller feed cost per gram of gain regardless of whether dried skimmed milk was a constituent of the ration or not. These results are in line with those reported by Daniel and McCollum (8), Asmundson and Biely (4), Johnson and Brazie (11), and Record and co-workers (21, 22). However, with the exception of ration 4—which contained sardine meal, dried skimmed milk, and soybean oil meal—a slightly higher mortality was associated with the use of sardine meal in every case. (The use of "slightly higher mortality" here refers to a death rate of 0 to 7.5 per cent). No explanation for the increased death rate with the feeding of sardine meal is given. If sardine meal was fed in combination with soybean oil meal and dried milk, the percentage of the chicks that died was very low. The slight increase in the death rate when cottonseed meal was substituted for soybean oil meal in the above combination, is also unexplainable (Ration 3). With this exception, cottonseed meal and soybean oil meal may be used interchangeably or in combination in chick rations. This is in line with the work of Ringrose and Morgan (23) and Roberts and Carrick (25). The data given in Table 23 indicate that meat and bone scraps and dried skimmed milk may be used interchangeably in combination with soybean oil meal and cottonseed meal. Both of these combina-

tions gave satisfactory growth, though not as rapid growth as some other combinations used in these tests, at a reasonably economical feed cost per gram of gain and with a very low mortality. An explanation for this fact might be that certain factors contained in milk and required by chicks are also found in cottonseed meal and soybean oil meal and also that if there is a slight deficiency of these factors in the meat and bone scraps ration, it is offset by the meat and bone scraps.

## CONCLUSIONS

From the data secured under the conditions of the experiments herein reported, the following conclusions seem warranted:

1. Chick rations should contain either sardine meal, meat and bone scraps, or dried skimmed milk in combination with other protein feeds.

2. Vacuum-dried sardine meal is an excellent protein feed to use in chick rations to supplement other protein feeds. A slightly higher mortality is associated with the use of this feed in chick rations except when it is used in combination with dried milk and soybean oil meal.

3. Dried skimmed milk and meat and bone scraps are of about equal value as regards growth, efficient use of the feed, and percentage of the chicks that die when these feeds are supplementing soybean oil meal and cottonseed meal.

4. Cottonseed meal and soybean oil meal may be used interchangeably in chick rations.

5. Sardine meal and meat and bone scraps probably should not be used in the same ration with soybean oil meal in the amounts fed in these experiments because of the high mortality associated with this combination. Further work is needed to substantiate this point.

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