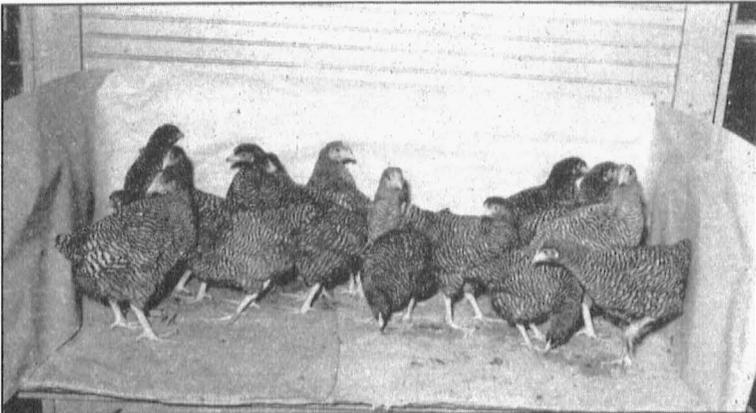


UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
M. F. MILLER, *Director*

The Value of Soybean Oil Meal in Broiler Rations

M. RICHARD IRWIN AND H. L. KEMPSTER



COLUMBIA, MISSOURI

The Value of Soybean Oil Meal in Broiler Rations

M. RICHARD IRWIN AND H. L. KEMPSTER

Feed costs alone, account for more than half the cost of producing poultry meat and protein supplements are the most costly ingredients used in the ration. Therefore, it is desirable to formulate rations using more economical sources of protein than are commonly used in poultry rations, so as to substantially lower feed costs, improve growth and development, and favorably affect other economic factors.

Rations that produce rapid growth and economical gains should interest poultrymen who raise large numbers of chicks annually for laying flock replacement. This type of ration should especially interest broiler producers, whose chicks must attain an average weight of two pounds or more within the relative short period of ten or twelve weeks. Of particular value at the present time are rations which attain the desired objectives at lower cost to the producer.

It has been observed and reported, that the rapidity of growth is related to the amount of protein in the ration. Within limits, more rapid growth is obtained by feeding rations having a higher protein content. Animal sources of protein are considered most desirable, because of their content of essential amino acids and minerals. However, the common sources of animal protein have lost some of their original value, because they have been "skimmed" of valuable glands for extraction in the preparation of pharmaceuticals for human use.

For years, soybeans and soybean products have been used as a substitute for meat in the diet of the people of the Orient and have also been used extensively in the diet of infants and of diabetics. More recently soybeans and their products have been used in the rations of swine, cattle and poultry.

The data and discussion given in this bulletin are the results of a two year study undertaken for the purpose of formulating rations in which soybean oil meal was substituted at different levels for the comparatively high priced meat scraps and dried milk. These food-stuffs are the more common sources of animal protein used in poultry rations. The objective was to develop rations using soybean oil meal that would promote rapid growth and produce economical gains in young chicks.

Source of Chicks

The chicks used in these experiments were of three dual purpose breeds commonly used by broiler producers in this area. The New Hampshires in all lots were hatched from eggs produced at the College Poultry Farm. The White Rocks and Barred Rocks were purchased from a local hatchery. All chicks were banded and weighed individually on the day hatched and immediately placed in brooders with the experimental ration and water before them at all times. The chicks of each lot were brooded together and the sexes were recorded at 8 weeks and observed again at 10 weeks of age.

Brooding and Rearing Quarters

The brooding quarters used during the first six weeks of the growth period were the starting batteries which were available at the College Poultry Farm. The same type of battery brooder was not used in every case, but all lots of the same age were allowed exactly the same amount of floor, feeder, and water space.

The desired starting temperature was 95°F for the first week, with a reduction in temperature of 5°F each week as the chicks became older. Failure to reduce the starting temperature as described may result in slow feather growth. After six weeks the birds were moved to more roomy quarters which did not provide additional heat. The chicks did not receive direct sunlight at any time nor was artificial light used at night to encourage the chicks to consume more feed.

Preparation of Rations

The rations formulated were mixed by hand. The ingredients were weighed out, the cod liver oil was mixed with the bran portion of the ration, and the ingredients were then shoveled back and forth until thoroughly mixed. Enough feed was prepared to supply each lot for the ten weeks feeding period. When repeat trials were run, a new mixture was made so that feeds were not over ten weeks old when fed to any particular lot.

The Missouri chick starting ration was used as the control for all feeding trials and has been designated as Ration No. 4001. It will be noticed that this ration is at slight disadvantage for making comparisons on early growth of chicks because the crude protein content is lower than for any of the other rations. However, the higher levels of crude protein were attained by adding different levels of soybean oil meal so that an economical ration of high crude protein content is produced. Table 2 gives the composition of all rations used in these feeding trials. The crude protein content was calculated from values given in Henry and Morrison tables. Since vitamin G is nec-

essary for growth, units of this vitamin were also calculated. A level of 290 units of vitamin G per 100 grams of feed is considered essential for normal growth.

The source of the protein concentrates used and their analyses as given on the sack are shown in the following table:

TABLE 1.—ANALYSES OF PROTEIN CONCENTRATES USED.

Protein Concentrate	Per Cent				
	Crude Protein	Crude Fat	Crude Fibre	N.F.E.	Ash
Meat scraps	50	6	2	1	—
Soybean Oil Meal (old process, expeller)	41	5	7	28	7.5
Dried buttermilk	31	6	1	35	—

At the beginning of these trials, dried skim milk was used in the rations fed to the hatch of November 28, 1939. All other hatches received dried buttermilk as indicated in Table 2.

Procedure

A total of 630 chicks were started in 7 trials, and records were kept on 42 different lots of chicks. Rations which showed promise were repeated in later trials and the better rations were repeated in 4 separate trials.

The chicks were weighed when one day old and then weighed individually at intervals of two weeks throughout the ten weeks growing period.

Feed was weighed out each time that the chicks were weighed, and the feed consumption for the two week period was calculated.

Basic Trials with Rations Containing Soybean Oil Meal

The first feeding trial with New Hampshire chicks was started November 27, 1939. This trial was an attempt to establish the optimum protein level in rations for growing chicks which might serve as a guide for future trials and also to study rations using soybean oil meal as a partial substitute for protein concentrates of animal origin, i.e., meat scrap and dried milk. From a study of other work it was decided to use rations containing approximately 20 per cent protein. Ration 4001, the control, contained 17.3 per cent protein and ration 4005, which was formulated to test the effect on early growth of additional protein concentrates, contained 22 per cent protein. The other rations, 4002, 4003, and 4004 contained 20 per cent protein. The primary differences in the rations was the proportion of dried milk, meat scrap and soybean oil meal used. All rations except the control contained from 42 to 45 per cent yellow corn meal,

TABLE 2.—COMPOSITION OF RATIONS.

Ration No.	4001	4002	4003	4004	4005	4006	40 07	4008	4009	4010	4011	4012	4013	4014	4015
Yellow corn meal	53	45	45	43	42	45	45	45	45	53	42½	40	40	40	41
Bran	10	10	10	10	10	8	7	5	5	7½	10	7½	10	10	10
Alfalfa leaf meal	5	5	5	5	5	7	8	10	10	7½	10	10	10	10	10
Shorts	15	15	15	15	15	15	15	15	15	15	15	10	10	10	10
Dried Buttermilk	5	5	3	3	6	3	2			2½		5		2	
Meat scrap	10	13	10	6	10	10	8	7	10	10	5	5	2		
Soybean oil meal		5	10	15	15	10	13	15	15	2½	20	20	25	25	25
Bone meal				1				½			½	½	1	1	2
Salt	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cod liver oil	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Crude Protein*	17.30	20.08	20.04	20.00	22.06	20.19	20.21	20.00	21.52	17.47	21.76	21.92	21.32	21.00	20.39
Units of Vitamin G*	353	368	325	314	397	357	3 48	382	350	341	343	435	331	359	296

*Calculated.

10 per cent bran, 5 per cent alfalfa leaf meal, 15 per cent shorts and 1 per cent each of salt and cod liver oil. The cod liver oil contained 85 A.O.A.C. units of vitamin G per gram. Because of the lower meat scrap content of ration 4004, 1 per cent bone meal was added in order to maintain the calcium phosphate level. The essential differences in the rations and a summary of the results of this trial are shown in the following table. All tables shown in this discussion give the weights in grams and the efficiency of gains at 10 weeks of age. One pound is equal to 454 grams.

TABLE 3.—EFFECT OF VARIOUS COMBINATIONS OF MEAT SCRAP, DRIED SKIM-MILK AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Skim-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	1090	921	3.28
4002	5	13	5	20.0	1051	890	3.64
4003	3	10	10	20.0	984	925	3.39
4004	3	6	15	20.0	1181	940	3.35
4005	3	10	15	22.0	1026	953	3.54

*Control.

From the above data no definite conclusions relative to the optimum protein level in rations for young chicks can be drawn. On the basis of growth, ration 4004 gave best results while from the standpoint of economy of gains it ranked slightly below the control ration. The significant conclusion that can be drawn from this test is that soybean oil meal can be used as a partial substitute for meat scrap and dried skim milk in rations for growing chicks.

In the second trial started January 27, 1940, rations 4001, 4002, 4003 and 4004 were repeated with White Rocks as the experimental chicks. The essential differences in the content of these rations have been explained in the foregoing description of the first trial. The results of this trial are given in the following table:

TABLE 4.—EFFECT OF VARIOUS COMBINATIONS OF MEAT SCRAP, DRIED BUTTERMILK AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	1146	1083	3.60
4002	5	13	5	20.0	1294	1088	3.28
4003	3	10	10	20.0	1277	1107	3.57
4004	3	6	15	20.0	1305	1091	3.48

*Controls.

In the second trial, it is interesting to note that the lower level of protein in the control ration resulted in slower growth in the males than was experienced in the other rations with the higher protein

level. This difference in growth rate was not evident among the females where no significant differences were experienced.

This experiment further demonstrated that lowering the milk content of the ration by use of soybean oil meal did not impair the ration. Ration 4004 in which the amount of dried milk and meat scrap used was only 60 per cent of the amount normally recommended, was satisfactory. The favorable results obtained from this ration were due, no doubt, to the substitution of soybean oil meal. In this, as in the previous trial, there appeared no significant differences between the various rations. The three rations containing 20 per cent protein produced results comparable to the control ration which contained 17.3 per cent protein so that, on the basis of these trials, no conclusions can be drawn as to the optimum protein level to employ.

Rations Using Low Levels of Dried Milk

In the spring of 1940, dried buttermilk and dried skim milk prices advanced and feed manufacturers began making inquiry regarding the advisability of lowering the dried milk content of the chick starting and growing ration.

When soybean oil meal is added to the ration and the amount of dried milk is decreased, it must be kept in mind that the vitamin G content of the ration may be vitally affected. Alfalfa leaf meal may be employed as a substitute for dried milk in the ration in order to maintain the vitamin G content at an optimum level. This adjustment is limited, however, to the extent that the alfalfa leaf meal is not as palatable as other ingredients when fed at high levels and the fiber content of the ration is increased by this exchange.

New Hampshire chicks were used in the third feeding trial which was started April 26, 1940. The new rations formulated, from 4006 to 4009 inclusive, contained 45 per cent of yellow corn meal while ration 4010 contained 53 per cent of yellow corn meal. The bran portion of the rations was lowered to 5 per cent in rations 4008 and 4009 which is one half the amount normally recommended. The alfalfa leaf meal was increased in the same proportion by which the bran was lowered. These changes were made so that the alfalfa leaf meal might be safely added to supply the vitamin G without materially affecting the fiber content of the rations involved.

The essential changes made in these new rations from those used in previous trials was in the decided lowering of the dried buttermilk content. Ration 4006 contained only 3 per cent dried milk, ration 4007 contained 2 per cent dried milk, while ration 4008 and 4009 contained no dried milk. Ration 4010, at the time, was a more economical mix than the Missouri chick starting ration which is the control ration

4001. Ration 4010 contained 17.4 per cent protein while the other rations contained 20 per cent protein. Ration 4009 was an exception to this, however, as it carried the high level of 21.5 per cent protein. One-half of 1 per cent bone meal was added to ration 4008 because the meat scrap was lowered and the dried milk omitted entirely. The essential differences in the composition of the rations used in this third trial and the results obtained are shown in the following table:

TABLE 5.—EFFECT OF LOW LEVELS OF DRIED MILK WITH VARIOUS COMBINATIONS OF MEAT SCRAP AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	772	731	4.01
4006	3	10	10	20.2	997	895	3.29
4007	2	8	13	20.2	994	841	3.48
4008	..	7	15	20.0	944	774	3.72
4009	..	10	15	21.5	1000	862	3.73
4010	2½	10	2½	17.4	844	749	4.53

*Controls.

From these results it is evident that better growth and more economical gains were obtained from the use of rations containing 20 per cent protein than from rations containing 17+ per cent protein. Ration 4009 containing 21.5 per cent protein produced growth comparable to ration 4006 but not as economical gains. The essential difference between these two rations is that ration 4006 contained 3 per cent dried milk and 10 per cent soybean oil meal whereas ration 4009 contained 15 per cent soybean oil meal. While the results from rations 4008 and 4009 which contained no milk were not quite as efficient as measured by the amount of feed to produce a pound of gain, the results demonstrate that satisfactory results can be obtained even though milk is not used in the ration. The value of milk in rations for young chicks has long been recognized. This is demonstrated by comparing rations 4006, 4007, and 4008. All contain approximately 20 per cent protein but the economy of gains was in direct proportion to the amount of milk used in the diet.

It is noticeable that the chicks in this trial did not attain the weights of chicks fed in the two previous trials. This may be explained by the fact that the chicks were hatched later in the season and extremely high temperatures prevailed during the latter part of the growing period. High temperatures have an adverse effect on the growth rate of young chicks as shown by the work of Kempster and Parker (1936).

On June 15, 1940, small lots of New Hampshire chicks were fed rations 4006 to 4010, inclusive, in another trial to again test these rations which employed low levels of dried milk.

TABLE 6.—EFFECT OF LOW LEVELS OF DRIED MILK WITH VARIOUS COMBINATIONS OF MEAT SCRAP AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	752	773	3.90
4006	3	10	10	20.2	949	741	3.27
4007	2	8	13	20.2	1008	925	3.00
4008	..	7	15	20.0	885	692	3.80
4009	..	16	15	21.5	1041	817	3.10
4010	2½	10	2½	17.4	800	775	4.18

*Controls

In this trial the results agree with the previous experience in that the rations with higher protein levels produced the greater and more economical gains. No explanation can be made as to the absence of appreciable weight differences between the males and females fed the two rations having the lower protein levels. Ration 4009 containing 21.5 per cent protein produced results comparable to ration 4007. It will be recalled that ration 4009 contained no milk, whereas ration 4007 contained 2 per cent dried milk. These results again demonstrate that milk is not indispensable in poultry rations. While every attempt was made to have the various lots of chicks uniform, inherent differences in the ability to grow do occur and the effect is more pronounced when small numbers are involved.

Rations Containing High Levels of Soybean Oil Meal

Rations containing a maximum of 15 per cent soybean oil meal had been used in trials up to this point. Since these rations had been reasonably successful, the results indicated that it might be practical to feed even higher levels of soybean oil meal and correspondingly lower levels of both meat scrap and dried milk. When this type of ration is formulated, an adjustment must be made in the mineral content because when the meat scrap is lowered to as much as one-half the normal amount the mineral content of the ration is materially reduced. Then too, the amount of alfalfa leaf meal must be increased when the dried milk content is lowered in order to maintain the vitamin G level of the ration.

Rations 4011, 4012, 4013, and 4014 were formulated with the above points in mind and fed to New Hampshire chicks hatched June 15, 1940. Rations 4006 to 4010, inclusive, were fed at the same time in order to compare results obtained under similar conditions.

Ration 4011 contained 42½ per cent of yellow corn meal and the other rations contained only 40 per cent. This is about the lowest limit that it would be advisable to go with levels of yellow corn meal in this section of the country when the widespread availability of

this foodstuff is considered. All of the rations in this group, 4011 to 4014, contained 10 per cent of alfalfa leaf meal which is twice the amount normally recommended. Another essential difference in the basal portion of these rations was in the amount of wheat shorts. Ration 4011 contained the usual level of 15 per cent while rations 4012, 4013, and 4014 each contained 10 per cent of wheat shorts. Because of the lowered meat scrap content, rations 4011 and 4012 each contained one-half of 1 per cent of bone meal and rations 4013 and 4014 each contained 1 per cent of bone meal. Other essential differences with reference to the three protein concentrates involved are shown in the following table:

TABLE 7.—EFFECT OF HIGH LEVELS OF SOYBEAN OIL MEAL COMBINED WITH VARIOUS LEVELS OF MEAT SCRAP AND DRIED MILK ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	752	773	3.90
4011	..	5	20	21.7	1030	871	3.12
4012	5	5	20	21.9	1020	..	2.98
4013	..	2	25	21.3	1004	810	3.68
4014	2	..	25	21.0	888	790	3.99

*Controls.

In this as in previous trials, the rations containing the higher protein levels resulted in better growth as compared to the controls. It will be recalled that previous trials carried much higher levels of meat scrap and dried milk than rations 4011 to 4014 inclusive. Even though lower levels of animal protein concentrates were used the growth experienced and economy of gains compared favorably with previous trials. The two rations used which contained no milk, 4011 and 4013, produced results comparable to ration 4012 which contained 5 per cent milk.

A study of the data shown in Tables 6 and 7 reveals the effect of the protein level on growth. In this trial, the weights of the male chicks increased directly as the amount of protein in the ration increased. The weights of the female chicks were not increased proportionately even though the protein content was as much as 4.5 per cent greater than in the control ration. In these two trials it was apparent that on the basis of growth experienced, the male chicks utilized the additional protein to better advantage than was the case for the female chicks fed the same ration.

The rations containing levels of 20 to 25 per cent of soybean oil meal were again fed in a trial started a week later than the group just described. The chicks were New Hampshires and the feeding

trial started June 22, 1940. The results of this feeding test are shown in the following table:

TABLE 8.—EFFECT OF HIGH LEVELS OF SOYBEAN OIL MEAL COMBINED WITH VARIOUS LEVELS OF MEAT SCRAP AND DRIED MILK ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	960	911	2.98
4011	..	5	20	21.7	1108	824	3.05
4012	5	5	20	21.9	1062	943	2.82
4013	..	2	25	21.3	1171	892	3.04
4014	2	..	25	21.0	907	791	3.24

*Controls.

The results of this trial fail to reveal any superior growth and economy of gains by feeding rations of higher protein level. In this respect the results parallel the first experiment reported in which the controls made gains and economy of gains equal to the other rations tested. As in the previous test there was no significant differences between rations 4011, 4012 and 4013 even though ration 4012 contained 5 per cent dried milk.

The complete removal of the meat scrap from ration 4014 and the use of 2 per cent of dried milk again resulted in lower weights at 10 weeks of age when compared with the other lots in this trial.

Under the conditions of these two trials, meat scraps proved superior to dried milk as the sole supplement used with soybean oil meal in the ration. Rations 4011 and 4013 which contained 20 and 25 per cent, respectively, of soybean oil meal produced satisfactory growth and efficient gains in these trials. These results indicate that high levels of soybean oil meal are practical when animal protein sources are considered too costly.

Further Studies of the Better Rations

It was decided to compare a few of the rations which had given superior results in previous trials from the standpoint of efficiency of gains, rate of growth, and physical appearance of the birds. When rations gave equally good results, the ration most economical to prepare was selected to use in these additional studies.

After careful study and consideration of all factors, rations 4004, 4007, 4011, and 4013 were selected because the first two mentioned had given outstanding results and the latter two rations had also given excellent growth and efficiency of gains despite the fact that dried milk had been omitted entirely and the rations contained comparatively high levels of soybean oil meal. Ration 4001 was used again as the control and ration 4015 was added to study the value of a ration which did not contain protein from animal sources.

Essential differences in these rations have been discussed but are summarized again in the following table to facilitate comparison of differences in content of protein concentrates and results.

TABLE 9.—EFFECT OF VARIOUS COMBINATIONS OF MEAT SCRAPS, DRIED BUTTERMILK, AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Buttermilk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	907	842	3.48
4004	3	6	15	20.0	1175	910	3.22
4007	2	8	13	20.2	1114	1035	3.23
4011	..	5	20	21.7	1095	956	3.53
4013	..	2	25	21.3	1032	889	3.44
4015	25	20.4	1004	921	3.57

*Controls.

In this feeding trial, ration 4007 produced the heaviest chicks at 10 weeks of age and together with ration 4004 required less pounds of feed to produce a pound of gain than the other rations compared in this test. Both of these rations contained dried buttermilk, meat scrap and soybean oil meal. This would suggest that combinations of proteins from various sources are more satisfactory than from only two sources.

The use of a single protein concentrate, as was the case when ration 4015 was fed, failed to produce as satisfactory growth even though the ration contained the same amount of protein. Further evidence of the desirability of using a variety of protein concentrates in the ration may be found in comparing rations 4004 and 4007 with rations 4011 and 4013. In spite of the fact that these latter rations carried a higher level of protein the results were not as satisfactory where two sources of protein were used as where three were employed.

Ration 4015 which contained only soybean oil meal as the protein concentrate and with 2 per cent of bone meal added to adjust the calcium phosphate level produced slightly heavier chicks at 10 weeks of age than the control ration but was not as efficient in the production of gains as the control or other rations fed in this trial. The chicks did not eat this ration readily and seemed to pick over the feed and to scratch the mash from the feeders which resulted in considerable waste.

In a feeding trial which started September 23, 1940 Barred Rock chicks were fed rations 4004, 4007, 4011, 4013 and 4015 in an effort to obtain additional data on these particular rations. The essential differences in the rations have been described and therefore only the results in growth and efficiency of gains are shown in the following table:

TABLE 10.—EFFECT OF VARIOUS COMBINATIONS OF MEAT SCRAPS, DRIED MILK, AND SOYBEAN OIL MEAL ON GROWTH AND EFFICIENCY OF GAINS.

Ration No.	Protein Concentrates			Protein content Per cent	Wt. at 10 Wks.		Lbs. feed per pound gain
	Dried Butter-milk	Meat scrap	Soybean oil meal		Grams		
					Males	Females	
4001*	5	10	..	17.3	915	760	3.98
4004	3	6	15	20.0	1032	906	3.43
4007	2	8	13	20.2	1074	887	3.42
4011	..	5	20	21.7	1051	927	3.76
4013	..	2	25	21.3	996	877	4.15
4015	25	20.4	919	950	3.93

*Controls.

Rations 4004, 4007, and 4011 all of which contained 5 per cent or more of meat scraps gave superior results in growth and efficiency of gains when compared with rations 4001, 4013, and 4015. Ration 4011 which did not contain dried milk was somewhat less efficient in producing gains than rations 4004 and 4007. Ration 4004 and 4007 are very similar and differ only slightly in the amount of the three protein concentrates contained in each. The apparent growth and pounds of feed required to produce a pound of gain were essentially the same for chicks fed rations 4004 and 4007.

In this trial, ration 4013 which contained 2 per cent of meat scrap and no dried milk was less efficient in producing gains compared to the other rations including 4015 which did not contain either meat scrap or dried milk. Ration 4015 would appear to have possibilities, but additional study is needed to work out the proper mineral balance for this type of ration. Chicks in both hatches fed ration 4015, were uneven in size and feathering and 3 cases of perosis developed among the 31 individuals on this ration.

The significance of difference between these better rations and the control was determined by the method of analysis of variance. For this determination the 10 weeks weights of all chicks regardless of breed, fed on a particular ration were grouped and considered as a whole.

Using this method of analysis, under the conditions of this experiment and with the number of individuals ranging from 48 to 76, all four rations showed highly significant differences for males when compared with the males fed ration 4001. Fisher's table of 1 per cent points of distribution of z were considered in this determination. Rations 4007 and 4011 gave significant differences for females, but the analysis of rations 4004 and 4013 gave values for z which indicated that the weight differences of female chicks when compared with the controls were not significant.

Efficiency of Gains

In order to facilitate the comparison of efficiency of gains, a method was used by which the control ration 4001 was given a base value of 100 and the merits of the other rations as judged by the pounds of feed to produce a pound of gain to 10 weeks of age were compared. All rations used in all trials were compared on this basis as illustrated in Table 11.

Using this method, the rations considered of sufficient merit for further studies gave values that compared favorably and in most cases gave better results than any used. Ration 4002, for instance, was not selected for additional experiments because it contained high levels of animal protein and the initial cost was higher than that of other rations considered. In two trials, ration 4002 was found to be exactly equal to the control in efficiency of gains with a value of 100 despite the fact that it contained 3 per cent more crude protein. Of the four rations selected, 4007 gave consistently better results in all trials than the other rations under consideration. The cumulative efficiency to 10 weeks for all trials involving the selected rations produced a value of 117 for ration 4007, 107 for ration 4004, 106 for 4011, 100 for ration 4013, indicating it equal to the control, and 99 for ration 4015.

TABLE 11.—RELATIVE EFFICIENCY OF GAINS.

Ration Number	4001	4002	4003	4004	4005	4006	4007	4008	4009	4010	4011	4012	4013	4014	4015
<u>Date Hatched</u>															
Nov 27	100	90	97	98	92										
Jan. 18	100	119	101	104											
Apr. 26	100					122	115	108	108	89					
June 15	100					120	130	103	126	93	125	131	106	98	
June 22	100										95	103	95	89	
Sept. 16	100			108			108				99		101		98
Sept. 23	100			116			116				105		96		101
Average	100	100	99	107	92	121	117	105	117	91	106	117	100	93	99

SUMMARY

1. Rations containing soybean oil meal at levels of 2½ to 25 per cent were fed in seven feeding trials. Growth and feed consumption to 10 weeks of age was recorded at bi-weekly intervals.
2. Rations containing soybean oil meal to the extent of 25 per cent of the total ration produced gains equal to the average of the controls when fed in combination with 2 per cent or more of animal protein supplement.

3. Under the conditions of these experiments, meat scraps proved superior to dried milk as the sole protein supplement used with soybean oil meal in the ration.
4. Rations containing lower levels of dried milk than generally recommended produced rapid growth and economical gains when the alfalfa leaf meal content was adjusted to provide 290 units or more of vitamin G (ribo-flavin) per 100 grams of feed.
5. Rations 4004, 4007, 4011, and 4013 were selected as superior in these trials when all factors were considered including initial cost of ingredients, rate of growth, and economy of gains.
6. Ration 4007 produced significantly greater differences in weight at 10 weeks for both males and females than the other rations considered when compared to ration 4001. Significance of weight differences was determined by the method of analysis of variance.
7. Rations 4004, 4007, 4011, and 4013 gave average values of 107, 117, 106, and 100 respectively, when efficiency of gains was calculated and the control ration, 4001, was given a base value of 100.
8. The results of this study suggests that combinations of proteins from various sources are more satisfactory than from only two sources.
9. The results of trials in which the protein levels ranged from 17.3 per cent to 21.9 per cent indicate that on the basis of growth experienced male chicks utilize the additional protein to better advantage than do female chicks fed the same rations.
10. On the basis of growth alone rations 4002, 4007 and 4009 produced 22 per cent greater growth than did ration 4001. Rations 4004, 4006, 4008, 4011, 4012 and 4013 gave 10 per cent better gains while the other rations 4003, 4005, 4010, 4014 and 4015 produced growth comparable to the control ration.