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Soybean Oil Meal as a Protein Supplement For Baby Chicks

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SUMMARY

A ration which contains soybean oil meal as the only protein supplement is satisfactory for the growth of baby chicks when it is supplemented with riboflavin. The chicks grow at a rapid rate and there are very few abnormalities. The rate of growth is almost as rapid when the soybean oil meal is supplied at level of 25 per cent as when it is supplied at a level of 30 or 40 per cent. When supplied at a level of 15 or 20 per cent the rate of growth is markedly reduced.

The soybean oil meal ration is deficient in riboflavin. The evidence of a deficiency of any other vitamin is inconclusive. The addition of dried whey, dried skim milk, dried yeast or meat scrap to the soybean oil meal ration increases the rate of growth approximately 10 per cent. The addition of dehydrated alfalfa meal has very little effect. When these supplements were added in pairs growth was not more rapid than when each was added separately. When they were added in combinations of more than two the rate of growth, as a rule, was not accelerated.

The amount of steamed bone meal and other sources of calcium and phosphorus were investigated. Three per cent of steamed bone meal supports the most rapid rate of growth. One or two per cent is fairly satisfactory, but a ration which contains calcium carbonate and no steamed bone meal is entirely unsatisfactory. Autoclaved ground bone, U.S.P. tricalcium phosphate, and a defluorinated rock phosphate are effective substitutes. Although the soybean oil meal ration supplies more than 0.5 per cent of phosphorus, it is necessary to add some source of inorganic phosphorus for a satisfactory rate of growth.

The rate of growth was increased and the incidence of perosis was reduced by substituting wheat for corn.

Soybean Oil Meal as a Protein Supplement For Baby Chicks

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It is frequently stated in the literature that rations for baby chicks are unsatisfactory if they contain no animal protein, but the more important animal proteins such as meat scraps, fish meal, and milk products were frequently unobtainable during the war emergency. Soybean oil meal is more readily available than animal protein concentrates, but there has been some uncertainty as to its biological value for poultry. Irwin and Kempster (1942) have shown that soybean oil meal can be used as a partial substitute for meat scraps and dried skim milk. The earlier literature on the nutritional properties of soybean oil meal prepared by various methods, and its use in rations for chicks, has been reviewed by Hammond and Titus (1943) and by Heuser and Norris (1944).

The present investigation was undertaken to determine whether baby chicks grow satisfactorily on a ration that contains no protein supplement except soybean oil meal, and to determine the degree of improvement when the critical constituents such as meat scraps, fish meal, milk products and alfalfa meal are also included.

EXPERIMENTAL

The experimental animals were single-comb White Leghorn and Barred Plymouth Rock chicks which were obtained from a commercial hatchery. They were divided into groups of 5 to 15 chicks in such a manner that their average initial weights were the same. The number of times that an experiment was repeated is indicated by the number of trials as shown in the tables. The chicks were kept for the first three weeks in an electrically heated battery maintained at a temperature of 90° to 95° F. At the end of this period they were transferred to a growing battery in a room in which the temperature varied from 75° to 80° F. Feed and water were available at all times.

The chicks which died during the first week were omitted from the records. The experimental periods in all tables were six

weeks in length. The mean weight as used in this report is the sum of the average weights of the males and of the females divided by two. This weight is used because it simplified the tables, and it measures the difference in response to the various rations as accurately as would the average weights from which it was computed. The natural feedstuffs which were used in the rations were obtained on the open market. The alfalfa meal was a commercially dehydrated product and the yeast was brewers' blended yeast. All materials were purchased in relatively small quantities and since new supplies were ordered frequently the data obtained gave a reliable indication of the results that would be expected in practice. When a natural feedstuff was added as a supplement it usually replaced an equal weight of corn, but in the more recent experiments the corn and soybean oil meal were varied to maintain a constant protein content.

Unless otherwise stated, in studies of any one supplement, only those trials are included for which there was a corresponding control. For example, in Table 3 there were six trials with White Leghorns and two with Barred Rocks. The control for each of these eight trials was under observation at the same time, and the results on the control and experimental rations are strictly comparable. However, the various experimental diets were not always studied simultaneously, and the results are not necessarily comparable. The necessity for caution in this respect is confirmed by a comparison of the weights of the various controls, which were somewhat variable. Table 6 is an exception as in each trial all experimental groups, and their controls, were under observation at the same time. The basal rations for the different trials within a comparison, although similar, are not necessarily identical in composition.

The investigations described in this report are discussed under the following headings:

(1) Soybean oil meal as a protein supplement
(2) Supplements to a soybean oil meal ration
    (a) Addition of one natural feedstuff
    (b) Addition of two natural feedstuffs
    (c) Addition of more than two natural feedstuffs
(3) Vitamins as supplements to soybean oil meal rations
(4) The value of steamed bone meal and other sources of mineral supplements
(5) The value of corn as compared to wheat in a soybean oil meal ration

Soybean Oil Meal as a Protein Supplement

Soybean oil meal was fed as a protein supplement to single comb White Leghorn baby chicks at 40, 30, 25, 20 and 15 per cent levels. In every case the ration was supplemented with crystalline riboflavin.

An example of a typical ration is as follows:

Yellow corn	52	Iodized salt	0.5
Wheat bran	5	Steamed bone meal	2.0
Wheat shorts	15	$MnSO_4$ $4H_2O$	.04
Soybean oil meal	25	A-D Conc[1]	0.5
		Riboflavin Mg/100	0.4

1. Supplied 3000 I. U. of vitamin A and 212 I. U. of vitamin D per gram of ration.

TABLE 1. - AMOUNT OF SOYBEAN OIL MEAL REQUIRED IN RATIONS FOR BABY CHICKS[1]

Amount of soybean oil meal	No. of trials[2]	Observations on Chicks					Calculated Amount In the Ration		
		No. Observed	Mean Wt.	Mortality		Perosis	Protein	Ca	P
%			gm.	No.	%	No. %	%	%	%
40	5	38	401	1	2.6		24.8	0.8-1.2	.9
30	6	53	370	1	1.9	1 1.9	21.3	.8	.8
25	4	81	392	1	1.2		19.6	.7	.8
20	4	65	353	2	3.1		17.7	.7	.8
15	2	18	305	1	5.5		16.0	.7	.8

[1]Single comb White Leghorns

[2]All comparisons were not made simultaneously

The data summarized in Table 1 show that the chicks grew at about the same rate when 25, 30, or 40 per cent soybean oil meal was included in the ration, with a mean weight of approximately 390 grams. When the amount of soybean oil meal was decreased to 20 or 15 per cent the rate of growth was decreased and the mortality rate, although not excessive, was increased. In order to obtain a measure of the degree of adequacy of the rations described, this weight was compared with the weights reported in a few publications that happened to be at hand on practical poultry feeding. The most rapid rate of growth of White Leghorns described in these papers was observed by Horlacher, Smith and Wiley (1941). The average weight of the males and females together was 359 grams at six weeks. Barred Plymouth Rocks were used in our later studies and an excellent rate of growth for this breed was observed by Roberts and

Carrick (1933). The average weights of the males was 451 grams. In a later report these same authors (Roberts and Carrick, 1937) reported the exceptional weight of 547 grams for male Barred Plymouth Rock chicks at six weeks.

It is our experience that chicks on practical poultry rations grow more slowly than they do on our better synthetic diets. Richardson, Hogan and Karrasch (1942) reported a mean weight of 465 grams for White Leghorns on synthetic diets. An average weight of 555 grams at six weeks was obtained with synthetic diets in unpublished observations on Barred Plymouth Rocks.

The ration which contained 25 per cent of soybean oil meal was fed in separate trials to White Leghorn chicks at the University of Missouri Poultry Farm. These chicks had a mean weight of 342 grams and there were no abnormalities. At the same time a second group of chicks received a similar ration except that it contained 10 per cent of alfalfa meal, 7 per cent of meat scrap and 15 per cent of soybean oil meal. These chicks weighed exactly the same as those which received the soybean oil meal ration. These experiments, carried out under practical conditions, supply additional evidence that soybean oil meal is a satisfactory protein supplement for baby chicks when it is supplied at a level of 25 per cent and supplemented with riboflavin.

TABLE 2. - THE EFFECT OF SOYBEAN OIL MEAL ON SIZE OF THE THYROID GLAND

Ration	Average Weight of Thyroid per 100 gm. body Weight			
	Males		Females	
	No.	Wt.	No.	Wt.
		mg.		mg.
Control[1]	5	7.8	7	11.7
20% SBOM	5	8.8	6	8.5
25% SBOM	4	7.2	2	10.2
30% SBOM	17	8.0	17	10.5
40% SBOM	4	11.2	1	15.0

[1]A synthetic ration which contained casein and gelatin as a source of protein.

These observations are not in complete agreement with those of Berry, Carrick, Roberts and Hauge (1943a, b) and Hammond and Titus (1944) who found that in the absence of animal protein, 35 per cent of soybean oil meal may be required for a rapid rate of growth.

In some of our earlier experiments common table salt was used instead of iodized salt. The thyroid glands of a few chicks

on different amounts of soybean oil meal were removed and weighed to determine if there was any goitrogenic effect of soybean oil meal in the absence of iodized salt. The thyroid glands from a group of chicks which received a synthetic ration that contained casein and gelatin were also removed and weighed as controls. The weights of the thyroid in milligrams per 100 grams of chick are summarized in Table 2. The data show that soybean oil meal has no goitrogenic effect at a level of 30 per cent. Only a few chicks were available which received 40 per cent, but the thyroid glands of these chicks were definitely heavier than those of chicks which received a lower level of soybean oil meal.

Natural Feedstuffs as Supplements to a Soybean Oil Meal Ration For Baby Chicks

Addition of One Natural Feedstuff.—Dehydrated alfalfa meal, dried whey, dried skim milk, dried yeast, and meat scrap were each tested separately as supplements to soybean oil meal. With the exception of meat scrap, each was fed at a 5 and at a 10 per cent level, but since the chicks which received 5 per cent of any one supplement grew as rapidly, in practically every case, as those which received 10 per cent, the data at the two levels have been combined. The results are summarized in Table 3. The composition of a typical ration is as follows:

Yellow corn	47	Steamed bone meal	2.0
Wheat bran	5	Iodized salt	0.5
Wheat shorts	15	A-D Conc.	0.5
Soybean oil meal	25	$MnSO_4$ $4H_2O$	.04
Dehydrated alfalfa	5		

The data show that the addition of any one of the feedstuffs which was tested increased the rate of growth, with the exception of dehydrated alfalfa meal, by approximately 10 per cent. Table 3 indicates that dehydrated alfalfa has no value as a supplement to soybean oil meal but in another trial, summarized in Table 6, it did give a small increase in the rate of growth. As a rule though, alfalfa has not improved our rations in any significant way when they were fortified with adequate amounts of vitamin A and riboflavin. Dehydrated alfalfa meal, when fresh or when stored for only a short period, supplies 95,000 international units of vitamin A as carotene and 8000 micrograms of riboflavin per pound (Titus 1942). At a level of 5 per cent this grade of alfalfa supplies 4750 I. U. of vitamin A and 400 micrograms of riboflavin per pound of ration. This is about the minimum requirement

TABLE 3. - SUPPLEMENTS TO A SOYBEAN OIL MEAL RATION FOR BABY CHICKS - ADDITION OF A SINGLE NATURAL FEEDSTUFF

Supplements	Observation on Chicks								Calculated	Amount in Ration	
	No. of Trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
%				gm.	No.	%	No.	%	%	%	%
Alfalfa 5, 10	6	WL	44	339	1	2.3	2	4.5	20.4-22.5	.9-1.1	.8
	2	BR	39	395	3	7.7	1	2.6	19.6	1.1	.9
None	6	WL	75	344	3	4			19.5-24.8	.8-1.0	.8
	2	BR	50	392	2	4			19.6	1.1	1.0
Whey 5, 10	7	WL	65	357					18.2-21.7	.8-1.0	.8-1.0
None	7	WL	80	316	1	1.2			18.2-21.7	.8-1.0	.8-1.0
Skim milk 5, 10	6	WL	81	385	7	8.6	1	1.2	19.2-24.9	.8-1.2	.8-1.1
	2	BR	29	433					19.8	1.1	1.0
None	6	WL	91	335	6	6.6			19.6-23.7	.7-1.1	.8-1.0
	2	BR	50	397	2	4	1	2	19.6	1.1	1.0
Yeast 5, 10	10	WL	119	383	5	4.2			19.7-24.8	.7-1.0	.8-1.0
None	10	WL	108	343	7	6.5			18.2-24.8	.7-1.0	.8
Meat Scrap 10	2	BR	20	434					19.4	1.2	1.0
" " 7.5 [1]	9	WL	81	406	1	1.2	1	1.2	20.6-24.8	.8-1.3	.7-1.0
" " 7.5 [1]	2	WL	17	272	3	17.6					
" " 5	4	WL	33	385	1	3.0			19.6-24.3	1.2-1.4	.7-1.1
" " 2.5	4	WL	33	377	1	3.0			18.7-22.2	.9-1.2	.8- .9
None	9	WL	87	374	2	2.3	2	2.3	19.5-23.0	.7-1.2	.8-1.0
	2	BR	30	394			1	3.3	19.6	1.1	1.0

1 These chicks did not receive riboflavin; 11.8 per cent developed curled-toe paralysis. The chicks in the other groups received crystalline riboflavin.

of vitamin A and one-third the minimum requirement for riboflavin. Both of these vitamins are unstable and a poorer grade of alfalfa contains much less of the vitamins. Since a poor grade of alfalfa is low in vitamins and high in crude fiber it may be more harmful than beneficial in rations for growing chicks.

The supplementary value of meat scraps was tested at a 10, 7.5, 5 and 2.5 per cent level. All groups, with the exceptions of one which received 7.5 per cent of meat scrap, received crystalline riboflavin in addition. The chicks in the group which did not receive riboflavin grew very slowly and the mortality rate was high. In addition 11.8 per cent developed typical curled-toe paralysis. These data show that meat scrap is a very poor source of riboflavin. The rate of growth was most rapid when meat scrap was supplied at 7.5 and at 10 per cent levels. It was less rapid at the 5 per cent level and at the 2.5 per cent level the rate of growth was no faster than it was with none. No attempt has been made to determine what specific nutrient is responsible for the supplementary effect of meat scrap, but it is high in protein, which may furnish essential amino acids that are not supplied in sufficient quantity for an optimum rate of growth by the soybean oil meal. From other data which are given in another publication there is no reason to suppose that meat scrap supplies unrecognized vitamins. Regardless of the specific nutrient responsible for the value of meat scrap, these data show that it has very little value in supplementing soybean oil meal when supplied at a level of 5 per cent or less. As pointed out above the addition of dried skim milk, of dried yeast, of meat scrap, or of dried whey, to the soybean oil meal ration increases the rate of growth of chicks up to 6 weeks of age. However, as shown in Table 3 the control group in each comparison grew at a fairly satisfactory rate and it demonstrates that a ration which contains soybean oil meal as the only protein supplement is satisfactory.

These observations agree for the most part with those of Berry et al. (1943a, b), Hammond and Titus (1944), Heuser and Norris (1944) and Wilgus and Zander (1945). However, these authors are of the opinion that from 2 to 6 per cent of animal protein must be added along with soybean oil meal in order to maintain a satisfactory rate of growth.

Ott (1944) reported that a ration which contained soybean oil meal as the sole protein concentrate supported as rapid a rate of growth in chicks as did commercial starter rations which

contained various animal and vegetable protein supplements. Recently Marvel et al. (1945) have reported a remarkably rapid rate of growth by chicks on rations that contained 10 per cent of distillers' dried solubles, and 26 per cent of soybean oil meal as the only protein concentrate. Males on these rations (Lots 19 to 24, Table 4) weighed an average of 514 to 546 grams at 6 weeks. Evidently soybean oil meal by itself is entirely satisfactory as a protein supplement, if the meal is of suitable quality, and if the other nutrients are present in suitable quantity. It should be emphasized though that records of comparable growth rates, on similar diets, are rare. In fact this same group of investigators has reported excellent growth in one trial and moderate growth in another, when the differences between the ration formulas seemed too trivial to explain the differences in rate of growth. We have had the same experience.

It will be observed in Table 3 that the chicks in the control groups grew more slowly as a rule than did those described in Table 1. These trials were not all conducted at the same time and as pointed out previously the rations, although similar, are not necessarily identical in composition in every respect. It is believed the variability is due to qualitative differences in the constituents, chiefly in the soybean oil meal. It is quite certain that the simple rations described in this report do not provide all nutrients in optimum amounts, and a high degree of variability is to be expected.

Addition of Two Natural Feedstuffs.—The same feedstuffs which were tested singly in the preceding section were tested in pairs as supplements to soybean oil meal. The combinations were (1) whey and alfalfa, (2) dried skim milk and alfalfa, (3) dried yeast and alfalfa, (4) dried skim milk and yeast, and (5) meat scrap and yeast. The experimental data are decribed in Table 4 and an example of a typical ration follows:

Yellow corn	42.0	Dried skim milk	5.0
Wheat bran	5.0	Steamed bone meal	2.0
Wheat shorts	15.0	Iodized salt	0.5
Soybean oil meal	25.0	A-D Conc.	0.5
Dehydrated alfalfa meal	5.0	$MnSO_4$ $4H_2O$	.04

It was shown in Table 3 that dehydrated alfalfa meal has no value as a supplement to the soybean oil meal ration when added alone, and the data which are summarized in Table 4 show that it has no value when it is added with dried whey, dried skim milk or dried yeast. When supplied as a single addition

TABLE 4. - SUPPLEMENTS TO SOYBEAN OIL MEAL RATIONS FOR BABY CHICKS - ADDITION OF TWO NATURAL FEEDSTUFFS

Supplements	Observations on Chicks								Calculated Amount in Ration		
	No. of Trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
%				gm.	No.	%	No.	%	%	%	%
Whey 5, 10 + alfalfa 5, 10	4	WL	40	350	2	5	1	2.5	19.2-22.4	1.0	.8
Whey 5, 10	4	WL	47	350	5	10.6			18.2-21.6	.8-1.0	.8
Alfalfa 5, 10	4	WL	22	309	1	4.5	2	9.1	20.4-22.5	.9-1.1	.8
Skim milk 5 + alfalfa 5	2	BR	21	412					19.6	1.1	.9
Skim milk 5	2	BR	30	431			1	3.3	19.8	1.1	1.0
Alfalfa 5	2	BR	21	418					19.6	1.1	.9
Yeast 5 + alfalfa 5	3	WL	60	408	4	6.7			19.4-24.1	.9-1.0	.8
	1	BR	10	410					19.3	1.0	.9
Yeast 5	3	WL	25	390	1	4	1	4	23.1-24.8	.7- .9	.8-.9
	2	BR	20	416					19.9	1.1	1.0
Alfalfa 5 [1]	5	WL	44	339	1	2.3	2	4.5	22.4-22.5	.8- .9	.8
	2	BR	39	395	3	7.7	1	2.6	19.6	1.1	.9
Skim milk 5 + yeast 5	2	BR	31	448					19.6	1.1	.9
Skim milk 5	2	BR	19	450			1	5.2	19.8	1.1	1.0
Yeast 5	2	BR	20	416					19.9	1.1	1.0
Yeast 5 + meat scrap 7.5	2	WL	20	438					22.4	1.4	.9
Meat scrap 7.5 [1]	4	WL	40	435			1	2.5	20.8	1.3	.9

1 Two trials were not run simultaneously.

dried yeast improves the soybean oil meal ration, but when it is included with dried skim milk or with meat scrap the rate of growth is no faster than when it is omitted.

When yeast, skim milk, or meat scrap is added to the soybean oil meal ration, either singly or in various combinations, the protein content of the ration is increased. It may be suggested that the increase in protein is responsible for the more rapid rate of growth when these ingredients are added. The trials, which are summarized in Table 6, in which the protein content of the rations is constant, do not support this hypothesis. The addition of these same ingredients either singly or in combination still gave about a 10 per cent increase in the rate of growth.

Addition of More Than Two Natural Feedstuffs.—The natural feedstuffs which were under investigation as supplements to soybean oil meal were added to the ration in combination of three

or more. An example of a typical ration follows:

Yellow corn meal	40.5	Dried yeast	5.0
Wheat bran	5.0	Steamed bone meal	2.0
Wheat shorts	15.0	Calcium carbonate	1.5
Soybean oil meal	20.0	Iodized salt	0.5
Dehydrated alfalfa meal	5.0	A-D Conc.	0.5
Meat scrap	5.0	$MnSO_4$ $4H_2O$	0.04

The following combinations were tested: (1) meat scrap, alfalfa and whey, (2) meat scrap, alfalfa, and skim milk, (3) meat scrap, alfalfa and yeast, (4) meat scrap, yeast and skim milk, (5) meat scrap, yeast, alfalfa and skim milk, and (6) liver meal, yeast, alfalfa, and skim milk. These data are summarized in Table 5.

With one exception the chicks which received a supplement of more than two natural feedstuffs grew at a slightly more rapid rate than those which received meat scrap, or meat scrap and yeast. The chicks themselves were more vigorous and appeared more uniform than those which received single addi-

TABLE 5. - SUPPLEMENTS TO SOYBEAN OIL MEAL RATIONS FOR BABY CHICKS - ADDITION OF MORE THAN TWO NATURAL FEEDSTUFFS

Supplements	Observations on Chicks								Calculated Amount in Ration		
	No. of Trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
				gm.	No.	%	No.	%	%	%	%
Meat scrap 5 + alfalfa 5 + whey 5	1	WL	9	420					20.19	1.5	.8
Meat scrap 5	1	WL	9	401					19.65	1.2	.7
Meat scrap 5 + alfalfa 5 + skim milk 5	2	BR	21	429					19.6	1.1	1.0
Meat scrap 10	2	BR	20	434					19.4	1.1	1.0
Meat scrap 7.5 + alfalfa 5 + yeast 5	1	WL	15	497	1	6.6			22.97	1.5	.8
Meat scrap 7.5 + yeast 5	1	WL	14	447					22.4	1.4	.9
Meat scrap 5 + yeast 5 + skim milk 5	2 1	WL BR	21 10	509 474	1	4.7			22.7	1.4	.8
Meat scrap 5 + yeast 5 + alfalfa 5 + skim milk 5	3	WL	22	425	1	4.5			26.04-27.3	1.3-1.8	1.0-1.2
Meat scrap 5	3	WL	20	412	1	5	1	5	20.8-24.8	.8-1.4	.8-1.1
Liver meal 5, 10 + yeast 5 + alfalfa 5 + skim milk 5 [1]	1	BR	20	472					25.0	.9	1.0

1 The ration contained wheat instead of corn. The liver meal was purchased from Wilson and Co.

tions. There were no abnormalities and the mortality rate was low. The combinations which gave the most rapid rate of growth were (1) meat scrap, alfalfa and yeast, (2) meat scrap, yeast and skim milk, and (3) liver meal, yeast, alfalfa and skim milk. The chicks which received a combination of meat scrap, alfalfa and whey grew slightly faster than those which received meat scrap alone. Those which received meat scrap, alfalfa and skim-milk grew at about the same rate as those which received meat scrap.

Since the number of trials and the number of chicks per trial is small in the above comparisons the differences may be misleading. In another series with Barred Rock chicks in which the comparisons were made simultaneously, the addition of either dried skim milk or meat scrap, to the soybean meal ration accelerated the rate of growth as much as did the addition of any combination of two or more of the natural feedstuffs under investigation. In these rations the protein content was constant. The observations on the chicks are summarized in Table 6, and examples of two typical rations are as follows:

	I	II
Yellow corn meal	51	55
Wheat bran	5	5
Wheat shorts	15	15
Soybean oil meal	25	14
Meat scrap	—	10
Steamed bone meal	3.0	—
Iodized salt	0.5	0.5
A-D Conc.	0.5	0.5
$MnSO_4 \cdot 4H_2O$	0.04	0.04
Riboflavin Mg/100	0.4	0.4

When alfalfa or yeast was added the chicks grew at a slightly faster rate than those which received the basal ration alone. When alfalfa was combined with dried skim milk or with dried skim milk and meat scrap the rate of growth was slower than when either skim milk or meat scrap was added without the alfalfa. The chicks in the one trial which received a combination of dried skim milk, dried yeast and meat scrap grew at about the same rate as those which received skim milk alone. As a rule the addition of one, of two, or of three natural feedstuffs gave about the same increase in the rate of growth, but the increase is never very large in any case.

Vitamins as Supplements to a Soybean Oil Meal Ration.—There is no doubt, from the experiments which are described above, that meat scrap, dried skim milk or dried yeast either singly or

TABLE 6. - SUPPLEMENTS TO A SOYBEAN OIL MEAL RATION. ADDITION OF ONE, TWO, AND OF THREE NATURAL FEEDSTUFFS

	Observations on Chicks						Calculated Amount in Ration		
	No. of trials[1]	No. observed	Mean Wt.	Mortality	Perosis		Protein	Ca	P
			gm.	No.	No.	%	%	%	%
Basal	2	20	389						
Alfalfa 5	2	21	419		1	4.7	19.6	1.1	.9
Yeast 5	2	20	419				19.9	1.1	1.0
Skim milk 5	2	19	449		1	5.2	19.8	1.1	1.0
Meat scrap 10	2	20	434				19.4	1.2	1.0
Alfalfa 5 Skim milk 5	2	21	412				19.6	1.1	.9
Alfalfa 5 Yeast 5	2	20	416				19.6	1.0	.9
Skim milk 5 Yeast 5	2	31	448				19.6	1.1	.9
Alfalfa 5 Skim milk 5 Meat scrap 5	2	21	429				19.6	1.1	1.0
Skim milk 5 Yeast 5 Meat scrap 5	1	10	451				22.7	1.4	.8

[1]Barred Rocks were used, and all trials were run simultaneously.

TABLE 7. - VITAMINS AS SUPPLEMENTS TO A SOYBEAN OIL MEAL RATION

	Observations on Chicks [1]								Calculated Amount in Ration		
Supplement per 100 gm.	No. of trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
				gm.	No.	%	%	No.	%	%	%
Riboflavin 0.4 mg.	7	WL	48	368	4	8.3			18.2-24.8	.7-.9	.8-.9
No Riboflavin [2]	7	WL	53	295	4	7.5			18.2-24.8	.7-.9	.8-.9
Riboflavin + choline	5	WL	49	376	4	8.2			18.2-24.8	.7-.9	.8-.9
Riboflavin, no choline	5	WL	38	364					18.2-24.8	.7-.9	.8-.9
All vitamins [3]	3	WL	98	385	1	1			18.2-24.8	.7-.9	.8-.9
Riboflavin 0.4 mg.	3 [4]	WL	32	365					18.2-24.8	.7-.9	.8-.9

1 No perosis.

2 Nine chicks or 17.0 per cent developed curled-toe paralysis.

3 The vitamins in milligrams per 100 gm. of ration were thiamine, riboflavin and pyridoxine, each 0.4, calcium pantothenate 2.0, niacin 5.0, and choline 200. These were generously supplied by Merck and Co., Rahway, N. J.

4 When 3 additional trials (conducted at another time) are combined with these a total of 112 chicks has a mean weight of 280 grams, and a mortality rate of 1.6 per cent.

in various combinations improve the soybean oil meal ration. However, it is seen in Table 1 and in the controls in Table 3 that soybean oil meal alone is satisfactory as a protein supplement if it is supplemented with riboflavin.

This portion of the report is to show the value of pure vitamins as supplements to soybean oil meal. The following comparisons are made: (1) Riboflavin and no riboflavin, (2) choline and no choline, (3) riboflavin and all the water-soluble vitamins. These observations are summarized in Table 7.

The chicks which received riboflavin grew at a much faster rate than those which did not receive it. In addition there were 9 chicks, or 17.0 per cent, in the latter group which developed curled-toe paralysis. Occasionally a group of chicks which did not receive riboflavin grew as rapidly as those which received it, but these were exceptions. At the most this ration supplies only border-line amounts, and it would be hazardous to use it without a riboflavin supplement. The chicks which received choline grew at a slightly faster rate than those which received no choline. In another comparison a total of 98 chicks in 3 trials with all the water-soluble vitamins grew slightly faster than a total of 32 chicks in 3 trials with riboflavin as the only supplement. These tests indicate that there is a border-line deficiency of some recognized vitamin, and it may be inferred that this is choline. However, when three additional trials with a total of 80 chicks with riboflavin as the only supplement are combined with the 32 chicks there is no indication that any vitamin other than riboflavin is deficient. The difference in the weight in any case is relatively small and may not be highly significant. However, these trials were conducted under optimum conditions. If the environment had been less suitable it is possible that a vitamin deficiency would have become evident in the chicks on the basal diet. It was demonstrated in another investigation, which will be published elsewhere, that chicks on an adequate diet withstand exposure to slightly subnormal temperatures with only slight ill effects. On the other hand, chicks which received insufficient pantothenic acid had a disastrous mortality rate. Also it should be remembered that soybean oil meal is superior to some of the other protein concentrates in its vitamin content. Therefore, it is possible that substitution of another protein concentrate, without regard to its vitamin content, for all or a portion of the soybean oil meal may decrease some vitamin so that the total amount available would be inadequate. This warning is also

suggested by the fact that feedstuffs are variable in nutritive value. As an example Berry et al. (1943), reported that some preparations of soybean oil meal are deficient in choline. Our data, in Table 7, show that riboflavin was deficient in the basal diet. It is by no means improbable that other vitamins are present in border-line amounts.

The Amount of Steamed Bone Meal and Other Mineral Supplements for Baby Chicks

For a short period during the present emergency it appeared that the amount of steamed bone meal available for poultry rations would be greatly reduced and that a substitute would have to be found. Investigations were carried out to determine the amount of steamed bone meal required for growing chicks, and to determine the value of autoclaved ground bone, tricalcium phosphate and defluorinated rock phosphate as substitutes. The basal ration was the same as that given in the section entitled Soybean Oil Meal as a Protein Supplement. Steamed bone meal was supplied at a level of 3, 2, 1, and 0 per cent; the calcium content of the ration was maintained at a constant level by the

TABLE 8. - THE AMOUNT OF STEAMED BONE MEAL AND THE VALUE OF OTHER MINERAL SUPPLEMENTS FOR BABY CHICKS

	Observations on Chicks								Calculated Amount in Ration		
Supplement	No. of Trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
%				gm.	No.	%	No.	%	%	%	%
Steamed Bone Meal 3	1 2	WL BR	9 18	406 445			1	11.1	19.6	1.1	1.0
Steamed Bone Meal 2	1 2	WL BR	16 16	383 420	1	6.2	2	12.5	19.6	1.0	.8
Steamed Bone Meal 1	1 2	WL BR	9 19	366 390	1	11.1			19.6	1.0	.7
Steamed Bone Meal 0	2	BR	18	297	2	11.1			19.6	1.1	.5
Autoclaved [1] Ground Bone 5, 10	4	WL	55	372	7	12.7	1	1.8	21.5	.9	1.0
Steamed Bone Meal 2	4	WL	39	364	2	5.1			19.6	1.0	.8
Tricalcium Phosphate USP 2.5	2	BR	32	440			2	6.2	19.6	1.0	1.0
Steamed Bone Meal 3	2	BR	18	445			1	5.5	19.6	1.1	1.0
Defluorinated Phosphate [2] 3	1	BR	10	444					19.6	1.0	.9

1 Raw bone autoclaved, dried and ground.

2 A defluorinated rock phosphate. Kindly supplied by International Minerals and Chemical Corp., Chicago, Ill.

addition of calcium carbonate. Autoclaved ground bone was supplied at a 5 per cent level; tricalcium phosphate at 2.5 per cent and the defluorinated rock phosphate at 3 per cent. These observations are summarized in Table 8.

The most rapid rate of growth was obtained when steamed bone meal was supplied at the 3 per cent level, and it was reasonably satisfactory when the steamed bone meal was supplied at a level of 1 or 2 per cent. It was entirely unsatisfactory when no steamed bone meal was added even though the ration contained slightly more than 0.5 per cent of phosphorus. This observation is in agreement with that of McGinnis, Norris and Heuser (1944), but Singsen and Mitchell (1944) reported that phosphorus in cereals and legumes is readily available if the ration contains unheated leafy material or if the chicks have access to green grass. The chicks which received autoclaved ground bone, tricalcium phosphate or defluorinated rock phosphate grew as rapidly as those which received steamed bone meal. Barrentine, Maynard, and Loosli (1944) have shown that certain defluorinated rock phosphates may be inefficient in bone formation and may inhibit growth of rats. It should be emphasized, therefore, that if a defluorinated rock phosphate is to be substituted for steamed bone meal it should be low in fluorine (less than 0.10 per cent), and it should contain calcium and phosphorus in a form which is readily available.

TABLE 9. - THE VALUE OF CORN AS COMPARED TO WHEAT IN SOYBEAN OIL MEAL RATIONS FOR BABY CHICKS

	Observations on Chicks								Calculated Amount in Ration		
	No. of Trials	Breed	No. observed	Mean Wt.	Mortality		Perosis		Protein Range	Ca Range	P Range
				gm.	No.	%	No.	%	%	%	%
Corn	2	WL	69	364			3	4.3	17.9-19.7	1.1	.8-1.0
	2	BR	40	385			1	2.5	19.8	1.1	1.0
Wheat	2	WL	52	416					20.6-21.4	1.1	.9-1.0
	2	BR	30	395	2	6.7			19.6-21.4	1.1	.9-1.0

Value of Corn as Compared to Wheat in Soybean Meal Rations

It will be observed in Table 9 that the rate of growth was slightly accelerated when wheat was substituted for corn. The difference in the rate of growth was small and may not be significant under practical conditions. No attempt was made to determine whether the difference was due to the higher protein

content of the wheat ration. There was no perosis on the wheat ration and this difference may be significant. Wheat is deficient in carotene while yellow corn contains this vitamin. However, when vitamin A is provided from other sources wheat may be superior to corn.

Hammond and Titus (1944) observed that wheat is slightly superior to corn or a combination of corn and oats. They attributed this superiority to the relative age of the two cereals. In the experiments which are described here the age of the corn or of the wheat before grinding was not available. They were ground in the laboratory or purchased from a local mill immediately after they were ground, in quantities which were used up within a period of 6 to 8 weeks.

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